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Healthcare Quality Reporting Program

HOSPITAL-ACQUIRED INFECTIONS SUBCOMMITTEE

8-9am, June 16, 2014
Healthcentric Advisors, 235 Promenade Street, Suite 500

1. Welcome (8am)

- Meeting chairs: L. Mermel and S. Viner-Brown
- Program staff: R. Baier, E. Cooper
- Voting members in attendance (9/19): N. Alexander, M. Fishman, Y. Jiang, M. Marsella, L. Mermel, K. O'Connell, S. Turner, N. Vallande, S. Viner-Brown
- Others in attendance: L. Martino, J. Rocha

2. Today's meeting objectives (8:05am)

- To discuss the MRSA CLABSI data source, hand hygiene measurement and the new HEALTH Taskforce on Antimicrobial Stewardship

3. Previous meeting's action items (8:05am)

- Follow-up with Gina about the HARI Board discussion of HAIs (Maureen) - Complete
- Share additional feedback on the legislative idea via Survey Monkey (All) - Complete
- Research the evidence base for hand hygiene requirements and reporting (Emily/Rosa) - Complete
- Conduct an environmental scan of other states' hand hygiene reporting (Emily/Rosa)
- Share hand hygiene data collection forms with Emily and Rosa (All) - Pending
- Provide Whitehouse's staff with HAI policy feedback (Rosa) - Complete

4. MRSA CLABSI Data Source (8:10am)

- Discussion of MRSA CLABSI data source for public reporting, NHSN (MRSA CLABSI, current) or Hospital Compare (MRSA, data now available)
- Discussion themes included:
  - Reporting of LabID (MRSA, Hospital Compare) or infections (MRSA CLABSI, NHSN)
  - Which data source is more current (NHSN)
  - Which data source aligns with what is being reporting nationally and to the hospital CEOs (Hospital Compare)
  - The need to continue the preview period, which allows the hospitals to review the data before they are published, if we continue to use NHSN
- Recommendations: The group decided to continue using data from NHSN.

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5. Hand hygiene measurement (8:30am)

- Discussion of Dr. Fine's request that the Subcommittee recommend a standard best practice for hand hygiene for all hospitals to implement and potentially report
- Discussion themes included
  - The evidence base (CDC, Joint Commission, and WHO)
  - Hospitals' current measurement practices (mostly observation, but with different methods)
  - The need for additional support for the hospitals' infection prevention programs to monitor compliance
  - The difficulty of collecting comparable data across facilities.
- Recommendation: The group agreed to three suggestions for the Steering Committee:
  - Standardize hand hygiene education requirements for all LIPs in license renewal, including a pre/post test
  - Require facilities to develop programs for 'repeat offenders' who are non-compliant with the hospital's hand hygiene policy
  - Recommend research of automated electronic measurement systems with the goal of all facilities using a single manufacturer to assure identical measurement accuracy which, although costly, would standardize data collection and allow reporting of comparable data

6. Update: New HEALTH Taskforce on Antimicrobial Stewardship (8:45am)

- Discussion deferred until our next meeting

7. Action items (8:55am)

- Research CDC hand hygiene education videos and tests (Rosa/Emily)
- Bring hand hygiene recommendations to the Steering Committee (Rosa/Emily/Sam)

Next Meeting: August 18, 2014

ORIGINAL ARTICLE

Measuring Rates of Hand Hygiene Adherence in the Intensive Care Setting: A Comparative Study of Direct Observation, Product Usage, and Electronic Counting Devices

Alexandre R. Marra, MD; Denis Faria Moura, Jr, RN; Ângela Tavares Paes, PhD; Oscar Fernando Pavão dos Santos, MD; Michael B. Edmond, MD, MPH, MPA

OBJECTIVE. To compare 3 measures of hand hygiene adherence—direct observation, product usage, and electronic counting devices—in an intensive care unit.

DESIGN. A 12-week observational study.

SETTING. A 40-bed medical-surgical intensive care unit at a private tertiary care hospital.

METHODS. Over a 12-week period, we assessed hand hygiene adherence by 3 different methods: direct observation of practice, collection of data from electronic counters for dispensers of alcohol-based hand rub, and measurement of the amount of product used (alcohol-based hand rub and chlorhexidine).

RESULTS. There were 2,249 opportunities for hand hygiene observed, and the overall rate of hand hygiene adherence was 62.3% (representing 1,402 cleansing episodes). A total of 76,389 dispensing episodes were recorded by the electronic devices. The mean number of dispensing episodes per patient-day was 53.8. There was 64.1 mL of alcohol-based hand rub used per patient-day (representing 65.5% of total product used) and 33.8 mL of chlorhexidine used per patient-day (representing 34.5%). There was no significant correlation between observed hand hygiene adherence and total product used per patient-day ($r = 0.18$; $P = .59$).

CONCLUSIONS. Direct observation cannot be considered the gold standard for assessing hand hygiene, because there was no relationship between the observed adherence and the number of dispensing episodes or the volume of product used. Other means to monitor hand hygiene adherence, such as electronic devices and measurement of product usage, should be considered.

Infect Control Hosp Epidemiol 2010; 31(8):796-801

Hand hygiene is the most important strategy for nosocomial infection prevention in healthcare settings.[1] The effectiveness of hand hygiene has been demonstrated in a number of studies in which decreased transmission of infection has occurred as hand hygiene adherence increases.[2-4] However, actual adherence to recommended hand hygiene practices by healthcare workers (HCWs) remains suboptimal,[5] despite high levels of self-reported adherence.[6]

There is no standard for measuring adherence to hand hygiene practices; however, directly observing adherence to hand hygiene recommendations is the method used in the majority of hand hygiene studies.[7-9] Although there are many advantages to direct observation, the major disadvantage is that data for only a very small sample of all the hand hygiene opportunities are captured.[10] Moreover, having observers walk into patient rooms violates patient privacy, the presence of an observer may produce the Hawthorne effect, and observing HCWs is time-consuming and expensive. For these reasons, we used electronic counters for product dispensers to monitor the hand hygiene adherence of HCWs in the intensive care unit (ICU) in a previous study.[11] Another strategy for measuring adherence to hand hygiene practice is to record the volume of hand hygiene product used and to calculate the amount used per 1,000 patient-days.[10-12]

The purpose of this study was to compare methods for assessing adherence to hand hygiene in an ICU. We used direct observation of practice, electronic counters for dispensers of alcohol-based hand rub (ABHR), and measurement of the volume of product used (ABHR and chlorhexidine).

METHODS

This study was conducted in the 40-bed ICU of a private tertiary care hospital in São Paulo, Brazil. The ICU is an open-staffing model, medical-surgical unit with all private

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rooms. The rooms are configured in seven 4-room and two 6-room suites or "pods." For the study, we selected three 4-room pods (units 8, 10, and 18) and one 6-room pod (unit 12) that are located in the west side of the ICU. The east side of the ICU was not included. The study was approved by the facility's institutional review board and was conducted over a 12-week period (May 16–August 15, 2009).

The 4-room pods selected for the study are each composed of 4 individual rooms with dedicated equipment for patient care, such as stethoscopes and thermometers. There are 6 sinks (1 sink in each room and 2 outside the rooms). The 4 patients in each pod are cared for by 1 nurse, 1 medical intern, and 4 technicians. Three attending physicians and 6 respiratory therapists are responsible for the care of all the ICU patients. The one 6-room pod has 8 sinks (1 in each room and 2 outside the rooms).

Hand hygiene adherence was compared using 3 different methods: direct observation of practice, electronic counters for dispensers of ABHR, and measurement of the volume of hand hygiene product used (ABHR and chlorhexidine, in milliliters per patient-day).

Direct Observations

Before the study began, 4 ICU nurses were trained in hand hygiene observation by an infection control practitioner. Hand hygiene observations by the 4 ICU nurses were validated in the ICU pods that were not part of our study (east side of the ICU) by having the ICU nurses and the infection control practitioner observe hand hygiene performance in the same pod concurrently and by comparing their measured rates of adherence. Then the ICU nurses (while not on clinical duty) were directed to perform hand hygiene observations for a 60-minute period in only 1 study pod per day and to vary the time of day of the observations (morning, afternoon, and night) randomly. The hand hygiene observations were performed every day, 7 days per week, for 12 weeks. These 4 ICU nurses recorded the opportunities for hand hygiene and the adherence on a handheld personal digital assistant (PDA, Motorola Symbol MC 50). During these audits, the 4 ICU nurses counted only hand hygiene opportunities that represented the points in time within the care process when hand hygiene should be performed, in accordance with the World Health Organization's Five Moments for Hand Hygiene.[13] All HCWs who provided care in the unit were included in the hand hygiene observations. All observations took place between 8:00 AM and 8:00 PM.

When questioned by the ICU HCWs, the observing nurse (who was not on clinical duty but who was dressed as if on clinical duty) explained that she was observing problems that needed to be corrected in the unit. To our knowledge, the ICU team never became aware that the nurses participating in the study were performing hand hygiene audits.

Electronic Counters and Measurement of Products

Hand hygiene episodes were recorded by electronic counters for dispensers of ABHR (1-L bags of Hand Instant Sanitizer [62% ethyl alcohol and 4% isopropyl alcohol]; Purell). The ABHR dispenser (NXT 1-L model; Purell) records only 1 episode in any 2-second period even if more than 1 aliquot of alcohol is dispensed. Chlorhexidine dispensers (chlorhexidine 2%) were also available for use, but these dispensers did not have electronic counters. The ABHR and the chlorhexidine devices dispensed the same volume of product per use (approximately 1.3 mL). We ensured that the nozzle of each dispensing device remained free of obstruction by having a nurse (not on clinical duty) check the number inside the signal counters, check the nozzle, and change out empty dispensers every 48 hours. There are 12 ABHR dispensers in each of the 4-bed pods: 2 dispensers per bed and 4 outside the rooms. There are 16 ABHR dispensers in the 6-bed pod: 2 dispensers per bed and 4 outside the rooms. Chlorhexidine dispensers were located at each sink (1 sink in each room and 2 outside the rooms).

The total volume of product used and the number of ABHR aliquots per patient-day were determined, as was the total volume of ABHR and chlorhexidine used. Statistical analyses were performed using SPSS, version 17.0 (SPSS). Correlations were calculated by the Spearman rank correlation coefficient. All tests of statistical significance were 2-sided, with a significance level set at $P \leqslant .05$.

RESULTS

During the 12-week trial, there was a total of 1,420 patient-days for the 4 study pods. There were 2,249 opportunities for hand hygiene observed, and the overall rate of hand hygiene adherence was 62.3% (representing 1,402 cleansing episodes). The mean number of observed opportunities per day was 26.8. A total of 76,389 dispensing episodes were recorded by the ABHR-dispensing counters; 30,851 (40.7%) occurred inside the patient rooms and 45,538 (59.6%) occurred outside the patient rooms in the unit. The mean number of dispensing episodes per patient-day was 53.8. There were 64.1 mL of ABHR used per patient-day (representing 65.5% of total product used) and 33.8 mL of chlorhexidine used per patient-day in the 4 units (representing 34.5%). The distribution of ABHR and chlorhexidine consumption is shown in Figure 1.

The highest observed rate of adherence to hand hygiene was 78.3% of opportunities (week 4), and the lowest rate was 56% of opportunities (week 8). The week with the highest number of dispensing episodes per patient-day (95.7) was week 10, when the respective rate of hand hygiene adherence was 57.1% of opportunities. The week with the lowest mean number of dispensing episodes per patient-day (21.1) was week 6, when the respective rate of hand hygiene adherence was 58.2% of opportunities. The week with the highest mean consumption of total product used (131.2 mL per patient-

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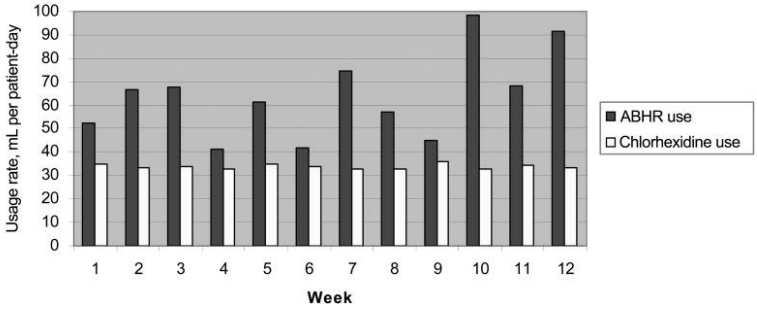

FIGURE 1. Bar graph showing consumption of alcohol-based hand rub (ABHR) and chlorhexidine during the 12-week study.

day) was week 10, and the week with the lowest mean consumption of ABHR (74.4 mL per patient-day) was week 4 (Table 1). The correlation between the rate of hand hygiene adherence and the mean number of hand hygiene dispensing episodes per patient-day was $r = 0.27$ ($P = .40$). The correlation between the mean number of hand hygiene dispensing episodes per patient-day and the mean ABHR consumption per patient-day was $r = 0.73$ ($P = .004$). There was no statistically significant correlation between the observed rate of hand hygiene adherence and the ABHR consumption ($r = 0.18$; $P = .59$) or the total volume of product used ($r = 0.18$; $P = .59$). Figure 2 shows the observed rate of hand hygiene adherence, the number of dispensing episodes per patient-day, and the volume of total product used by week during the 12-week study.

In an analysis by ICU pod, the best rate of hand hygiene adherence was 66.6% of opportunities in pod 12; however, this unit had the lowest mean product usage (83.6 mL per patient-day). Conversely, pod 10 had the lowest rate of adherence by direct observation (58.9% of opportunities) but had the highest mean product usage (108.3 mL per patient-day) (Table 2).

DISCUSSION

Use of ABHR was introduced to our adult ICU in 2002 and to the rest of the hospital gradually over 2 years. Improving hand hygiene adherence is one of the key performance improvement objectives of our institution, especially with regard to the care of critically ill patients. In our ICU, we have observers who perform hand hygiene observations; however, the time-consuming nature of the observations precludes the generation of large numbers of observed opportunities for adherence.

The electronic counter for dispensers of ABHR was an important tool for obtaining data about hand hygiene that gave us a different view of hand hygiene adherence in the ICU.[14] Some studies give feedback to HCWs about their hand hygiene adherence.[4,6,9] However, feedback on hand hygiene did not occur during the 12 weeks of our study.

TABLE 1. Comparison of Data on Adherence to Hand Hygiene (HH) Obtained with 3 Methods of Measurement, by Study Week

		Electronic counter data		Direct observation data			Product usage data, mean mL/patient-day		
Study week	No. of patient-days	No. of DEs	Mean no. of DEs/ patient-day	No. of HH episodes	No. of HH opportunities	Rate of adherence, % of opportunities	ABHR	Chlorhexidine	Both
1	115	4,647	40.4	109	167	65.3	52.2	34.8	87.0
2	120	7,501	62.5	116	175	66.3	66.7	33.3	100.0
3	118	3,512	29.8	101	146	69.2	67.8	33.9	101.7
4	121	5,878	48.6	101	129	78.3	41.3	33.1	74.4
5	114	3,123	27.4	101	146	69.2	61.4	35.1	96.5
6	119	2,505	21.1	103	177	58.2	42.0	33.6	75.6
7	121	9,610	79.4	87	142	61.3	74.4	33.1	107.5
8	122	7,488	61.4	122	218	56.0	57.4	32.8	90.2
9	111	4,411	39.7	141	239	59.0	45.0	36.0	81.0
10	122	11,676	95.7	117	205	57.1	98.4	32.8	131.2
11	117	7,379	63.1	156	262	59.5	68.4	34.2	102.6
12	120	8,659	72.2	148	243	60.9	91.7	33.3	125.0

NOTE. ABHR, alcohol-based hand rub; DE, dispensing episode.

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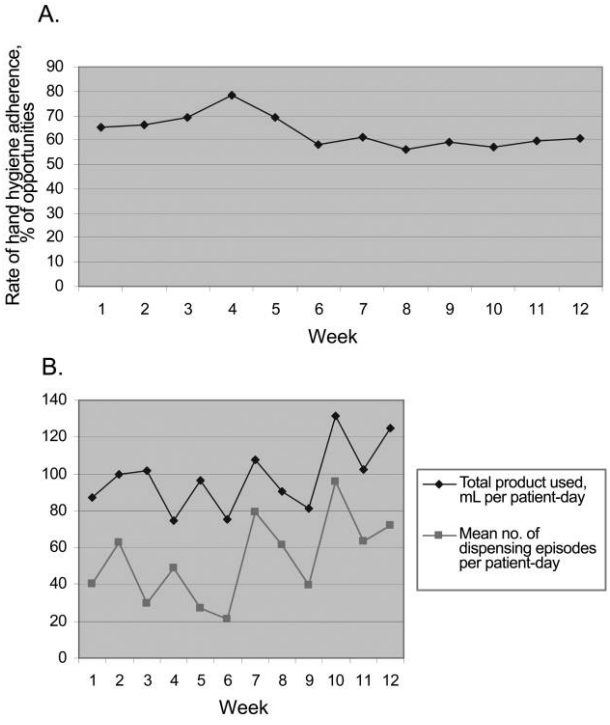

FIGURE 2. *A,* Line graph showing observed rate of hand hygiene adherence. *B,* Line graph showing electronically counted dispensing episodes and total product usage by week during the 12-week study.

We believe that directly observed rates of adherence are not accurate, because they did not correlate with mean volumes of product used, assuming that the number of opportunities for hand hygiene is relatively stable. There were 60-minute hand hygiene observation periods in only 1 pod per day; however, the electronic counters recorded episodes 24 hours per day in all of the pods. For example, in week 10, the observed rate of hand hygiene adherence was 57.1% of opportunities (the overall rate of hand hygiene adherence for the entire study was 62.3% of opportunities), the mean number of dispensing episodes per patient-day was 95.7 (the mean number of dispensing episodes per patient-day for the entire study was 53.8), and the total product consumption (131.2 mL per patient-day) was the highest in the study.

When the total volume of product used during the course of the study is divided by the volume of product used for 1 hand hygiene episode (1.3 mL), we can estimate the number of hand hygiene episodes. Assuming that the rate of hand hygiene adherence was 62% of opportunities, the total number of opportunities for the study period can be estimated at 172,457. The 2,249 episodes observed represent only 1.3% of the estimated number of hand hygiene opportunities. The extremely small fraction of hand hygiene opportunities that can be directly observed limits the utility of this method. However, it should be noted that the number of direct observations performed in this study greatly exceeds the number of observations that hospitals typically perform in their audits of hand hygiene adherence. Sheithauer et al[15] reported a rate of adherence of 59.3% (1,124 cleansing episodes in 1,897 opportunities), with data obtained in 2-hour observation periods in 3 different types of ICUs. Sheithauer et al[15] also compared the rate of adherence obtained by direct observation to that inferred by calculating product usage, revealing a 2.75-fold difference.

Boyce et al[11] found that the use of electronic devices provided specific data on how frequently HCWs used ABHR dispensers when they performed hand hygiene (ie, the time of day and the day of the week), revealing the locations of dispensers with the highest and the lowest rates of use. We found that there were more hand hygiene episodes per dispenser outside the patient rooms than in the rooms. This likely demonstrates an effective placement of ABHR dispensers, because HCWs use the hand hygiene product before entering the ICU patient room. Boyce et al[11] showed similar results and suggested that having ABHR dispensers in corridors as well as in patient rooms may be useful for improving hand hygiene.[11]

The electronic counters have yielded details about patterns of ABHR use other than the number of liters of ABHR used per 1,000 patient-days.[10,11,14] In our study, we observed a strong correlation between number of dispensing episodes per patient-day and ABHR consumption per patient-day, but there was no correlation between the rate of hand hygiene adherence and ABHR consumption per patient-day.

Although there are no standard methods for measuring rates of hand hygiene adherence, direct observation is noted

TABLE 2. Comparison of Data on Adherence to Hand Hygiene (HH), Stratified by Nursing Unit

		Electronic counter data		Direct observation data			Product usage data, mean mL/patient-day		
ICU pod	No. of patient-days	No. of DEs	Mean no. of DEs/patient-day	No. of HH episodes	No. of HH opportunities	Rate of adherence, % of opportunities	ABHR	Chlorhexidine	Both
8	307	14,854	48.4	330	549	60.1	65.1	39.1	104.2
10	314	19,244	61.3	330	560	58.9	70.1	38.2	108.3
18	320	15,834	49.5	302	479	63.0	65.6	37.5	103.1
12	479	26,457	55.2	439	659	66.6	58.5	25.1	83.6

NOTE. ABHR, alcohol-based hand rub; DE, dispensing episode; ICU, intensive care unit.

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by the World Health Organization as the gold standard method for assessing hand hygiene adherence rates.[10] In many medical centers where ABHR use has been implemented, rates of hand hygiene adherence are only approximately 50%.[16,17] In our ICU, the overall rate of hand hygiene adherence (approximately 62%) is relatively high. However, it is important to note that, coincidentally, our study was performed in the same period that the swine flu pandemic occurred. We do not know whether this high rate of hand hygiene adherence was associated with the many strategies for improving hand hygiene in our ICU that have been implemented since 2007 or whether it is a consequence of heightened awareness about hand hygiene due in part to the media coverage of swine flu.

Surprisingly, our consumption of ABHR was nearly 2-fold higher than our consumption of chlorhexidine in the ICU. Other studies have demonstrated that adherence to use of alcohol-based preparations increases substantially over time.[4,8] Bischoff et al[5] documented substantial improvement after a 6-month observational period. Quantification of product usage over time may serve as an indicator for hand hygiene performance in hospitals.[18] To our knowledge, our study is the first to compare measurement of hand hygiene adherence by direct observation of practice, collection of data from electronic counters for dispensers of ABHR, and quantification of the amount of product (ABHR and chlorhexidine) used in a medical-surgical ICU.

There are several limitations to this study. Because this comparison was performed at a single medical center, the results may not be generalizable to other hospitals. We used electronic counters to monitor the use of ABHR only, but we had consumption data for both chlorhexidine and ABHR that corroborated the HCWs' preference for the ABHR product. Direct observation can change the behavior of HCWs who know that they are being observed; however, we used undercover observers (ICU nurses not on duty). The observers collected data with handheld devices that are used in our ICU presently. The Hawthorne effect can confound an observational study in which handwashing is being documented,[10] but it was not a factor in our case. Monitoring hand hygiene with electronic devices or by measuring the total consumption of disinfectants appears to produce more reliable results. However, observation is not only a method to measure hand hygiene adherence but also an intervention to enhance hand hygiene adherence. For this purpose, it remains a valuable part of hand hygiene campaigns. Finally, our study could be considered of short duration (12 weeks of observation); however, it was possible to assess a great number of episodes of hand hygiene (more than 70,000) with the electronic counters.

In conclusion, the amount of ABHR used was higher than the amount of chlorhexidine used. Hand hygiene episodes occurred more frequently before entering the patient room. Importantly, direct observation cannot be considered the gold standard for measuring rates of hand hygiene adherence, given the lack of correlation with other metrics of hand hygiene performance. We believe that electronic counters and measurement of product usage are better measures of hand hygiene adherence than is direct observation.

Because of the Joint Commission's National Patient Safety Goals, hospitals in the United States have spent a great deal of time attempting to measure hand hygiene adherence. Most have relied on direct observation. In this study, we found that compared with direct observation, measures of product usage were more representative of the true rate of hand hygiene adherence, because of the minority of opportunities captured by direct observation and the lack of correlation between direct observation and product usage.

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Potential conflicts of interest. All authors report no conflicts of interest relevant to this article.

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REVIEW ARTICLE

Measuring Healthcare Worker Hand Hygiene Activity: Current Practices and Emerging Technologies

John M. Boyce, MD

(See the commentary by Stewardson and Pittet, on pages 1029–1031.)

Monitoring hand hygiene compliance and providing healthcare workers with feedback regarding their performance are considered integral parts of multidisciplinary hand hygiene improvement programs. Observational surveys conducted by trained personnel are currently considered the "gold standard" method for establishing compliance rates, but they are time-consuming and have a number of shortcomings. Monitoring hand hygiene product consumption is less time-consuming and can provide useful information regarding the frequency of hand hygiene that can be used to give caregivers feedback. Electronic counting devices placed in hand hygiene product dispensers provide detailed information about hand hygiene frequency over time, by unit and during interventions. Electronic hand hygiene monitoring systems that utilize wireless systems to monitor room entry and exit of healthcare workers and their use of hand hygiene product dispensers can provide individual and unit-based data on compliance with the most common hand hygiene indications. Some systems include badges (tags) that can provide healthcare workers with real-time reminders to clean their hands upon entering and exiting patient rooms. Preliminary studies suggest that use of electronic monitoring systems is associated with increased hand hygiene compliance rates and that such systems may be acceptable to care givers. Although there are many questions remaining about the practicality, accuracy, cost, and long-term impact of electronic monitoring systems on compliance rates, they appear to have considerable promise for improving our efforts to monitor and improve hand hygiene practices among healthcare workers.

Infect Control Hosp Epidemiol 2011;32(10):1016-1028

Monitoring hand hygiene compliance and providing healthcare workers (HCWs) with feedback regarding their performance are considered essential elements of an effective multimodal hand hygiene promotion program.[1,2] In addition to providing groups of HCWs with feedback, monitoring hand hygiene can also be used to identify personnel with poor compliance, to plan targeted educational activities, to determine the impact of interventions, and to provide compliance rates that can serve as a quality indicator to satisfy requirements of external accrediting agencies or regulators. Methods for measuring hand hygiene frequency and hand hygiene compliance include direct observation of HCWs, self reporting by HCWs, observation by patients, measurement of product usage, and electronic systems for measuring hand hygiene compliance.[3-6]

OBSERVATIONAL SURVEYS

Observations by trained observers. Currently, direct observation of hand hygiene by trained observers is considered the gold standard for determining hand hygiene compliance rates among HCWs.[2,3] Direct observation of HCWs provides the most detailed information regarding hand hygiene and has the following advantages. It is currently the only method that can detect whether HCWs have performed hand hygiene during all types of opportunities with varying degrees of risk of contamination, including the five major indications for hand hygiene, in all clinical care settings and in facilities with varying levels of resources.[7-16] It is the only strategy that can provide detailed information about hand hygiene technique, such as the amount of time spent using an alcohol hand rub or a soap product, the extent to which all surfaces of the hands are covered, and hand hygiene frequency before or after glove use.[11,17-20] It is one of the few approaches that can provide compliance rates for HCWs of different types and levels of seniority and can identify specific situations that require further education of HCWs.[21]

However, direct observational surveys have several limitations, including the fact that they are time-consuming and costly. They provide information about a very low percentage (<1%–3%) of all hand hygiene opportunities occurring in healthcare settings, which raises the question of the statistical validity of compliance rates generated.[22-24] Direct observation of HCWs may affect their behavior and result in spuriously high compliance rates due to the Hawthorne effect.[25-31] Direct

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observations, particularly of some types of hand hygiene opportunities, may be difficult or impossible when caregivers pull curtains around a patient's bed during care.[6] Observational surveys are not performed in a standardized way, making realistic comparison of rates between facilities impossible. Observational surveys vary considerably among institutions with respect to the type of observers used, the level and type of training of the observers, the level of inter-rater reliability achieved (if assessed), the criteria for compliance versus noncompliance, the duration of observation periods, the level to which observations are covert or overt, and whether observations are made on all shifts or only during weekdays.[7,8,32-34]

To facilitate standardization of observational surveys, the World Health Organization (WHO) developed the concept of the "My 5 Moments of Hand Hygiene" to serve as a framework for training observers, conducting surveys, and educating HCWs and has published its WHO observational method.[35,36] These materials, brochures describing the 5 moments in detail and a training video with accompanying slide set, can be accessed on the WHO "Save Lives: Clean Your Hands" Web site.[37] Another hand hygiene observation tool that is intended to simplify somewhat the WHO method has also been described but requires further validation.[38]

Because of the time-consuming nature of direct observational surveys, new methods have been developed to facilitate the recording and analysis of such surveys by using wireless or Internet-capable mobile devices such as a personal digital assistant or smart phone. For example, the iScrub Lite 1.5 application can be used on an iPod Touch or iPhone. This application, developed by the Computational Epidemiology Research Group at the University of Iowa, is highly customizable, has an intuitive interface, and allows exported data to be opened in the Microsoft Excel format for easy analysis.[39] The iScrub app is available free from the iTunes App Store online. A similar application for use on smart phones has been developed in Switzerland,[40] and several iPad-based applications are commercially available.

Patient observers. Patients were invited to serve as observers of HCW hand hygiene practices in a small study by Bittle et al.[41] Although 86% of patient interviewed for the project agreed to participate, the patient response rate was only 22%. Of interest, HCW compliance rates reported by patients correlated very well with rates determined by an independent observer. The investigators concluded that engaging patients as hand hygiene observers did not appear to adversely affect patient-provider relationships. Further evaluation of the accuracy, practicality of implementing the strategy hospital-wide, and the generalizability of this approach to monitoring hand hygiene is needed.

In several other studies, patients were asked to remind HCWs to clean their hands by asking them, "Did you wash your hands?"[42-44] However, in these studies, participating patients did not always observe whether HCWs had cleaned their hands, and they did not report compliance rates. Estimates of hand hygiene compliance rates were derived by measuring the amount of soap and/or alcohol hand rub used.

SELF-REPORTING

Self-reporting of hand hygiene compliance by HCWs has been shown to be unreliable, because HCWs often tend to overestimate their level of compliance.[2,3,45-49] As a result, this approach to determining hand hygiene compliance is not recommended as the sole or major method for establishing compliance rates.

MEASURING PRODUCT CONSUMPTION

Measuring product volume or weight. Product consumption, expressed either as the number of liters or weight of products used or the amounts purchased has been used to monitor hand hygiene activity, often looking at trends in consumption over time or by type of patient care unit.[8,23,24,50-73] At least 13 studies have evaluated the relationship between product consumption and observed compliance rates (Table 1).[8,23,24,50-55,59,62,69,70] Ten (77%) of the 13 studies found that observed compliance rates increased in conjunction with increased use of alcohol hand rub.[8,50,52-55,59,62,69,70] Three studies did not find an association between product consumption and compliance rates.[23,24,51] A few studies have calculated the level of correlation observed between product consumption and observed compliance rates. For example, in a 4-year study conducted in a single hospital, the amount of alcohol hand rub delivered to wards was recorded prospectively, and periodic observational surveys of HCW hand hygiene compliance were conducted by experienced infection preventionists. Following implementation of a hand hygiene promotion campaign, consumption of alcohol hand rub increased from 3 to >30 L/1,000 patient-days, and observed compliance increased from 38% to 63% (Figure 1).[52] Increasing consumption of alcohol hand rub correlated well with increasing use of alcohol hand rub ($r^2 = 0.98$). Eckmanns et al[53] reported that the number of liters of alcohol hand rub used per 1,000 patient-days correlated well with observed levels of hand hygiene compliance ($r = 0.87$, $P = .05$). In contrast, Muller et al[51] found no correlation between alcohol hand rub use and observed compliance rates, with a correlation coefficient of 0.14. Similarly, a 12-week study by Marra et al[24] found no correlation between alcohol hand rub consumption and observed compliance levels ($r = 0.27$, $P = .40$) or total product (alcohol hand rub plus soap) consumption and hand hygiene compliance ($r = 0.18$, $P = .59$). The reasons for the disparity between the findings of these four studies are not clear but may relate to differences in study design and study populations or to the periods over which data were collected.

Because monitoring product consumption requires fewer resources than observational surveys, it has been used as a surrogate for hand hygiene compliance in at least one statewide and several national hand hygiene campaigns.[58,68,74-76] Hospital-wide usage of alcohol hand rub, expressed as num-

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TABLE 1. Studies Comparing Hand Hygiene Compliance Rates with Product Consumption (Usage) Data

Author	Setting	Observers	No. of observations	Compliance rates	Measurement of ABHR use	Usage rates
Pittet[8]	Hospital-wide	Trained observers	20,080	Increase from 48% to 66%	Volume sent to wards	Increase from 3.5 to 15.4 L/1,000 pt-d
Johnson[50]	5 wards	Trained nurses	>2,000 (not stated)	Increase from 21% to 42%	Volume purchased	Increase from 5.7 to 28.6 L/1,000 pt-d
Boyce[52]	Hospital-wide	Trained ICPs	2,878	Increase from 38% to 63%	Volume sent to wards	Increase from 3.0 to >30 L/1,000 pt-d
van de Mortel[23]	ICU	Trained staff volunteers	720	Increase from 51% to 58%	Volume dispensed	Increase from 23 to >34 aliquots/pt-d
Eckmanns[53]	5 ICUs	Trained investigator	2,808	Ranged by unit from 30% to 47%	Volume sent to ICUs	Ranged by unit from 57 to 102 L/1,000 pt-d
Eldridge[54]	4 ICUs	Trained ICU staff	4100	Increase from 47% to 80%	Grams used in ICUs	Increase from <1.0 to 3.2 g/pt-d
Pessoa-Silva[55]	NICU	2 trained observers	5,325	Increase from 42% to 55%	Volume sent to NICU	Increase from 66.6 to 89.2 L/1,000 pt-d
Ebnother[59]	Hospital-wide	Observers (not stated)	Not stated	Increase from 59% to 79%	Volume sent to wards	Increase from 4,968 to 6,495 L
Scheithauer[62]	3 ICUs	Experienced ICPs	1,897	SICU: 7% to 18%, MICU: 13% to 26%, NICU: 16% to 22%	Spending records of ICUs	41 to 101, ~64 to 116, ~58 to 80 L/1,000 pt-d
Ananda[69]	ICU	Experienced ICPs	Not stated	33% to 49% to 39%	Purchasing records	7.7 to 132 L/1,000 pt-d
Cheng[70]	ICU	Trained ICPs	>800	Increase from 29% to 64%	Volume sent to ICU	Increase from 54.8 to 167.3 L/1,000 pt-d
Marra[24]	ICU	Trained ICU nurses	2,249	62.3%	Volume of ABHR used	64.1 L/1,000 pt-d

NOTE. ABHR, alcohol-based hand rub; pt-d, patient-day; ICP, infection control practitioners; ICU, intensive care unit; NICU, neonatal ICU; SICU, surgical ICU; MICU, medical ICU.

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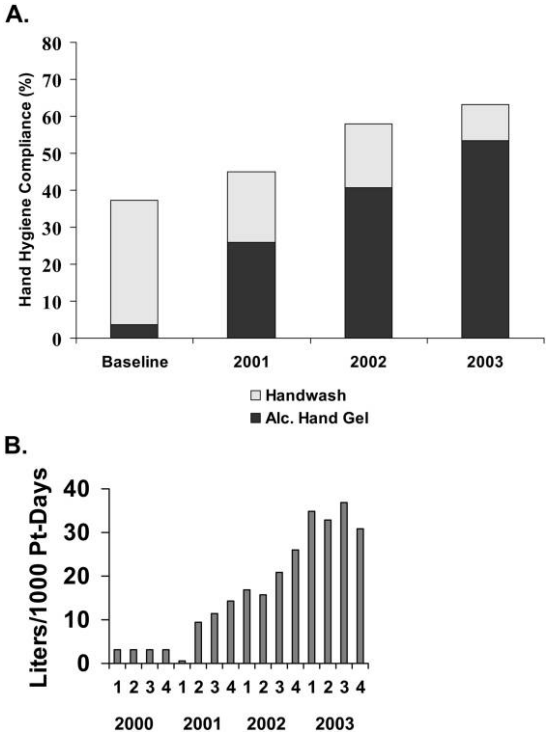

FIGURE 1. *A*, Hand hygiene compliance rate for surveys conducted at baseline and in 2001–2003. Proportion of hand hygiene episodes conducted with soap and water handwashing (open boxes) and proportion performed using alcohol hand rub (black boxes). *B*, Consumption of alcohol hand rub, expressed as liters used/1,000 patient-days, at baseline (2000) and in 2001–2003. Pt-Days, patient days.

ber of liters/1,000 patient-days, has been used to compare hand hygiene activity levels in hospitals, to set benchmarks for usage, and to establish trends over time in these large-scale campaigns. In at least one national campaign, periodic observational surveys established that increased use of alcohol hand rub was associated with a significant increase in hand hygiene compliance rates.[74]

A number of investigators have studied the relationship between alcohol hand rub use and rates of methicillin-resistant *Staphylococcus aureus* (MRSA). An analysis by Sroka et al[77] of 12 studies found a strong correlation ($r = 0.78$) between increased use of alcohol hand rub and improvement in MRSA rates. Of interest, the analysis revealed no significant correlation between hand hygiene compliance rates and MRSA rates.

Product consumption has also been used to estimate hand hygiene compliance rates in individual hospitals and in a multicenter collaborative systems.[23,42,62,78,79] McGuckin et al[42] developed a system wherein the volume (mL) of alcohol hand rub and soap products used per patient-day on each nursing unit is calculated. This number is divided by 1.7 (the proposed average mL of product used per hand hygiene episode) to arrive at the estimated number of hand hygiene episodes/patient-day for the nursing unit. The resulting estimated hand hygiene rate is compared to benchmarks for ICUs and non-ICU wards. Facilities that forward their results to a dedicated website (http://www.hhreports.com) are provided with graphs of their hand hygiene rates over time versus proposed benchmarks. A number of hospitals have found the information useful for providing HCWs feedback regarding their performance.[42,79] This approach, like other forms of product monitoring, requires that facilities establish a reliable method of determining the amount of product used on different hospital units and also requires electronic submission of data to an Internet Web site. Further studies are needed to determine how well estimated hand hygiene compliance rates generated by this system compare with those obtained in direct observational surveys conducted by trained observers.

Monitoring product consumption using electronic counting devices. Product consumption can also be monitored by using electronic counting devices placed inside hand hygiene product dispensers.[22,24,80-85] Such devices can record each time a product dispenser is accessed (hand hygiene event). Newer prototypes of these devices can time- and date-stamp each hand hygiene event, and permit event data to be downloaded wirelessly for analysis.[83] As a result, they can provide more accurate information about hand hygiene frequency rates than simply measuring the number of liters or grams of product used.

Some of the advantages of electronic counting devices are that they can record vastly greater numbers of hand hygiene events than can be achieved by observational surveys while avoiding a Hawthorne effect, and they can provide specific data on the number of hand hygiene events occurring per patient-day (Table 2).[22,24,60,71,80,83,84] Such devices can also be used to study the effects of dispenser type, number, and location on the frequency of use to examine trends in hand hygiene frequency over time, by shift and by unit, and to evaluate the impact of interventions on hand hygiene activity.[22,24,60,71,80-85]

In a controlled study conducted by Larson et al,[80] counting devices placed in soap dispensers documented that a campaign designed to change a hospital's organizational climate led to an improvement in handwashing frequency and to a reduction in vancomycin-resistant enterococcal infections. In other studies, electronic counting devices established that HCWs preferred touch-free dispensers to manual ones, that usage varied substantially by work shift, and that dispensers located in halls outside patient rooms were used more frequently than those in patient rooms.[24,81,83] A recent study utilizing a counting device detected a substantial increase in hand hygiene frequency in two nursing units when discovery of the novel 2009 H1N1 strain of influenza was first publicized. In that same study, the counting device was able to detect a significant decrease in the frequency of hand hygiene in a nursing unit when a different formulation of alcohol hand rub was introduced (Figure 2).[84]

More recently, Marra et al[24] conducted a 12-week study

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TABLE 2. Studies Using Electronic Counting Devices to Monitor Hand Hygiene Frequency

Author	Location	Product	Study period	No. of HHEs recorded	HHEs/patient-day
Larson[80]	4 ICUs	Soap	8 mo	860,567	Baseline, 30.3–42.6; intervention, 55.5–116.6
Bischoff[22]	2 ICUs, GMW	Plain soap, CHG soap, ABHR	6 mo	298,884	MICU, 143–158; CSICU, 91–109; GMW, 35–38
Larson[81]	Emerg. dept., PICU	Soap, ABHR	4 mo	Not stated	Emerg. dept., 10.3; PICU, 71.1
Marra[60]	2 SDUs	Soap, ABHR	6 mo	228,297	Soap, 26.7–34.0; ABHR, 70.7–72.5
Boyce[83]	SICU, GMW	ABHR	6 mo	150,462	SICU, mean = 48.7; GMW, mean = 12.2
Marra[71]	2 SDUs	ABHR	9 mo	506,111	Baseline, 44.5–46.9; phase 2, 33.6–62.0; phase 3, 40.0–57.9
Marra[24]	SICU	ABHR	3 mo	76,389	SICU, mean = 53.8
Boyce[84]	SICU, GMW	ABHR	4 mo	121,209	SICU, 36.1–46.7; GMW, 12.4–14.2

NOTE. HHE, hand hygiene episodes; ICU, intensive care unit; GMW, general medical ward; CHG, chlorhexidine gluconate; MICU, medical ICU; CSICU, cardiac surgical ICU; ABHR, alcohol-based hand rub; Emerg. dept., emergency department; PICU, pediatric ICU; SDU, step-down unit.

that included observational surveys, use of electronic counting devices in dispensers, and measuring the volume of hand hygiene products used. Observational surveys yielded a hand hygiene compliance rate of 62%. Electronic counting devices recorded over 76,000 alcohol hand rub dispensing episodes during the same time period, with a mean number of 53.8 per patient day. The 2,200 hand hygiene opportunities observed represented only 1.3% of the 172,000 estimated number of hand hygiene events, based on the total amount of alcohol hand rub and soap products used. There was no significant correlation between observed hand hygiene compliance rates and the number of alcohol hand rub–dispensing episodes or the total product used per patient-day. The authors questioned whether direct observational surveys provide an accurate measure of hand hygiene compliance.

However, when considering the results obtained by either manual measurement of product usage or hand hygiene frequency rates based on electronic counting devices, it is important to keep in mind the limitations of these monitoring systems. These include the inability of either product consumption or electronic counting devices to establish the number of hand hygiene opportunities that are occurring, provide compliance rates, distinguish between product use by HCWs versus patients and visitors, identify specific HCWs or type of HCW using the product(s), establish whether hand hygiene events are occurring at appropriate times (eg, the WHO "5 Moments"), evaluate hand hygiene technique, or identify specific issues that warrant further education of HCWs. Measuring product volume requires ongoing personnel resources for recording usage, whereas there are costs associated with using electronic counting devices and replacement batteries.

To provide more robust estimates of compliance rates based on product consumption data, Steed et al[86] conducted a study that included 6,640 observed hand hygiene opportunities in 2 different hospitals. Observations using the WHO data collection methodology were made on general medical wards, intensive care units, and emergency rooms, and the investigators developed denominator estimates that may be used to calculate compliance rates using product consumption data. Additional studies comparing such product-derived estimated compliance rates with those generated by observational surveys are needed.

ELECTRONIC HAND HYGIENE COMPLIANCE MONITORING SYSTEMS

Systems for electronic monitoring hand hygiene compliance have recently been developed and can be divided into several categories, including (*a*) dedicated hand hygiene monitoring systems, (*b*) real-time locating systems (RTLS) for tracking HCWs and hand hygiene events, and (*c*) video monitoring of hand hygiene activity.

Dedicated hand hygiene monitoring systems. Several electronic methods have been developed specifically for monitoring hand hygiene activities of HCWs. Swoboda and col-

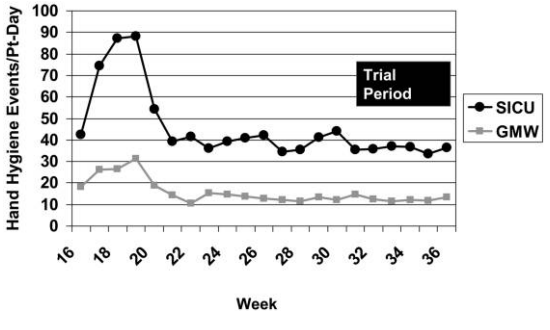

FIGURE 2. Number of times alcohol hand rub dispensers were accessed per patient-day, expressed as hand hygiene events/patient-day, based on electronic counting devices, in surgical intensive care unit (SICU) and on a general medical ward (GMW), by week, in 2009. Pt-Day, patient day.

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leagues[87] conducted a three-phase intervention trial in an intermediate care unit. Motion sensors were used to detect room entry and exit, and sensors attached to sinks and hand rub dispensers detected hand hygiene events. Phase I included electronic monitoring and direct observations of hand hygiene compliance. Phase 2 consisted of electronic monitoring and computerized voice prompts issued when hand hygiene was not performed upon exiting a patient's room. Phase 3 involved only electronic monitoring. The results revealed that compared to phase I, hand hygiene compliance, as measured by the electronic monitoring system, improved 35% during phase 2, and 41% during phase 3. When adjusting for patient days, a number of infections decreased by 10% during phase 2, and 40% during phase 3. The investigators concluded that the electronic monitoring system provided effective feedback to HCWs and improved hand hygiene compliance and nosocomial infection rates.

A similar study conducted in another facility included electronic monitoring of hand hygiene compliance (phase 1), followed by electronic monitoring with electronic prompts (audible beeps, a flashing light, and prerecorded voice prompts) if hand hygiene was not performed (phase 2).[88] An electronic device served as both an alcohol hand rub dispenser and as a monitor of hand hygiene episodes on room entry and exit. Concurrent direct observations by trained observers were used to validate electronic data. Observation of 8,235 hand hygiene opportunities revealed that hand hygiene compliance improved from 36.3% at baseline to 70.1% during phase 2. Compliance improved on all shifts, and upon both room entry as well as when exiting the room. Nosocomial vancomycin resistant enterococcal infections decreased during the study, but not significantly. This study also suggested that electronic devices can effectively monitor hand hygiene compliance and result in improved compliance rates.

Sahud et al[89] conducted a study that included direct observation of baseline hand hygiene compliance rates (phase 1), followed by use of RFID readers and triggers to detect room entry and exit and the use of soap and alcohol-based hand rub dispensers (phase 2). Manual recording of room entry and exit and dispenser used by the principal investigator revealed that 98% of room entries and 95% of dispensing events were captured by the system. Overall, the observed hand hygiene compliance rate during phase I (32%) was higher than the rate calculated by the electronic monitoring system during phase 2 (25%). The investigators concluded that the electronic system may have provided more reliable compliance rates than direct observation, in part because it measured hand hygiene events during evening hours as well as daytime hours.

Polgreen et al[90] developed a low-cost, ZigBee-based method for tracking dispenser use by HCWs on room entry and exit. With one beacon inside a patient room and one outside and badged individuals, the system sensitivity, specificity, and positive- and negative- predictive values achieved ranged from 97% to 100%. With this method, careful placement of beacons and sensors, location accuracy can exceed that achieved by RFID alone.[90] The authors concluded that the system was a practical and inexpensive way to measure hand hygiene compliance.

Edmond and colleagues[91] conducted a 2-phase intervention study that included 4 weeks of direct observation of hand hygiene compliance (phase 1), followed by 2-week evaluation of a hand hygiene alerting system in which nurses wore alcohol-sensing badges. Room sensors detect room entry and exit by HCWs wearing badges, the badge alerts HCWs for the need for hand hygiene using a light and an audible reminder embedded in the badge. The light on the badge turns green if a sensor imbedded in the badge detects alcohol on the hands of the HCW within a set number of seconds after entering the room, but turns red if alcohol is not detected by the badge. Segmented regression analysis revealed that a baseline compliance rate of 23% (determined by observations) increased significantly to 92% (determined by electronic alerting system) during the intervention period ($P = .01$) This study also suggests that the use of dedicated hand hygiene monitoring systems can result in significant increases in hand hygiene compliance rates.

Granado-Villar et al[92] evaluated another dedicated hand hygiene monitoring system that uses a wall-mounted sensor to create an infrared/acoustic zone around a patient's bed and can detect the presence of badge-wearing HCWs near the bed. When HCWs pass their hands under another sensor that detects alcohol hand rub or alcohol-containing soap on their hands, a light on the badge turns green and the HCW is given credit for being compliant. If this is not done, the badge vibrates to remind the HCW to clean their hands. The investigators reported that 100% of 6,888 episodes of HCWs approaching patient beds and 100% of 6,315 hand hygiene events were detected by sensors. The system also detected all episodes of HCWs approaching a bed without performing hand hygiene and provided HCWs with reminders to clean their hands. Hand hygiene compliance, based on the monitoring system, was 94%.

Cheng et al[93] conducted a 3-month trial of an electronic hand hygiene monitoring system in a neurosurgical intensive care unit with 5 beds in one large room and a single bed in a second smaller room. A total of 13,694 hand hygiene opportunities were recorded. Hand hygiene compliance was 21.3% with the WHO's Moment 1 and 39.6% with Moment 4. Of interest, HCWs whose name was associated with an electronic badge had higher compliance than individuals who shared a badge.

Levchenko and colleagues[94] conducted a short trial of an electronic hand hygiene monitoring system among 11 nurses who worked in multibed rooms. The system could detect alcohol hand gel dispensed from both wearable electronic hand rub dispensers as well as wall-mounted dispensers. The hand hygiene compliance rate during the trial was higher than the rate generated by observational surveys conducted during the pretrial period.

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Real-time location systems. Recently, real-time location systems have received considerable interest as a means of monitoring hand hygiene compliance. With an RTLS, HCWs wear a special badge that can communicate wirelessly with dispensers and sensors located throughout the hospital or special areas of interest. The badges worn by HCWs can relay information to either hard-wired sensors or to wireless sensors. The wireless technologies that may be used with such systems include Wi-Fi, ZigBee, ANT, active radio-frequency identification (RFID) using 433 or 915 MHz range frequencies, infrared (IR), ultra-wideband, or ultrasound. Vendors often use more than one wireless technology to achieve accurate location of HCWs and the dispensers they access and to communicate data to a central server for real-time analysis of compliance rates. Each of these technologies has its own advantages and disadvantages (Table 3). Hand hygiene compliance rates at room entry (proxy for WHO Moment 1) and room exit (proxy for Moments 4 and 5) are estimated for individual HCWs and can be reported by nursing unit and time period (by day, week, or month), and can identify individuals with the lowest rates of compliance (Figure 3). Some systems can also alert housekeeper managers about which dispensers are likely to require refilling.

Unlike the dedicated hand hygiene monitoring systems, which are designed with the express purpose of providing data on hand hygiene compliance, infrastructure for RTLS can also be used for keeping track of the location of equipment (asset tracking), tracking patients, establishing workflow patterns, nurse call events, or monitoring the temperature of equipment. System characteristics that should be taken into consideration when choosing a dedicated hand hygiene monitoring system or an RTLS system with hand hygiene monitoring capabilities are listed in Table 4.

Dedicated hand hygiene monitoring systems and RTLS are currently not capable of detecting whether HCWs perform hand hygiene before an aseptic procedure (Moment 2) or after a potential body fluid exposure (Moment 3). However, several studies have found that Moments 1, 4, and 5, which would likely be captured by electronic systems, account for approximately 80% of all hand hygiene opportunities.[86,95] Furthermore, a study by Stewardson and colleagues[95] found that estimated compliance rates based on only Moments 1 and 4 were very similar to compliance rates based on recording all 5 Moments, suggesting that electronic systems may provide reasonable estimates of hand hygiene compliance. Nonetheless, further in-hospital trials are clearly needed to determine how well compliance rates generated by such systems correlate with the 5 Moments. It may be particularly important to establish how accurately detection of room entry reflects Moment 1, which requires hand hygiene before touching a

TABLE 3. Advantages and Disadvantages of Wireless Systems Used for Real-Time Locating Systems

Technology	Advantages	Disadvantages
WiFi	Hospitals may have existing WiFi infrastructure, reducing initial costs; long communication range; can be used in conjunction with other technologies	Some systems may not provide bed-level location accuracy unless additional beacons are used; badges may be large and relatively expensive; may have higher power consumption
RFID	Better location accuracy than WiFi alone	Requires parallel wireless infrastructure; goes through walls, so location accuracy may not be ideal
ZigBee	Low power consumption; can be portable; less expensive than some other wireless systems	Accurate location may require multiple beacons in an area, or combination with other technology; some systems may credit two HCWs with hand hygiene event if HCWs are very close together
ANT	Very low power consumption; faster transmission speeds than ZigBee; low system cost; long battery life	Not designed for complex high-frequency events
Infrared (IR)	Does not penetrate walls, so location accuracy good to subroom level; IR room ID devices can be battery-operated, so wiring not needed	Requires IR detectors and other technology such as RFID for communication
Ultrasound	Does not penetrate walls, so high-level room and subroom accuracy; no electromagnetic interference with other equipment; does not require line of sight between tag and detector	Requires ultrasound sensor on RFID or other tag; requires integration with WiFi, RFID, or local area network to transmit signals to central server
IR/RFID combination	Provides good location accuracy	Required both IR and RFID infrastructure
Ultrawide band	Low power, resistant to interference; good location accuracy	Shorter range than narrowband frequency; variable standards

NOTE. WiFi, wireless system based on IEEE 802.11 standards; RFID, radio frequency identification; ZigBee, wireless communication protocols based on IEEE 802.15.4 standards; HCW, healthcare worker; ANT, a proprietary wireless communication protocol utilizing 2.4 GHz frequency; Ultrawide band, wireless technology that permits high-bandwidth communications.

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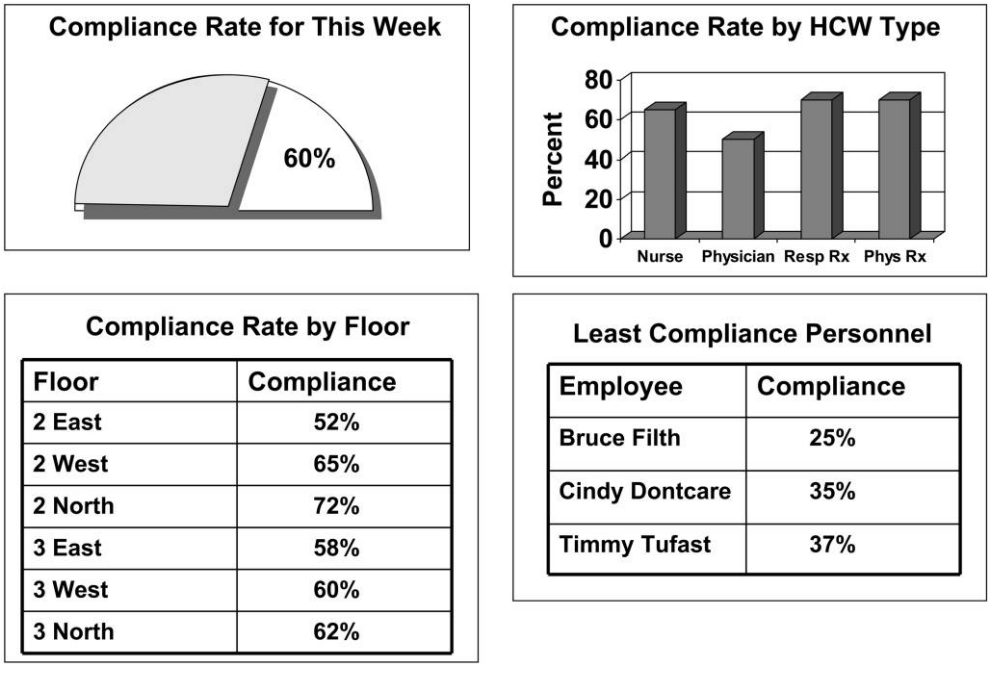

FIGURE 3. Example of type of real-time data provided on hand hygiene compliance by electronic hand hygiene monitoring systems.

patient (without touching anything outside the "patient zone" between the time they enter the room and when they touch the patient).

Video monitoring of hand hygiene. Only a few studies have evaluated the potential use of video monitoring of healthcare worker hand hygiene activities. Davis et al[96] employed a hidden surveillance video camera to determine how frequently individuals used alcohol hand rub upon entering a surgical ward during a baseline period and during a 6-month intervention, which involved placing a piece of red tape on the floor that directed individuals to a hand rub dispenser on the wall. Hand hygiene compliance, defined as using the hand rub dispenser on room entry or exit, was determined by reviewing footage of the hidden video camera. No feedback of the results was given to either HCWs or visitors. The video camera documented an increase in hand hygiene compliance from a baseline rate of 24% to 62% during the intervention period. Armellino et al[97] employed multiple video cameras to monitor use of soap and hand rub dispensers by HCWs on entry to and exit from an MICU. External auditors scored each use (pass) or failure to use (fail) of dispensers in real-time on a 24-hour/7 days a week basis. External auditor managers performed quality audits of 5% of events to assure validity. Phase I included a 4-month baseline period with no feedback to HCWs. Phase 2 included a 6-month period with feedback displayed on electronic boards placed in the MICU that updated compliance rates every 10 minutes and e-mails sent every shift to the MICU managers. Hand hygiene compliance increased from a baseline rate of less than 10% to 89% in the last 4 months of the trial ($P < .0001$). The investigators concluded that remote video monitoring of hand hygiene with real-time feedback to HCWs resulted in a significant increase in hand hygiene compliance.

In the same hospital, the same video monitoring system was subsequently used in an adjacent surgical intensive care unit (SICU).[98] The study included a 1-month baseline period with no feedback to HCWs, followed by a 2-week intervention period with real-time feedback on electronic boards and e-mails sent every shift to SICU managers. Of interest, baseline hand hygiene compliance rates in the SICU were 30.5%, compared to a baseline rate of 6.6% in the previous MICU study. After only 14 days with real-time feedback to HCWs, hand hygiene compliance increased to 69.8%. The authors concluded that the baseline compliance rate was higher in the SICU than in the adjacent MICU due to the "halo effect" of video monitoring and feedback.

Issues to consider when implementing an electronic monitoring system. Many questions regarding electronic systems remain, including various elements of their design, functionality, and acceptance by HCWs. Further information is needed regarding the costs and ease of installation of the necessary infrastructure, the proportion of hand hygiene opportunities captured, ability to detect opportunities that occur during an episode of care when the patient is not in bed and when HCWs wear gloves, and the impact on compliance rates when HCWs entering the room do not touch the patient or the environment.[99] Administrators will want to know about the information technology and personnel resources needed

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TABLE 4. Variables to Consider When Evaluating Electronic Hand Hygiene Monitoring Systems

Variable	Comments/questions
Required infrastructure	Systems using fixed hardwiring: Will additional hardwiring or sensor placement be required? Wireless systems: Will sensors require electrical connection or use batteries? How will sensors communicate with existing hospital network? Will wireless protocol interfere with medical equipment or overload existing wireless network? Will placement of location sensors for hard-wired or wireless system require removal of ceiling tiles?
HCW badges (tags)	Consider size of badge, badge's ability to provide HCW and/or patients a reminder or signal (auditory, vibratory, or red/green light) indicating that hand hygiene was performed or not, battery life of badge, battery type (rechargeable or not), cost per badge, and badge management (between shifts). Does badge have other functionality, such as help button, LED message?
Dispenser and integrated or attached sensors	Do sensors detect presence of alcohol (alcohol-containing soap) on HCW hands or delivery of product to HCW hand or simply proximity of HCW to dispenser? What is battery life of dispenser and sensors?
Location sensitivity (granularity)	Can system accurately identify location of HCW within a few feet? Can system determine which bed HCW has approached in multibed room? Are additional location beacons required by WiFi-based system to achieve sufficient location accuracy?
Sensitivity to detect interactions between HCW and patient	How will system handle episodes when HCWs enter room briefly without contact with patient or environment? Will system accurately identify use of dispensers in patient rooms, in hallways, or other treatment areas?
Software; report format	Type and amount of information technology services required? How will compliance be analyzed and displayed? Who will have access to data? Will HCWs wearing badges have access to their own compliance data? Will real-time compliance data be available on unit-based computer terminals?

NOTE. LED, light-emitting diode, a method for displaying messages on badge; HCW, healthcare worker; WiFi, wireless system based on IEEE 802.11 standards.

and whether or not the infrastructure employed is used strictly for monitoring hand hygiene activities. The costs of implementing RTLS for hand hygiene compliance may be less of a barrier if the system infrastructure will also be used for asset tracking, nurse call management, monitoring of equipment temperatures, or patient flow patterns. A number of other variables to consider when evaluating electronic monitoring systems for possible implementation are listed in Table 4.

The acceptability of electronic monitoring systems by HCWs requires further study. Personnel will want to know whether compliance information will be confidential, who will have access to their compliance data, how feedback will be provided, and whether compliance rates will be used in annual performance evaluations.[100] Contrary to early concerns, several short-term studies suggest that a majority of HCWs may not object to wearing badges that provide individual-level compliance rates.[91,94,100] Finally, we need further information about the potential impact of such systems on healthcare worker behavior and delivery of care.

CONCLUSIONS

In conclusion, periodic direct observational surveys conducted by trained observers will likely have a continuing role in monitoring healthcare worker hand hygiene compliance, as they provide unique information that cannot be provided by other methods currently available. Because of the time required to conduct observational surveys and concerns regarding their accuracy, many facilities will continue to look for other methods to complement observational surveys. Monitoring the volume of hand hygiene product used is less labor intensive than observational surveys and can be used to establish trends in hand hygiene activities and provide feedback to HCWs. Electronic counting devices can record many more hand hygiene episodes than can be achieved by observational surveys and can be used to monitor trends in hand hygiene frequency and changes that may occur as a result of interventions. However, neither method of monitoring product usage yields denominator data necessary to accurately determine compliance rates. Limited studies suggest that combining electronic counting device data on hand hygiene episodes with validated, unit-based benchmarks of the number of hand hygiene opportunities may yield reasonable estimates of hand hygiene compliance. Electronic hand hygiene compliance monitoring systems can provide real-time analysis and feedback of hand hygiene activities at the individual and unit level, and preliminary studies suggest that they may provide reasonably accurate compliance rates for WHO Moments 1, 4, and 5, which account for the bulk of all hand hygiene opportunities. Limited trials have been

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associated with substantial increases in compliance rates. Such systems appear to have considerable promise for improving our ability to measure hand hygiene compliance. However, it should be pointed out that most studies of electronic monitoring systems have one or more limitations, which include short study periods, implementation on only 1 or 2 wards, failure of some studies to establish the sensitivity and specificity of electronically derived compliance rates as determined by direct observations of hand hygiene, limited data on the impact of the systems on healthcare-associated infection rates, and lack of cost-benefit or return on investment analysis. If further studies adequately address these issues, it seems likely that electronic hand hygiene monitoring systems will be adopted with increasing frequency in facilities with adequate resources.

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Rhode Island *Clostridium difficile* Infection Trends and Laboratory ID Events Ranking

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In January 2013, the Centers for Medicare & Medicaid Services (CMS) began requiring acute-care hospitals to submit any laboratory-identified ("LabID") *Clostridium difficile* cases to the Centers for Disease Control and Prevention's surveillance system, the National Healthcare Safety Network (NHSN).[1] By collecting data from acute-care hospitals across the nation, Medicare was able, for the first time, to systematically assess the burden of *C. difficile* nationwide and to publicly report LabID incidence on Hospital Compare.[2]

CMS's requirement to collect *C. difficile* surveillance data reflects the fact that *C. difficile* infection (CDI) is a high public health priority—both because of the impact on patients, who suffer diarrhea due to mucosal inflammation and damage[3] and because it is the most common healthcare-associated infection (HAI).[1,4,5] In 2011, there were 383,498 cases of CDI at hospital discharge in just 36 states with available data.[6] The cost of an inpatient CDI is more than $35,000 and estimates of annual medical costs exceed $3 billion nationally.[1]

The recent inclusion of CDI LabID data in Hospital Compare provides an opportunity to assess Rhode Island's performance. The objectives of this analysis were to: (1) describe RI's longitudinal trends in CDI using available historical data, and (2) compare RI's performance to neighboring states and the nation, using the newly-available LabID events data.

METHODS

Data sources

We used two data sources: (1) Healthcare Cost and Utilization Project (HCUP) data from 2002 to 2012, which includes CDI, and (2) Hospital Compare data for the first quarter of 2013, which includes LabID events. Of note, these two data sources use different measures of *C. difficile:* CDI is based on clinical diagnosis, whereas LabID events do not distinguish between *C. difficile* colonization and infection. As a result, LabID events overestimate the true CDI infection rate.[7]

HCUP databases are sponsored by the Agency for Healthcare Research and Quality and include longitudinal administrative data (inpatient, ambulatory surgery, and emergency department) for all patients, regardless of payer.[8]

Hospital Compare includes data on care processes and outcomes for selected conditions, and patient experience with care.[2] CMS requires the acute-care hospitals that participate in the Inpatient Prospective Payment System (IPPS) to submit select data, including *C. difficile* LabID event, and penalizes facilities that fail to comply. We downloaded the most recently available data (Q1 2013), which includes standardized infection ratios (SIRs)[2] comparing each hospital's and state's observed number of infections to the predicted number of infections, estimated using regression models based on data from 2010-2011.[9] SIRs are summary measures used to track and compare HAIs at the facility, state and national levels. If the upper limit of the SIR 95% confidence interval (CI) is less than 1.0, the infection rate is better than predicted; if the 95% CI includes 1.0, it is the same as predicted; if the lower limit of the 95% CI is greater than 1.0, it is worse than predicted.

Statistical Analyses

We used HCUP to query the number of CDIs by primary or secondary *C. difficile* diagnosis (ICD-9-CM code 008.45) and the number of hospital discharges. We calculated CDI rates (the number of infections per 1,000 hospital discharges) from 2002-2012 for Rhode Island, the two neighboring states with available data (Massachusetts and Vermont) and the U.S. as a whole, and then graphed these results. We also downloaded *C. difficile* LabID event SIRs from Hospital Compare and used Geographic Information System 10.2 (Environmental Systems Research Institute, Inc., Redlands, CA) software both to rank the 50 states and D.C. and to map the rankings.

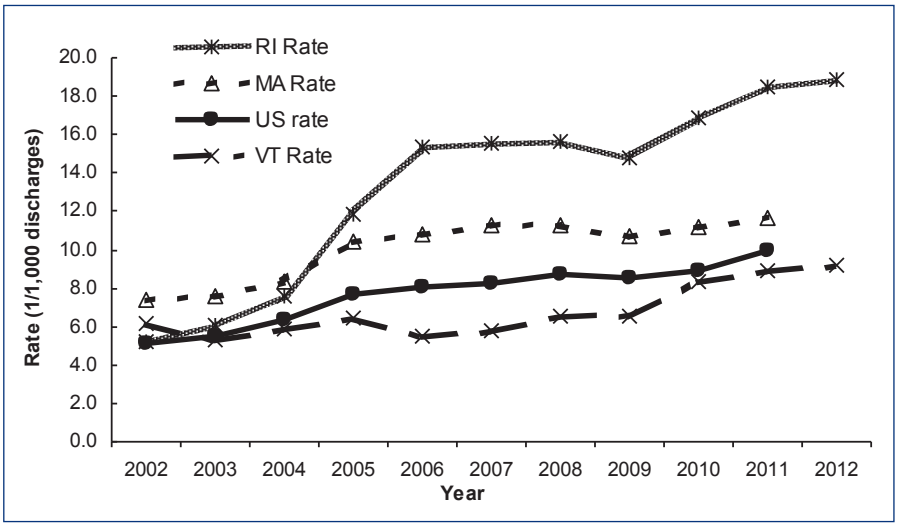
RESULTS

HCUP data reveal that the rate of CDI (listed as any diagnosis in administrative data) in Rhode Island increased more than three-fold over the past decade (5.21 per 1,000 discharges in 2002 vs. 18.87 per 1,000 in 2012), outpacing national trends and neighboring states (**Figure 1**). In comparison, CDI slightly increased in Massachusetts, Vermont, and U.S. between 2002 and 2011.

In the first quarter of 2013, RI ranked 51st among the 50 States and Washington, D.C., for *C. difficile* LabID SIRs (Figure 2). There were 19 states with upper limits of 95% CI of the SIR below 1.0 (i.e., better than the U.S. average); 22 states with 95% CI of the SIR crossing 1.0 (i.e., same as U.S. average); and 10 states, RI, AZ, NM, MD, NV, NJ, VA, NY, CA, and MA with lower limits of 95% CI of the SIR above 1.0 (i.e., worse than U.S. average).

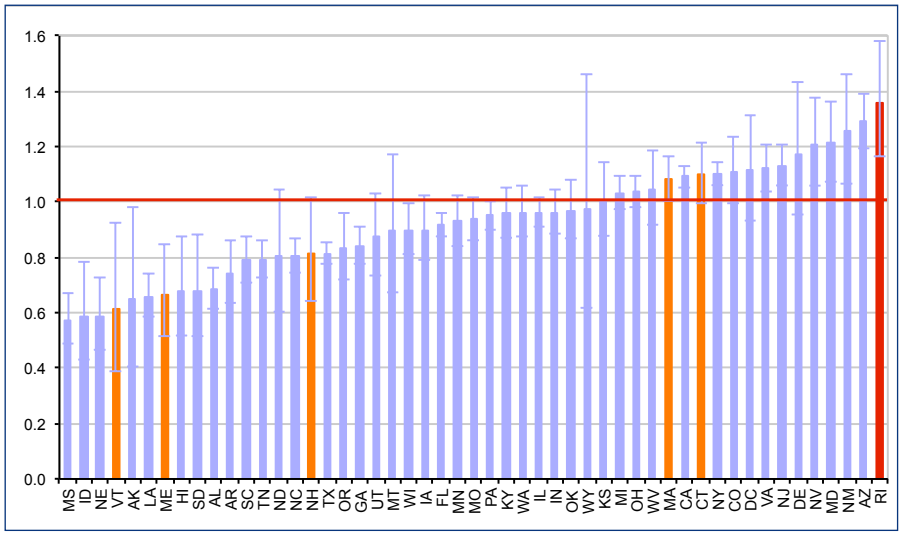
The SIRs display some region clustering, with the highest (worst) SIRs in the Northeast (VA, MD, D.C., DE, NJ, NY, RI) and West (NV, AZ, NM, CO) (Figure 3). The states with the 10 lowest (best) rankings were more widespread and included states in the Midwest (ID, SD, NE), South (LA, MS, AL) and elsewhere (VT, ME, AK, HI). In New England, VT and ME were better than the U.S. as a whole; NH and CT were same as U.S.; and MA and RI were worse than U.S. (**Table 1**), first quarter of 2013.

Figure 1. *Clostridium difficle* Infection Rate, New England Area and U.S. 2002–2012



Note: Data from Healthcare Cost and Utilization Project (HCUP) (http://www.hcup-us.ahrq.gov/)

Figure 2. States Ranked by Standardized Incidence Ratio (SIR) of *Clostridium difficile* LabID Events, First Quarter of 2013



Note: Data from Hospital Compare Website (https://data.medicare.gov/)

DISCUSSION

Between 2002 and 2012, CDI increased throughout the U.S., but the increase was greater in RI compared to other New England states (MA and VT) and the U.S. as a whole. In the first quarter of 2013, RI ranked 51st among the 50 States and D.C. for *C. difficile* LabID SIRs. The highest (worst) *C. difficile* LabID SIRs are in the Northeast and West.

CDI is spread by the fecal-oral route[3] and is strongly associated with antibiotic overuse; widespread use of broad-spectrum antibiotics is a likely contributor.[1,3] A resistant strain of *C. difficile* (BI/NAP1/027) appeared in 2004. This strain is associated with more severe clinical outcomes and may be contributing to the rapid global spread of CDI[1,3,4,8,10] and the increasing trends we noted between 2002 and 2012. Robust antibiotic stewardship programs can reduce CDI risk.[3] Although all RI hospitals have antibiotic stewardship programs in an effort to reduce targeted antibiotic use, none have a full-time physician or infectious diseases-trained pharmacist whose sole responsibility is to manage an antibiotic stewardship program, as is done in some hospitals around the country.[11] It may be that the thin profit margin of hospitals in RI compared to other states has limited the resources needed to further control CDI.

Elderly patients and those with comorbidities are the most affected by CDI.[10] Over two-thirds of patients with CDI are 65 years of age or older[1,8] and nearly 90% of CDI deaths are in elderly persons.[4] This may partially explain the regional trends we noted because the Northeast has the highest proportion of the population at least 65 years of age (14.1%) and at least 85 years of age (2.2%) in the U.S. based on 2010 census data.[12] More specifically, RI has a higher proportion of the population 65 years of age and older (14.4% in RI vs. 13.0% on average in the U.S.); and a higher proportion of those 85 years of age and older (2.5% in RI vs. 1.8% on average in the U.S.).[12]

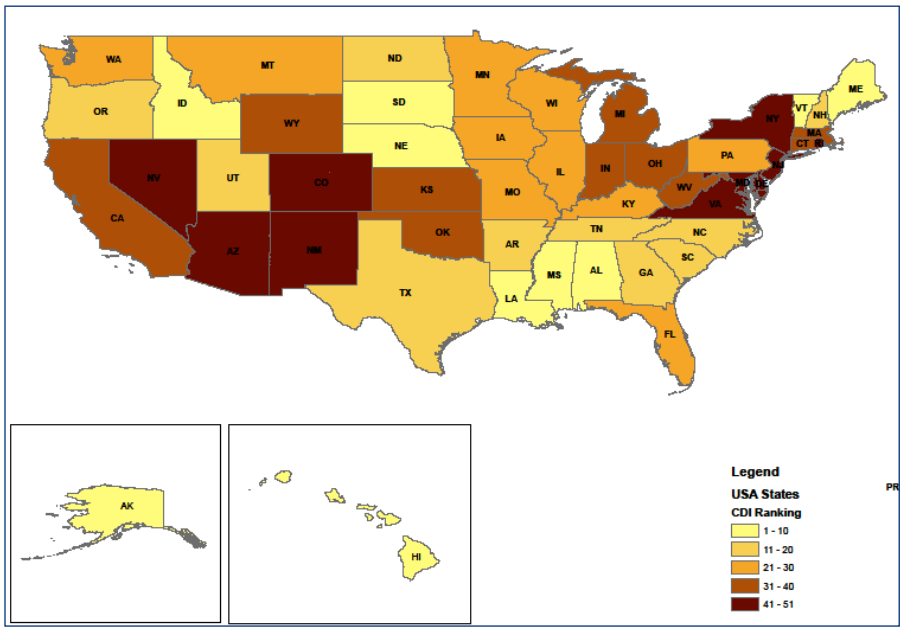
Although the CDC uses a regression model to risk-adjust the Hospital Compare data based on numerous factors, including hospital bed size, medical school affiliation, admission prevalence rate of community-onset *C. difficile* LabID events, and the test type used to detect *C. difficile* in stool,[9] HCUP does not adjust for the diagnostic test type and it is important to note that the various tests have differing sensitivities. Possibly unlike any other states, 100%

of RI hospitals currently use the most sensitive CDI diagnostic testing method, nucleic acid amplification test (NAAT) testing.[13] Ten of 11 hospitals in RI switched to NAAT from other test types over the past few years and, if these changes occurred more rapidly and uniformly than in other states, this may partially account for some of the difference in rates of CDI or *C. difficile* LabID events in RI compared to other states or national benchmark data. Although the CDC risk adjusts for diagnostic test method used, it is unclear if this is robust enough to address what is likely a statewide difference from other states or to account for facilities' changes in tests over time.

We note several additional limitations. First, HCUP uses administrative data that is collected for billing purposes and may not accurately measure HAIs.[14] Second, HCUP data cannot distinguish community-onset CDI from hospital-onset CDI, so we are unable to attribute infections to hospital care. Third, HCUP data for CDI are limited to 37 states and some states are missing data for one or more years. There is no CDI data for CT, precluding us from comparing RI against both adjacent states (MA and CT); ME does not have data for 2004 and 2005; and NH does not have data for 2002 and 2010-2012. Finally, we have only a single quarter of Hospital Compare data (Q1 2013) and are therefore unable to assess longitudinal trends or to compare CDI and *C. difficile* LabID estimates for the same time period.

These findings highlight the need to focus additional financial and human resources on reducing CDI. Although wearing gowns and gloves when entering the room of a patient with CDI and rigorous environmental cleaning of their room can decrease *C. difficile* transmission by 20%,[4] such interventions require sufficient staffing (e.g., to perform rigorous daily and discharging cleaning) and, in some cases, costly adjunctive measures (e.g., the use of portable robotic ultraviolet lights and hydrogen peroxide vapor to disinfect rooms when terminally cleaned). In RI hospitals, infection preventionists are now responsible not only for providing education and leading multi-disciplinary interventions across the hospital, but also for conducting surveillance and reporting results to the CDC and elsewhere. Additional resources may help to improve our state's *C. difficile* performance relative to past trends and our peers.

Figure 3. States Ranked by Standardized Incidence Ratio (SIR) of *Clostridium difficile* LabID Events, First Quarter of 2013.



Note: Data from Hospital Compare Website (https://data.medicare.gov/)

Table 1. Hospital *Clostridium difficile* LabID Events in New England States, First Quarter of 2013

State	Observed Cases	Predicted Cases	SIR	95% CI	Rank
Vermont	23	37.4	0.614	0.389-0.922	4
Maine	65	97.8	0.665	0.513-0.847	7
New Hampshire	77	94.6	0.814	0.642-1.017	16
Massachusetts	693	640.0	1.083	1.004-1.167	38
Connecticut	397	356.9	1.100	0.994-1.213	40
Rhode Island	170	125.2	1.358	1.162-1.578	51

SIR, standardized incidence ratio; CI, confidence interval.
Note: Data from Hospital Compare Website (https://data.medicare.gov/)

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Carbapenem-Resistant *Enterobacteriaceae* (CRE) Control and Prevention Toolkit

PREVENT HAIs
Healthcare-Associated Infections

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Carbapenem-Resistant *Enterobacteriaceae* (CRE) Control and Prevention Toolkit

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Cover photo: Carbapenem-resistant *Enterobacteriaceae*, courtesy of Centers for Disease Control and Prevention, Atlanta, GA

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Introduction

Many in health care are familiar with multiple-drug–resistant organisms (MDROs) such as methicillin-resistant *Staphylococcus aureus* (MRSA), but carbapenem-resistant *Enterobacteriaceae* (CRE) are less well known, in spite of their rapid emergence on a global level. CRE are the result of a complex family of plasmid-borne resistance factors that circulate among *Enterobacteriaceae*. In the United States, the overwhelming majority of CRE cases are caused by the plasmid-borne *Klebsiella pneumoniae* carbapenemase (KPC) gene circulating among *Enterobacteriaceae*, mostly commonly among *Klebsiella pneumoniae* isolates. KPC-producing organisms have spread epidemically in the United States and around the world among hospitalized patients. Accordingly, the focus of this toolkit is KPC control, and the term KPC will be used in this document rather than CRE. Although the KPC epidemic continues to evolve, there are still opportunities to develop interventions to control further spread of this MDRO.[1]

The toolkit is organized into six sections, and can be used either in its entirety, or by pulling out specific sections that meet your organization's needs. We expect that leaders in infectious disease and infection control, as well as those concerned with patient safety and performance improvement, may be users of this toolkit. For those familiar with leading change processes and implementing process changes, the first few sections may not be necessary; it is possible to move right to Section 3, Putting Your Intervention Into Practice, if you and your organization are at that point. Section 1, Assessing Your Readiness for Change, may be useful if you are concerned about your organization's ability to adopt new guidelines and/or change processes for any type of healthcare-associated infections (HAI) initiative. Section 2, Starting Your Project, will be useful in any situation where a task force or team is needed in order to carry out the project, and provides crucial guidance about integrating your team's efforts with existing infection control routines and practices. Next, Section 3, Putting Your Intervention Into Practice, may be useful in thinking through how to roll out the changes in policy and/or process. Section 4, Implementing Best Practices, provides many tools and strategies that can be used in educating staff about KPC and the need for greater vigilance. Section 5, Measuring the Impact of your Intervention, and Section 6, Implementing and Sustaining Your Intervention, provide tools and information for understanding how well the new processes are working and how to sustain the gains.

[1] Additional resources for understanding the terms CRE and KPC can be found in the following reference: Currie, B. The emergence of carbapenemase-producing *Enterobacteriaceae.* Inf. Dis Special Edition. 2012;15:9-13.

Section 1. Assessing Your Readiness for Change

The implementation of new clinical practice guidelines and procedures of any type can be challenging and complex, because efforts to reduce the spread of infection frequently require system-level changes and collaboration across multiple unit and even multiple facilities. However, it is even more difficult when it involves multiple simultaneous modifications to work flow, communication, and decisionmaking as is needed in the control of healthcare-associated infections, such as KPC. Failure to assess your organization's readiness to make changes across multiple levels and in multiple departments can lead to unanticipated difficulties in implementation of new practices.

In this section, you will consider the following questions:

1. Do organization members understand why new infection control guidelines are needed?
2. Is there urgency to implement a new KPC prevention strategy?
3. Is there leadership support?
4. Who will take ownership of this effort?
5. What resources will you need?
6. What if you are not ready?

1.1 Do Organization Members Understand Why New Infection Control Guidelines Are Needed?

Readiness requires both the capability to implement new practices and the motivation to make the necessary changes. While the motivations for change might be external, (e.g. new guidelines or reimbursement policies), you will have the greatest success if the new initiative is based on a clear understanding of the concerns behind the planned change at all levels of the organization.

The emergence of KPC in health care settings is a significant challenge to all health care professionals. These general statistics might help you engage others in your organization:

- KPC first emerged in North Carolina in 1999. By 2013, it had been documented in 42 States, and has reached endemic levels in 6 States.
- According to a 2010 study, overall mortality for patients infected with KPC was 23 percent in 7 days, 42 percent in 30 days, and 60 percent by the end of their hospitalization.

Also consider whether local cases might be more tangible or compelling. While those who work in infection control may have a clear understanding of the changes that need to occur, it's important to remember that there may be great variation across the organization in levels of knowledge/motivation around KPC and HAIs in general.

To gather support and identify potential barriers for a KPC prevention and control initiative, consider the following steps:

- Identify the reasons to start a KPC prevention and control program in **your** health care organization. If the reasons are general and not specific to your hospital, you may want to find KPC infection cases or examples that will help bring the issue home to your facility. Examples include cases in facilities similar to yours in size or population served, or cases that received negative publicity.
- Determine your facility leaders' interest in infection control. Assess the effort needed to obtain and sustain their support.

- Talk with people in various roles, levels, and clinical areas who have a stake in seeing new KPC prevention and control guidelines implemented.
- Seek their input and develop consensus on reasons this program needs to go forward.
- Assess the extent to which organization members beyond potential supporters understand why a comprehensive KPC control and prevention initiative is needed.
- Consider finding a unit where KPC has been identified, where patients might be at the greatest risk of infection, or where staff is particularly interested in implementing the initiative , and find out what staff members in that unit think .

Updating knowledge and changing attitudes requires not only sharing new information but also assessing and addressing knowledge and/or attitudes that may slow down implementation. Consider surveying staff members throughout the organization to assess their current attitudes and knowledge around infection control—it will help target educational efforts and provide a benchmark against which to assess improvement.

Use a survey to assess clinical staff attitudes about and knowledge of KPC. **A survey developed at Boston University can be found in Section 7, Tools and Resources (Tool 1A, Clinical Staff Attitudes Toward KPC Control and Prevention).**

Additional Resources:

Below are citations of recent articles about the emergence of KPC. These may provide helpful background for you and others who are supportive of new guidelines at your facility.

- Bratu S, Mooty M, Nichani S, et al. Emergence of KPC-possessing *Klebsiella pneumoniae* in Brooklyn, New York: epidemiology and recommendations for detection. Antimicrob Agents Chemother. 2005 Jul;49(7):3018-20. PMID: 15980389.
- Gupta N, Limbago BM, Patel JB, et al. Carbapenem-resistant *Enterobacteriaceae:* epidemiology and prevention. Clin Infect Dis. 2011 Jul 1;53(1):60-7. PMID: 21653305.
- Won SY, Munoz-Price LS, Lolans K, et al. Emergence and rapid regional spread of *Klebsiella pneumoniae* carbapenemase–producing E*nterobacteriaceae*. Clin Infect Dis. 2011 Sep;53(6):532-40. PMID: 21865189.

If senior leaders do not already support a new KPC initiative, you will need to build the case for implementation. The case for implementation may be different for different people in your organization. To get the support of the chief financial officer, you may need to make a business case—how much will KPC infections cost the hospital in terms lower reimbursement rates? For other stakeholders, such as clinical chiefs, you may need to make the case with clinical outcomes and patient care.

A template for developing a business case for KPC control and prevention can be found in Section 7, Tools and Resources (Tool 1D, Business Case Form).

1.2 Is There Urgency To Implement a New KPC Prevention Strategy?

Beyond understanding the need to change clinical guidelines, do organization members find something compelling about KPC prevention and control? If a sense of urgency does not yet exist among key leaders, your job as a change agent is to create it or increase it.

Consider the current organizational attention to healthcare-associated infections in general:

- Does the organization have infection control champions on each unit? If not, who has the lead responsibility for infection control on the units?
- Are HAIs regularly documented, and are the results/reports provided to the staff? Who receives the reports, and who takes action?

The answers to these questions will influence the way you make your case for a specific KPC prevention initiative. To the extent that an existing infection control program is not present, your task will be more difficult, and mounting an effective improvement effort will likely require strong leadership support.

Here are some ways to increase the sense of urgency:

- Reach out beyond those who are already supportive and begin talking with colleagues about KPC, and about infection control more generally and its importance to your facility.
- Use their responses to gather information about potential barriers.
- Conduct a stakeholder analysis to identify key individuals and departments invested in the success of this project.

A template for stakeholder analysis can be found in Section 7, Tools and Resources (Tool 1B, Stakeholder Analysis)

1.3 Does Leadership Support This Effort?

It is crucial to make sure your organization's leadership team shares the urgency about KPC prevention and is willing and able to provide complete and ongoing support for this effort. Lessons learned from past efforts suggest that support is needed from all levels. Ask these questions about leadership support:

- How does this effort fit with the values and goals of your organization?
- Are there other commitments, initiatives or projects around healthcare-associated infections?

Changes are going to require new or reallocated resources, both human and material. In order to assess leadership support and other questions raised here, consider using a facility-level assessment similar to **Tool 1C, Leadership Support Assessment**. This assessment can help you assess potential support you can enlist for this effort. If you find that many answers are not positive, this information can help you identify areas that need attention.

Other Resources:

Saint S, Kowalski CP, Banaszak-Holl J, et al. The importance of leadership in preventing health care-associated infections: results of a multisite qualitative study. Infect Control Hosp Epidemiol. 2010 Sep;31(9):901-907. PMID: 20658939.

1.4 Establishing Ownership

Improvement projects need strong advocates, members of the organization who are committed to the project's goals, will take responsibility for the outcomes, and can influence others to get involved. To be successful, you'll need more than just one or two champions. You will also need support from various disciplines. Given the high prevalence of multidrug–resistant organisms among the chronically ill and long-term–care populations, you may want to consider including medical staff from frequently referring long-term–care facilities.

- Look carefully at the yes and no answers in **Tool 1C, Leadership Support Assessment**. If senior leadership support is not adequate, take steps to inform leaders of the importance and potential benefits associated with KPC and infection control more generally.
- Answer the following questions: Who are the key leaders? What will get them on board, if they are not already on board? What will keep them on board? Which senior leader can be the sponsor, link, or champion for this effort?
- Develop the case for KPC prevention targeted to the priority concerns of the key leaders using **Tool 1D** as examples.
- Consider:
    - Who cares about this issue?
    - Where would the logical home base be for this effort in your organization?
    - Are there individuals in that part of the organization who might be willing to take ownership of this project?
    - Are there external organizations or facilities that need to be involved?

1.5 What Resources Will You Need?

In addition to identifying an implementation team, your project will require both material and human resources. It is also important to meet with senior administrators to determine if funding is available, and how much. Consider creating a checklist, such as the **Resource Needs Assessment (Tool 1E)**.

1.6 What If You Are Not Ready?

You should not move ahead unless you are confident that your organization is ready, based on the results of the tools discussed thus far. You should assess each area of readiness for the implementation of new clinical practice guidelines. To the extent that readiness is not yet evident, or only partial, it is critical to take steps to address those areas. At a minimum, the facility must have one senior leader who understands the importance of this effort and is committed to supporting the effort, both with resources and in terms of any necessary changes to workflow processes.

Ways to build readiness and support may include—

1. Trying implementation in a single receptive unit to demonstrate success to the rest of your organization.
2. Holding one-on-one meetings with key official and unofficial leaders to present your case for change and persuade them that improvement efforts will pay off.

3. Collecting and sharing data on the magnitude of KPC infection rates, either in your facility or in your geographic area.
4. Identifying and recruiting project allies who can help spread the word.
5. Conducting a general staff awareness campaign.

Section 2. Starting Your Project

The work of redesigning existing clinical practices must start with an assessment of the current state of staff knowledge and practice, so that a plan for change can be developed in response to specific needs in your organization.

In Section 1.5, you identified members of your organization who might be willing to take ownership of this effort. It is recommended that some or all of those people join the implementation team to oversee the prevention effort and help manage the clinical changes.

If you already have experience with using teams to guide practice change efforts, you may be able to skip ahead to Section 3.

In this section, we will consider the following questions:

- How can you set up the implementation team for success?
    - Who should be on the implementation team?
    - How can you help the implementation team get started?
    - How will the implementation team coordinate with other teams working on infection control in your facility?
- What needs to change?
    - How do you start the work of redesign?
    - What is the state of staff knowledge about KPC?
    - How does a KPC-specific intervention differ or fit into existing infection control efforts?
- How should goals and plans for change be developed?
    - What goals should you set?
    - How do you develop plans for change?
- How do you bring staff into the process?
    - How do you get staff engaged and committed to new KPC infection control guidelines?
    - How can you help staff adopt new practices?

2.1 How Can You Set Up the Implementation Team for Success?

An infrastructure to support clinical process redesign will help your organization adopt new clinical guidelines. The center of this infrastructure tends to be an interdisciplinary implementation team with strong links to hospital leadership, members who have necessary clinical expertise, a clearly defined task, and access to the necessary resources.

Successful teams have strong leaders who help define members' roles and responsibilities and keep the team accountable for achieving its objectives. Senior leadership support is important for successful change, but change must happen from the ground up. Frontline health care workers, including physicians and nurses, must be actively engaged.

This interdisciplinary team will be responsible for initiating the KPC prevention project, making key decisions about project design and working with the units to implement new clinical guidelines and monitor progress. It is essential that it include some members with clinical expertise who can bring that experience to bear in project design.

You will face a number of decisions in setting up the implementation team. Decisions will include—

- Who should you put on the team?
- How can you help the team get started on its work?

2.1.1 Who Should You Put on the Implementation Team?

As suggested above, the most effective teams have several characteristics:

- **Interdisciplinary:** Infection control nurses, infectious disease specialists, and bedside staff all will be key to bringing practical and clinical knowledge to the process. Use **Tool 2A (Multidisciplinary Team)** to help identify other possible team members.
- **Strongly linked to leadership:** One way to have adequate senior leadership support is to include a senior leader on the team, but this may not always be feasible or appropriate. As an alternative, consider asking senior leadership to designate a champion for KPC prevention, and the team's leader can stay in contact with that person.
- **Linked to Quality Improvement:** The implementation team will be strengthened by having a member with expertise in process improvement methodology and team facilitation.
- **Linked to the affected clinical areas:** It is not always possible to anticipate all of the areas of your facility that will need to be involved, but it's important to think broadly about the units and departments that might be affected by the initiative.

See Tool 2A for suggestions about different staff members and stakeholders to include on your implementation team.

Resources: Visit these Web sites for ideas on selecting implementation team members:

- www.ihi.org/IHI/Topics/ImprovementMethods/HowToImprove/formingtheteam.htm
- http://www.ahrq.gov/professionals/education/curriculum-tools/cusptoolkit/modules/assemble/index.html

2.1.2 How Can You Help the Implementation Team Get Started?

Changing routine processes and procedures to alter the way in which people conduct their day-to-day work is challenging. Successful implementation teams pay explicit attention to the development of systems that make new clinical practices obvious, easy, reliable, and efficient, but the way they do their work may vary.

The team will need to consider the following questions:

- **How will the team do its work?** This question refers to the day-to-day of team operations, what resources are needed and what methods the team will employ to do its work. How will the team assess current knowledge and practices? How will the team use that information to change clinical practices? How often will it meet? How will members communicate with each other?
- **What's the team's agenda?** The team needs a clear charge and scope for its work. Can leadership provide team members with a clear understanding of the short- and long-term goals and timeframes for implementation of KPC prevention efforts?

Here are some tips on effective teamwork:

- Write a clear statement articulating the scope of the implementation team's charge.
- Ensure that senior leadership agrees with the statement.

- Communicate with team members about why they have been included and make sure their efforts are recognized.
- Provide team members a basic orientation to quality improvement principles and approaches.
- Make sure your team has the information it needs about the scope of the KPC problem at your facility and at nearby health care institutions, and your reasons for doing this work.
- Be clear about the expected outcomes of the project.
- Schedule team meetings at a time and place convenient for team members, and make sure meetings are scheduled frequently enough to make progress.
- Develop a timeline for specific tasks and outcomes.
- Assign team members responsibility for those tasks and outcomes.

2.1.3 How Will the Implementation Team Coordinate With Other Teams Working on Infection Control?

In the remainder of this section we will discuss activities that the implementation team will manage. The implementation Team will need to collaborate with people involved in infection control more generally, as well as those working on quality improvement in individual units.

The KPC control project will look at the strengths and deficits in existing infection control efforts and evaluate how new clinical guidelines can fit into existing workflows. The team will determine what changes need to be made, and what specific practices, tools, and materials it needs to accomplish its goals. The implementation team will need to call on infection control or infectious disease specialists and/or unit-based quality improvement teams. Infection control and unit-based quality improvement teams will be responsible for maintaining gains.

The implementation team will need to ensure that all relevant stakeholders are involved, and that the respective roles of both the team and other relevant parties not on the team are clear in order to avoid overlapping and duplicated effort. Each team should be responsible for specific tasks and project outputs, and the breakdown of those tasks should be clear from the start. The implementation team needs to think about not only individual responsibilities of team members, but also ways those responsibilities interact, types of ongoing communication and reporting needed between members, and the best method to link work across organizational units.

2.2 What Needs To Change?

In this section, we identify the steps the implementation team needs to take to assess the current state of infection control practice. These steps are based on the principles of quality improvement, defined broadly to include system redesign and process improvement.

2.2.1 How Do You Start the Work of Redesign?

Many of the tools the team will need are either provided or referenced in this toolkit. Your organization may already be familiar with this type of quality improvement process. If you are not sure about the strength of your organization's quality improvement infrastructure, you may want to complete the quality Improvement Process Inventory (**Tool 2B**) found in the Tools and Resources section. If some of the quality improvement processes listed in this inventory are not fully operational or present at all in your organization, you may need to build your team's improvement capability. Improvement efforts tend to be the most successful when teams follow a systematic approach to analysis and implementation; however there are many different approaches.

Here are a few examples of improvement processes:

- **PDSA (Plan, Do, Study, Act)**—PDSA assumes that not all information or factors are available at the outset; thus, repeated cycles of change are going to be necessary in order to achieve the goal, each cycle closer than the previous. With the improved knowledge, we may choose to refine or alter the goal (ideal state).
- **Six Sigma**—Developed at Motorola, Six Sigma relies on careful analysis of data on deviations from specified levels of quality, and uses redesign to bring about measureable changes in those rates. Six Sigma incorporates a specific infrastructure of personnel with different levels of training in the methodology (e.g., "Champions," "Black Belts," etc.) to take different roles in the process.
- **LEAN/Toyota Production System (TPS)**—TPS is an integrated set of practices designed to bring problems to the surface in the context of continuous workflow, level out the workload, develop a culture of stopping to fix problems, promote the use of standardized tasks, enable worker empowerment to identify and fix problems, allow problems to be visible, and ensure the use of reliable technology that serves the process. If your organization already has a well-established quality improvement process, connect your KPC project with those processes.

2.2.2 What Is the Current State of KPC Prevention Activities?

It will be useful to link new KPC guidelines to existing work being done on infection control in your facility, your referral network, and your community. The work of implementing new KPC control guidelines will mean assessing current infection control practices. In addition to the tools discussed below, you may want to look ahead to Section 5 for additional tools assessing screening practices.

Consider the following questions:

- What aspects of your current KPC prevention procedures follow best practices?
- What practices diverge in small or major ways?
- Which gaps are organization-wide? Which are specific to one or more units?
- What are other facilities in your community already doing to control the spread of KPC?

Understanding the Organizational Context of Infection Control Activities

As a preliminary step, the implementation team will want to review the organizational context for existing screening and monitoring practices on the units:

- Have your efforts to control healthcare-associated infections in general been effective? If not, what barriers have they encountered? How can you avoid the same problems? If they have been successful, are there lessons they can build on?
- Does your organization have an infectious disease specialist or infection control nurses, or both? If not, what are your options for building or acquiring that expertise?
- Are physicians involved in infection control on the units? In what ways? What are their attitudes?
- How is information about emerging infections documented and shared? What metrics, if any, are used to assess organizational performance on infection control or with respect to regular screening of admitted patients?
- Is information about emerging infections documented and communicated with referring facilities? Or other facilities in your community?

Understanding the Current Process on the Units

In order to integrate KPC prevention activities into existing infection control procedures, it's important to have a full picture of those practices. In many organizations, there are gaps between best practices and actual work practices; the extent and size of these gaps is usually unknown until current practices are systematically examined. Understanding current practices will help you better target your approach and document progress that is made. Best practices for KPC prevention are outlined in Section 3, and approaches to measuring key processes of care are outlined in Section 5.

Process Mapping To Document Current Practices

You can use process mapping to examine the key processes where infection control activities could/should be happening. Process mapping can be applied to a specific process, such as inpatient admissions to the Emergency Department, to better understand which individuals carry out each step of the process. Pay particular attention to both the movement of the patient and the movement of the information.

Define who will conduct the mapping and exactly what process will be mapped. Clearly define a start point and an end point and a methodology of all of the processes that are mapped. Making these decisions ahead of time will greatly improve the quality of the data you collect.

Integrating Change Into Current Work Routines

Beyond mapping current clinical practices, and identifying gaps between best practices and actual practices, it's important for the team to think about how recommended care guidelines can be integrated into current infection control practices, or general patient care workflow. It is essential that the team examine how new activities relate to other existing efforts, such as those related to hand hygiene and infection control, in order to ensure that new processes fit logically with existing efforts and do not create unintended consequences. For example, in one hospital, collecting samples from patients was initially assigned to day-shift nurses; however, a later analysis of the unit workflow revealed that it fit better into the patient care activities carried out near the end of the night shift, and responsibility for this process was thus shifted from days to nights. Steps to consider:

- Conduct an assessment of current practices on a sample of representative units to determine existing infection control practices that can be translated to work on KPC prevention and control.
- Use process mapping to describe current control and prevention practices and identify potential problem areas. Process mapping will enhance your understanding of how and when infection control fits into existing care processes. Compare assessment results across units to determine which prevention challenges are organizationwide and which may be unit specific.
- Determine what practices need changing and consider how the new practices can be built into ongoing routines.

See Tool 2C, Current Process Analysis for tips on how to carry out a process analysis in order to understand the current state of practice.

2.2.3 What Is the Current State of Staff Knowledge About KPC?

KPC is an emerging infection that some staff members may not know about. Additionally, staff may have varying levels of knowledge about healthcare-associated infections more generally due to staff turnover, prior knowledge, and training. In order to address these gaps through education, you need to know what the gaps are and where they are located.

Based on an analysis of current staff knowledge, you can assess potential barriers to change. For example, do staff members believe infections are inevitable? Do they believe it's too challenging to maintain contact precautions with family members entering and leaving patient rooms? Because not all barriers are evident from the beginning, it's important to continue to be attentive to potential barriers as implementation moves forward. Here are some steps to consider:

- Administer an inventory of KPC infection knowledge and infection control knowledge more generally to staff members **(Tool 1A)**.
- Consider collecting demographic information at the same time so that your results can be analyzed by unit and occupation. Since this is an educational needs assessment, we do not recommend asking staff to include their names unless they want direct feedback on their score, since that may decrease participation. Develop methods to correct knowledge gaps and misunderstandings.

2.3 How Should Goals and Plans for Change Be Developed?

In the following sections, the toolkit provides guidance on how to develop goals and implementation plans for the changes you have determined are necessary.

2.3.1 What Goals Should You Set?

Once the team has analyzed the data collected, the team will want to review the evidence on best practices and the clinical guidelines found in Section 3. Before turning to these steps, the team will need to set goals for improvement. These may be related to specific outcomes (e.g., a reduction in the incidence rate of KPC in a specific unit, or an increase in successful isolation of colonized patients) and/or to specific processes (e.g., successful screening of all patients admitted through the emergency room). Goals should be related to both current data and broader benchmarks. It will help you identify your next steps.

For example, your analysis may have revealed specific problems related to processes of care:

- While staff maintain contact precautions when in physical contact with the patient, they do not wear masks or gowns when they enter the room but do not plan to touch the patient.
- Contact precautions are not maintained if/when patients are transferred to general medicine floors.

If you identify gaps in care processes, you may want to set improvement goals aimed at reducing those gaps. If you identify gaps in staff knowledge, you may want to set improvement goals in that area. These are key actions to take:

- Set improvement goals based on outcomes and processes
- Identify internal and external benchmarks to judge goals and progress
- Use goals to guide next steps in redesigning infection control practices

2.3.2 How Do You Develop a Plan for Implementation?

By now, the implementation team will be in place, and you will have developed much more information about the current state of infection control in your organization. The current state of

quality improvement efforts in your organization should also be clearer, and a specific team of staff members should have been identified to advance KPC control and prevention efforts. It is now time to develop a more specific plan for implementing new practices and assessing the plan through consistent data collection and analysis. This plan should be extended and refined by work to be completed in response to additional questions we explore in Section 4.

While this plan will need to be flexible in order to be responsive to particular unit-based variation, it is critical to formulate a comprehensive plan to guide next steps. The clinical guidelines and best practices discussed in the next sections are critical to the implementation plan, but are not independently sufficient. They must be implemented within the context of many other factors.

Also, it is important to begin thinking early about sustaining the improvements you have put in place (as discussed in Section 6). Thus, the implementation plan should address—

- Membership and operation of the interdisciplinary implementation team
- Clinical practice guidelines to be met
- Gaps in staff education/competence to be addressed
- Plans for rolling out new standards and practices where needed
- Accountability for monitoring implementation
- Ways changes in processes and performance will be assessed
- Ways the effort be sustained

The Plan of Action found in Section 7, Tools and Resources, can be a useful template for developing your implementation plan (Tool 2D)

2.4 Checklist for Managing Change

This is a good time to make sure the steps taken so far will contribute to a successful launch of your effort. Use this checklist to make sure you've addressed all of the key areas.

Area	**Completed**
Implementation Team composition	
• Team leader identified and in place	
• Members with necessary expertise/roles identified and invited	
• Linkage to senior leadership defined and established	
Team startup	
• Team agenda and charge clearly stated	
• Team has necessary training and resources to get started	
Current state of practice and knowledge	
• Current practice and policies systematically examined	
• Challenges to good practice identified at organization and unit levels	
• Staff knowledge assessed	
Starting the work of implementation	
• Approaches to implementation explored and chosen	
• Gap analysis of current practice and guideline-consistent practice completed	
Setting goals and plans for change	
• Specific goals set	
• Plan for making changes to meet those goals initiated	
• Preliminary plan for sustaining those changes established	

Section 3. Putting Your Intervention Into Practice

3.1 Understanding the Epidemiology of KPC and the Apparent Inability of Standard Infection Control Practices To Contain and Control KPC

KPC was first reported in North Carolina in 2001, and to date it is the most common type of carbapenemase encountered in the United States. KPC is an enzyme that inactivates all β-lactam antibiotics, including penicillins, cephalosporins, monobactams, and carbapenems. Genes encoding for KPC enzymes are located on plasmids, and other resistance-factor genes are often linked on the same plasmid. There are 10 variants of KPC (KPC-2 to KPC-11). ***Klebsiella pneumoniae* isolates positive for carbapenemases typically exhibit resistance to almost all available antimicrobial agents, and infection with a KPC-positive organism has been associated with high rates of morbidity and mortality, increased length of stay, and high costs.** KPCs have also been found in many other gram-negative species including: *Escherichia coli, Enterobacter species, Salmonella enterica, Proteus mirabilis, and Citrobacter freundii, Serratia species, Pseudomonas species,* and *Acinetobacter baumannii.*

Since first described, KPC has spread rapidly in the United States as well as around the world. Endemic in areas such as the northeastern United States, Israel, Colombia, and Greece, KPC colonization is routinely found in patients in both acute- and long-term–care facilities, but reports of community-onset infections with KPC-producing organisms have been rare. Patient risk factors for KPC colonization include recent treatment with broad-spectrum antibiotics, advanced age, nursing home residence, or recent acute-care hospitalization. The rapid spread of KPC is thought to be related to the inter-institutional transfer of asymptomatic patients with rectal KPC colonization. The spread of KPC-producing organisms in health care settings represents a serious infection control issue.

Accurate detection of isolates harboring KPC remains challenging because automated susceptibility testing systems fail to detect low-level resistance. In addition, traditional infection control strategies that only target monitoring of clinical isolates as a trigger for initiating control interventions have not proved effective for KPC control, and are only addressing the "tip of the iceberg," since there are about 100 colonized patients for every infected patient.

Recently, the CDC has provided CRE prevention guidelines for health care professionals, acute- and long-term–care hospitals, and health departments. The recommendations emphasize the need to develop CRE prevention interventions on both a facility and regional basis. The new recommendations include enhancing compliance with hand hygiene, placing CRE-colonized or CRE-infected patients on contact isolation precautions, minimizing use of invasive medical devices, patient and staff cohorting (i.e. designated nursing staff working with colonized or infected patients), promoting antibiotic stewardship, and screening patients with risks for CRE. The CDC recommends that, in areas where CRE is endemic, health care facilities undertake two additional measures: active surveillance for CRE and use of chlorhexidine bath or wipes. Visit www.cdc.gov/mmwr/preview/mmwrhtml/mm6209a3.htm?s_cid=mm6209a3_w and www.cdc.gov/hai/pdfs/cre/CRE-guidance-508.pdf for more information.

While active-surveillance–driven initiation of isolation precautions for MDRO control is a controversial topic in infection control circles, the literature suggests that active screening programs can effectively control MDRO prevalence when they rapidly identify colonized patients and place them into contact isolation precautions, such that a high percentage of total

MDRO patient colonization days are spent as contact isolation days (see Burton, et al, below). Furthermore, numerous reports indicate that this strategy has reduced the prevalence of KPC colonization on a hospital unit, within an institution, and on a regional and national basis.

Suggested references:

U.S. Centers for Disease Control and Prevention, National Center for Emerging and Zoonotic Infectious Diseases, Division of Healthcare Quality Promotion.Guidance for Control of Carbapenem-Resistant Enterobacteriaceae, 2012 CER Toolkit. Atlanta, GA: CDC. www.cdc.gov/hai/pdfs/cre/CRE-guidance-508.pdf.

Siegel J, Rhinehart E, Jackson M, et al. Management of Multidrug-Resistant Organisms in Health Care Settings, 2006. Atlanta, GA: U.S. Centers for Disease Control and Prevention. www.cdc.gov/mmwr/preview/mmwrthml/mm5810a4.htm.

Peterson L, Diekma D. To screen or not to screen for methicillin-resistant *Staphylococcus aureus*. J Clin Microbiol. 2010 March;48(3):683-689. PMCID: PMC2832433.
Currie B. Impact of molecular diagnostics on infection control. Inf Dis Special Edition. 2011;14:11-15.

Kochar S, Sheard T, Sharma R, et al. Success of an infection control program to reduce the spread of carbapenem-resistant *Klebsiella pneumoniae*. Infect Control Hosp Epidemiol. 2009 May;30(5):447-52. PMID: 19301985.

Burton N, Aguirre D, Leung S, et al. PCR based active surveillance for carbapenem-resistant *Klebsiella pneumoniae* (KPC) colonization with rapid initiation of contact isolation achieved significant reduction in KPC colonization prevalence in the ICUs of a NYC medical center. Presented as oral abstract at ID Week 2012, San Diego, CA.

Borer A, Eskira S, Nativ R, et al. A multifaceted intervention strategy for eradication of a hospital-wide outbreak caused by carbapenem-resistant *Klebsiella pneumoniae* in Southern Israel. Inf Control Hosp Epidemiol. 2011 Dec;32(12):1158-65. Epub 2011 Oct 17. PMID: 22080653.

Ben-David D, Maor Y, Keller N, et al. Potential role of active surveillance in the control of a hospital-wide outbreak of carbapenem-resistant *Klebsiella pneumoniae* infection. Infect Control Hosp Epidemiol. 2010 Jun;31(6):620-6. PMID: 20370465.

Munoz-Price L, Hayden MK, Lolans K, et al. Successful control of an outbreak of acute *Klebsiella pneumoniae* carbapenemase-producing *K. pneumonia* at a long-term acute care hospital. Infect Control Hosp Epidemiol. 2010 Apr;31(4):341-7. PMID: 20175685.

Schwaber M. Lev B, Israel A, et al. Containment of a country-wide outbreak of carbapenem-resistant *Klebsiella pneumoniae* in Israeli hospitals via a nationally implemented intervention. Clin Infect Dis. 2011 Apr 1;52(7):848-55. PMID: 21317398.

3.2 Detection of KPC Colonization

Detection of KPC has already proven itself to be a diagnostic problem for the clinical laboratory. KPC-positive bacterial isolates exhibit high variability regarding which carbapenems they hydrolyze, as well as exhibiting day-to-day variation in their ability to hydrolyze any given carbapenem drug. Particular issues with phenotypic or culture identification arise when measured minimum inhibitory concentrations are low, as phenotypic testing may misidentify some isolates as carbapenem susceptible when they are in fact KPC positive.

A variety of phenotypic (culture-based) approaches for the detection of KPC colonization have been reported in the literature. They rely on the use of selective screening plates to identify carbapenemase production, followed by speciation of the isolate using standard automated clinical microbiological systems routinely used. Selective screening plates have included:

1. MacConkey agar plates supplemented with 1.0 µg/ml of meropenem.
2. Selective and Disclosing Media (select for carbapenem resistant-colonies which are color tinged depending on species). These products are commercially available and are marketed as CHROM agar KPC, Brilliance CRE, Hardy CHROM carbapenemase, and Chrom ID.

Similar to routine diagnostic testing in the clinical lab, these screening plates will have issues with sensitivity and specificity, especially when carbapenem MICs are low. They are also associated with fairly long turnaround times to get results, and they require a trained microbiologist to pick appropriate colonies from the plates. They are labor intensive to perform and do not easily fit into clinical laboratory workflow patterns. On the other hand, they are relatively inexpensive and will work well in surveillance situations where rapid turnaround is not necessary. Typical turnaround times for phenotypic detection of KPC are 3–5 days.

A variety of molecular diagnostic approaches for KPC detection have been described in the literature. These approaches primarily consist of “homegrown” real-time multiplex polymerase chain reaction (PCR) assays. PCR primers have been designed to detect all known variants of the KPC gene (KP2 to KPC 12) and their sequences have been published. A single commercial product, Hy-KPC PCR (Hy Laboratories, Ltd.), is available. None of the assays are FDA approved. These assays have been proven to be highly sensitive and specific, with turnaround times of several hours, and have been optimized for use with direct swab samples. However, PCR testing will require purchase of specialized equipment and trained technicians. Successful KPC control interventions using PCR-driven active surveillance coupled with timely initiation of contact isolation have been previously reported. Rapid turnaround time may be critical to intervention success.

In summary, both traditional culture-based methodologies and PCR detection have been used successfully as part of KPC control efforts. While molecular detection methods appear to offer many advantages as a screening tool (rapid turnaround time and improved sensitivity and specificity), they are not FDA approved and are only commercially available on a limited basis.

Each institution will need to carefully choose among the available screening methodologies to support their active surveillance program, and lack of ability to implement molecular testing should not otherwise prevent pursuit of aggressive CRE control efforts using existing culture techniques.

Suggested references:

Birgy A, Bidet P, Genel N, et al. Phenotypic screening of carbapenemases and associated *β*-lactamases in carbapenem-resistant *Enterobateriaceae.* J Clin Microbiol. 2012 Apr;50(4):1295-1302. Epub 2012 Jan 18. PMID: 22259214.

Wilkinson KM, Winstanley TG, Lanyon C, et al. Comparison of four chromogenic culture media for carbapenemase-producing *Enterobateriaceae*. J Clin Microbiol.2012 Sep;50(9):3102-4. Epub 2012 Jul 3. PMID: 22760041.

Singh K, Managold KA, Wyant K, et al. Rectal screening for *Klebsiella pneumoniae* carbapenemases: comparison of real-time PCR and culture using two selective screening agar plates. J Clin Microbiol. 2012 Aug;50(8):2596-2600. Epub 2012 May 23. PMID: 22622443.

Richter SN, Frasson I, Biasolo MA, et al. Ultrarapid detection of $bla_{\text{KPC ½-12}}$ from perirectal and nasal swabs by use of real time PCR. J Clin Microbiol. 2012 May;50 (5):1718-1720. Epub 2012 Feb 29. PMID: 22378915.

Chen L, Mediavilla JR, Endimiani A, et al. Mulitplex real-time PCR assay for detection and classification of *Klebsiella pneumoniae* carbapenemase gene (bla_{KPC}) variants. J Clin Microbiol. 2011 Feb;49(2):579-585. Epub 2010 Dec 1. PMID: 21123529.

Section 4. Implementing Best Practices

The decision to choose a KPC detection methodology should be made in collaboration with your institution's clinical microbiology laboratory director and should include a careful review of existing staffing, equipment, financial resources, and laboratory expertise. Planning strategies should include the resources to handle the anticipated volume of samples and include a plan to notify appropriate staff when patients colonized with KPC are identified. Important questions to address include—

- How and when will samples be collected and transmitted to the lab as part of the clinical workflow?
- How will the lab handle this new and additional workflow?
- What is the anticipated volume of samples?
- How and when will clinicians be notified of screening results? What will happen then?
- Are adequate supplies of personal protective equipment available on the unit(s) where screening occurs? Do all staff know when/how to use them in caring for KPC-positive patients?

4.1 Collecting Patient Specimens

Although patients can be colonized with KPC at any anatomic location (e.g., asymptomatic bacteruria, chronic wounds, etc.), previous studies have documented that a peri-anal swab sample will detect all KPC colonized patients.[2] Cotton-tipped swabs in use at the institution will suffice. Do not assume that the collection of samples is intuitive to hospital staff—consider providing laminated sheets that document and illustrate the sampling process (see **Tool 4A** for an example). While obtaining a peri-anal swab sample is a noninvasive procedure, it is a sensitive issue for many patients. Strong consideration should be given to having nursing staff obtain the samples. They can incorporate sampling seamlessly into their normal patient care activities, enhancing patient acceptance and compliance with sampling and preventing disruption caused by unnecessary patient maneuvering for the sole purpose of sampling. Patient samples should be identified with routine labels currently in hospital use. Place pickup containers on each patient care unit for pickup of specimens at designated times. Specimen pickup provides an opportunity to review with nursing staff whether any issues or problems associated with obtaining samples. Specimens do not require either incubation or refrigeration, as *Enterobacteriaceae* are robust organisms. The importance of complete sampling of all target patients should be stressed as an important determinant of intervention success.

4.2 Surveillance Strategies

No single approach to KPC surveillance will optimally address all scenarios of KPC prevalence, and your approach should be designed and customized to address the situation at your institution. Active surveillance should be considered when KPC clinical cultures begin to appear at your institution, or at another health care facility in your geographic area (many public health departments are facilitating the sharing of this information about MDROs in recognition

[2] Simkins J, Pokharel R Dogra S, et al. Prevalence of carbapenemase-producing *Klebsiella pneumoniae* colonization at an academic medical center in New York City. Abstract 1349 presented at Infectious Diseases Society of America annual meeting, Boston, October 22, 2011.

that the problem requires population-level monitoring). Surveillance approaches might include periodic prevalence surveys involving a representative sample of inpatients, including both geriatric and intensive care unit (ICU) patients, such that every third inpatient is sampled during a 1- to 2-week period.

Given the importance of inter-institutional transfer of KPC-colonized patients to the spread of KPC, the survey should include a sampling of emergency department patients who are nursing home residents or recent discharges from other acute-care hospitals who have been admitted but not yet transferred to an inpatient unit. Also include a sample of patients directly transferred to your hospital's inpatient areas from similar facilities. Here rapid reporting of test results is not important, and you may elect to use a culture-based technique for KPC detection.

If results reveal a significant presence of KPC among your patients or in patients recently discharged or transferred from other institutions, escalate your KPC control program to include more aggressive approaches. If results indicate a low prevalence, repeat your survey at regular intervals. If the KPC prevalence rate is greater than 2 percent or KPC is present at a neighboring institution, immediately escalate your KPC control efforts. Even with KPC colonization rates of 5 to 7 percent (endemic to epidemic rates), enhanced KPC control programs have significantly reduced the prevalence of KPC colonization. If you and your neighboring institutions share a significant KPC colonization prevalence rate, consider collaborating on a joint KPC control program.

Infection control practitioners may find it valuable to contact their peers at other institutions in their region to periodically exchange information about the emergence and/or prevalence of KPC in nearby institutions. Both acute- and long-term–care facilities should be included in these information exchanges. In addition, the CDC recommends that public health authorities develop programs to monitor KPC activity within their jurisdictions. Some state and county health departments now require reporting of all KPC isolates. Local health authorities may provide valuable information about potential KPC activity in your area. See the recent CDC toolkit for more information (CDC CRE 2012 Toolkit, "Guidance for Control of Carbapenem-Resistant Enterobacteriaceae (CRE), 2012 CRE Toolkit" www.cdc.gov/hai/pdfs/cre/CRE-guidance-508.pdf). Escalation of your control program should include active surveillance coupled with rapid initiation of contact isolation precautions for every colonized patient. Here the emphasis is on testing all patients in a target group, rapidly identifying KPC-colonized patients, and initiating contact isolation. The process needs to be designed and executed in timeframes that will allow at least 85 percent of total patient KPC colonization days to be in contact isolation. Complete sampling of the target population is required, as well as daily sampling of patients transferred or admitted to the target population.

A typical active surveillance program would include weekly sampling of the total target population and daily testing of newly admitted/transferred patients. To measure your impact on KPC colonization prevalence rates, collect baseline data before you initiate your intervention strategy. This can be accomplished by weekly sampling of all target patients pre-intervention. Results from a previous cross-sectional sample of your patients can provide important information to identify your target population. KPC colonization prevalence may cluster in certain locations in your facility, such as geriatric service, critical care units, or patients transferred from other institutions directly to inpatient areas or admitted through the emergency department. Alternatively, if you have not conducted exploratory cross-sectional sampling for KPC colonization or believe the prevalence of KPC patient colonization is already increased at your hospital, you may choose to strategize to limit the prevalence of KPC among vulnerable patient populations, such as ICU patients.

References from Section 3.1 provide road maps for successful KPC control interventions for a single clinical unit, all ICU patients in a multihospital network, and an entire acute-care or long-term–care facility.

Section 5. Measuring the Impact of Your Intervention

It is important to measure the impact of your program. While the primary goal of collecting outcome data is to improve patient care, outcome data can serve many other purposes. Tracking appropriate outcome measures allows you to fine tune your intervention program to maximize successful implementation. It is important to demonstrate success to your multidisciplinary team to ensure members' ongoing active participation and compliance. In addition, the information may prove valuable in convincing your leadership to keep supporting your initiative administratively and financially.

5.1 Types of Outcome Measures

Outcome measures can be divided into three major categories:

a. Measuring **the impact** of your intervention

The goal of your intervention program is to reduce the horizontal transmission of KPC to prevent patient colonization. Ideally, you should track the prevalence of KPC colonization (number of KPC positive patients among all those screened) before and after your intervention. If baseline data are not available, track KPC prevalence rates for downward trends. In the prevalence rate, each patient can only count once in the numerator, even those who have been repeatedly positive on weekly sampling. A second helpful measure is to track the number of patients who initially tested negative for KPC and then tested positive. This outcome targets and measures the impact of disrupting horizontal transmission of KPC and preventing colonization. Finally, a crucial outcome measure to track is the percentage of total patient KPC colonization days spent in contact isolation. This is a good indication of how well your intervention is being executed and, in particular, will reflect the timeliness of patient sampling, turnaround testing times, feedback of results to clinical staff, and initiation of contact isolation. Institutions may also want to track actual KPC infections, but it is important to realize that the number of infected patients will be low, even in facilities that are hyperendemic for KPC. Once KPC is established in a facility, there will be approximately 50–100 KPC colonized patients for every detected KPC infection. Monitoring infections as the only outcome can be quite misleading in this setting.

b. Measuring **potential confounders**

Even a well-designed and executed intervention can fail if hospital staff do not comply with the requirements of contact isolation when it is initiated. You may consider tracking staff compliance with hand hygiene; proper use of barrier precautions, including gloves and gowns; and compliance with placement of patients in single rooms. This is best accomplished by periodic unannounced direct observation sessions to ascertain compliance with the elements of contact isolation. Tools for this purpose can be found in **Tool 5A, Infection Control Observation Tool** and at www.jointcommission.org/Measuring_Hand_Hygiene_Adherence_Overcoming_the_Challenges_.

While seemingly reviewing a patient chart, the observer documents compliance on a checklist tool for a predetermined number of staff-patient encounters. All types of staff need to be observed (physicians nurse, respiratory therapists, etc.). Typically, 30 staff-patient encounters a week is sufficient. This information should be shared with the health care team, and a plan to correct deficiencies should be implemented when necessary, keeping in mind that failures are

often systemic and not solely attributable to individual noncompliance. For example, systemic failures can occur when—

- There is a lack of communication about a patient's colonization status
- There is a lack of accessible personal protective equipment
- There is a lack of understanding about the reasons for the contact isolation

Staff members are frequently not aware of the clinical importance of KPC, even at endemic hospitals, and the fix for poor compliance with contact isolation may need to include staff education about the epidemiology and clinical importance of KPC.

c. Measuring **unintended negative outcomes**

Your KPC control program maybe highly successful but may simultaneously negatively impact other aspects of patient care and hospital operations. Many hospitals already struggle with other multiple MDRO organisms, and the availability of single rooms for contact isolation may already be at a premium. Additional demand for single rooms for the KPC program may result in difficulty in transferring patients within the hospital when the required level of care changes. Tracking delays in transfer related to the inability to find an appropriate single room for continued contact isolation may be important to continued acceptance of your intervention. Concerns about this issue should be explored with staff in targeted areas during the planning stages, and when appropriate, delays should be tracked and measured. Knowledge of KPC colonization status may inappropriately influence the selection of empiric antibiotic therapy. In addition, if PCR detection is used. It is important to remember that these assays are not FDA approved and results should not be used to guide patient therapy. Finally, it is not clinically appropriate to base therapy on colonization status. You may consider tracking polymyxin use before and after you initiate your intervention on the targeted clinical units.

Section 6. Implementing and Sustaining Your Intervention

Before rolling out your intervention, it is helpful to present your program and its objectives to relevant standing committees of the hospital (infection control committee, performance improvement and quality management committee, medical staff committee, and nursing leadership committee) for formal endorsement. Similarly, meet with the nursing director and the chief medical officer to ensure they are aware of the timing of your rollout and to renew their continuing support of your program. Endorsement by the governing structure of the hospital will aid acceptance of your initiative by direct caregivers who will be impacted by the program, and helps assure them that your planning process has been thorough and appropriate and has been carefully reviewed before its initiation.

The actual rollout will take time, at least several weeks, and you should view this initial phase as a "testing the waters." Your program requires multidisciplinary participation and is a complex process with many moving parts. It will take some time to "iron out the wrinkles" until everyone's tasks are integrated into their normal workflow patterns. The project leadership will need to be patient and flexible in rethinking some project design issues, and should spend a great deal of time overseeing this critical period of the rollout process. Rolling out large-scale interventions will almost certainly require a dedicated team approach with daily followup and tracking of each step in the process. Identification of "bottlenecks," poor coordination of activities, and failure to accomplish assigned tasks may require coaching to help participants achieve their tasks and thus enable the overall success of the program. The more you can incorporate each participant's tasks into their normal work routine, the more likely that your program will succeed.

Initiating your rollout should take advantage of already existing meetings and conferences that the involved direct caregivers already attend, such as grand rounds and unit-based nurse manager/nursing staff meetings. This is an effective way to achieve general awareness of your program. Your team should also meet with unit staff for a detailed briefing on their participation and roles. These meetings should be open ended, and participants should be encouraged to ask questions and point out design issues they anticipate. These meetings should "recruit" the participants to all become team members and to take ownership of the program.

These localized rollout meetings are most effective if they: (1) educate staff about the epidemiology and emerging threat of KPC, (2) stress the importance and necessity of this initiative for their clinical practice, (3) introduce the overall design of the intervention, (4) identify specific tasks and responsibilities for each participant, (5) remind them that they must pay close attention to hand hygiene and contact isolation compliance, and (6) reassure them that the intervention team will provide close collaboration and support during the rollout. Consider scheduling meetings in the early morning to simultaneously capture staff from day and night shifts, or videotaping one of the meetings for presentation to staff working off-hour shifts. During initial rollout, the intervention team should visit units daily at sample pickup times to ensure complete sampling of target patients. Team members also will need to track laboratory testing turnaround times, reporting of positive patients to the units, and the speed at which patients are placed on contact isolation.

It is important to give participants periodic feedback about achieving intervention performance metrics. The previous paragraph outlines some metrics you need to track. It is important to share successes with participants to ensure their continued engagement and

enthusiasm. In addition, analyze the intervention clinical outcome data periodically and also share these metrics with participants. Sharing success will help sustain the intervention and provide clinical relevance for participants. Make certain that hospital leadership recognizes and appreciates their success for its importance to the well-being of the hospital's patients and the institution.

Section 7. Tools and Resources

Tool 1A. Clinical Staff Attitudes Toward KPC Control and Prevention

Background: Use this tool to assess clinical staff attitudes before starting your KPC infection control project. It will help identify needs for additional education and advocacy in order to get staff engaged.

I**nstructions**: Let staff know that the information is being collected anonymously, and administer either on paper or via a web survey application.

Use: Use the results to provide feedback to the clinical team on their attitudes.

Clinical Staff Attitudes Toward KPC Control and Prevention

You are being asked to complete this anonymous survey because you are in a staff group that has some responsibility for infection control. Please answer each question based on your own experiences and perceptions. Thank you for taking the time to participate in this important project.

Improving Performance in Infection Control

Definitions: In this survey, we ask about organizational goals, priorities and activities at your facility and in your clinical unit. To clarify a few items as you begin to respond:

By **facility**, we mean the medical center where you are receiving this survey.

By **clinical unit**, we mean the part of the facility in which you work. If you work in more than one unit, please think about the unit on which you spend the most time.

By **team,** we mean the group of people you work with regularly in your clinical unit.

By **senior management,** we mean the top officials in the facility, such as the chief of staff and the nurse executive.

Please indicate the extent to which you agree with the following statements:

1. About your facility:

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
My facility is committed to delivering the highest quality patient care					
My facility has a clear sense of direction					
My facility has a clear action plan that details the steps needed to improve patient care					
At my facility, it is a high priority to provide patient care according to evidence-based guidelines					
The leadership at my facility places high priority on improving infection control in our clinical areas					

2. **About the care provided in your clinical unit:**

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
Day-to-day activities demonstrate that patient care quality is important					
It is difficult to fix quality problems that involve other services at this facility					
Some patients receive too little care					
Patient care processes have been standardized					
Patient care is well coordinated across different parts of the facility					
Handoffs of patients or information across units go smoothly					
I would feel completely comfortable having a family member treated at this facility without my being able to monitor their care					

3. **About your team in your clinical unit:**

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
Our team learns from the efforts of others to improve compliance with infection control guidelines in our facility					
Senior management supports our efforts and helps us obtain the necessary resources and cooperation					
After we have implemented a change, team members think about and learn from the results					
This organization makes sure people have the skills and knowledge to work as a team					
Our service chief or service line manager helps us obtain cooperation and resources from other services or clinical units when needed					
Analyzing clinical processes to identify areas for improvement is a regular part of our work					
When trying to improve performance, we systematically test out new ideas					

4. **About knowledge specific to KPC infections and guidelines**

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
The incidence of KPC colonization and infection among our patients is likely to increase in the near term					
KPC is likely to become as big a threat as MRSA and *C. diff*					
Clear and complete information about KPC has been shared with our team					
Our team understands the new infection control guidelines specific to KPC					

5. **About possible barriers to compliance with NEW infection control policies**

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
There is a lack of awareness of the new guidelines					
I sometimes forget to follow the new guidelines					
The new guidelines are inconsistent and/or confusing					
The new guidelines are not effective					
Ancillary personnel from outside the unit are not adequately trained on the new guidelines					
The new guidelines are not realistic given our workflow					
There was enough education about the new guidelines					
The necessary supplies/equipment are available to follow the new guidelines					
The supplies/equipment are conveniently located					
Following the new guidelines takes time away from patient care					
Our workload is too heavy to follow the new guidelines					

6. About you

Advanced practitioner (NP, PA, Nurse Manager, Clinical Nurse Specialist)	
Registered Nurse	
LPN or Nursing Assistant	
Physician	
Other Clinical	

Please check the box corresponding to the clinical unit you work in, if you work in more than one please respond with the unit you spend the most time in.

(Put the names of the relevant units at your site here)	
Medical/Surgical ICU	
CT Surgery ICU	
(CCU)	

Tool 1B. Stakeholder Analysis

Background: The purpose of the stakeholder analysis is to help the project team identify departments/individuals who will have an interest in the project, potential barriers, and actions needed to obtain the buy-in and participation of those departments and individuals.

Instructions: The project team can complete this as a group at one of its first few meetings in order to identify relevant stakeholders and their interests and roles.

Use: The team can use this information to develop strategies for getting those stakeholders engaged.

Stakeholder Analysis

Stakeholder	Interest or Requirement in the Project	What the Project Needs	Perceived Attitudes and/or Risks	Next Steps

Tool 1C. Leadership Support Assessment

Background: Many initiatives and projects fail due to lack of senior leadership support and engagement.

Instructions: Use this tool within your team to assess the extent of leadership support for your effort.

Use: If you discover that there are many “no” answers, the team should take some time to develop a strategy for gaining greater leadership support for HAI-related activities. This may include strategies for raising the profile of this issue on the leadership agenda.

Leadership Support Assessment

Leadership Support Assessment	Yes	No
Patient safety is clearly articulated in the organization's strategic plan		
Someone in senior management is in charge of patient safety		
The facility has implemented a shared leadership model		
Funding is allocated for patient safety activities		
The budget includes funding for education and training on patient safety issues		
Prevention of HAIs is a priority within the facility		
The facility has implemented policies to help prevent the spread of HAIs		
Current infection control and prevention goals are being addressed		
There are visible role models/champions for the prevention of HAIs		

Tool 1D. Business Case Form

Background: This tool can be used to make the case for the implementation of a quality improvement initiative by addressing the concerns of key leadership.

Instructions: Please complete the form with all the required information.

Use: Present the completed form to your project sponsor and discuss the potential benefits of the KPC infection control project

Business Case Form

Background of the project (PLEASE KEEP BRIEF)
General aims(s)
Initial Risks
Expected Outcomes
Benefits of Conducting This Project
Initial Cost and Time Estimates **$:** **Time:**
Outcome of the Business Case

Tool 1E. Resource Needs Assessment

Background: Beyond general leadership support, the team is also likely to need specific resources.

Instructions: The team should review this list and consider which entries are needed for its efforts.

Use: Team leaders can use the results of the assessment to shape their resource requests to leadership.

Resource Needs Assessment

Resource Needs Assessment	Resources Needed?	Comments
Staff education programs		
Quality improvement experts		
Infection control consultation		
IT support		
Easily accessible personal protective gear		
Facilities (e.g., meeting rooms)		
Printing/copying		
Protected time for meetings and activities		
Other		

Tool 2A. Multidisciplinary Team

Background: When creating a team, it's important to make sure that participants reflect the range of disciplines and functions that may need to be involved in the team's work. Not all areas listed may be relevant to your particular situation, so it's important to customize this list to your institutional context.

Instructions: Team leaders should use this tool to identify potential team members in each related area.

Use: Team leaders can then use the names generated to help them develop a team that is representative and inclusive on key dimensions.

Multidisciplinary Team

Discipline	Names of Possible Implementation Team Members From Each Area	Area of Expertise
Senior manager		
quality improvement/safety/risk manager		
Infection control specialist		
Staff nurse		
Nursing assistants		
ICU physicians		
Infectious disease specialist		
Medical/Surgical staff		
Other providers		
Patient representative		
Educator		
Materials manager		
Information systems staff		
Lab/Microbiology staff		
Environmental services		
Auxiliary services		
Clerical staff		
Clinicians from frequently referring nursing facilities		

Tool 2B. Quality Improvement Process Inventory

Background: This tool will help you and your team identify the extent to which you have the resources for quality improvement in your organization. Turning Point Initiative developed this form to assess whether an organization has systems in place to improve quality and performance.

Instructions: The implementation team leader should complete this tool in consultation with the quality improvement department. “You” refers to your organization as a whole. Check the box that most accurately describes your organizations current resources.

Use: If you find that your organization has fully operationalized quality improvement processes, connect the pressure ulcer prevention initiative with these existing processes. If some processes are missing, advocate for them to be put into place in the context of the pressure ulcer initiative.

Reference: Turning Point Performance Management National Excellence Collaborative. Performance Management Self-Assessment Tool. Available at: www.turningpointprogram.org/toolkit/pdf/PM_Self_Assess_Tool.pdf.

Quality Improvement Process Inventory

Assessment Questions	No	Somewhat	Yes (Fully operational)
1. **Do you have a process(es) to improve quality or performance?**			
A. Is an entity or person responsible for decision-making based on performance reports (e.g. top management team, governing or advisory board	❒	❒	❒
B. Is there a regular timetable for your quality improvement process?	❒	❒	❒
C. Are the steps in the process communicated?	❒	❒	❒
2. **Are managers and employees evaluated for their performance improvement efforts (i.e., is performance improvement in their job descriptions)?**	❒	❒	❒
3. **Are performance reports used regularly for decision-making?**	❒	❒	❒
4. **Is performance information used to do the following? (check all that apply)**			
A. Determine areas for more analysis or evaluation	❒	❒	❒
B. Set priorities and allocate/redirect resources	❒	❒	❒
C. Inform policy makers of the observed or potential impact of decisions under their consideration	❒	❒	❒
5. **Do you have the capacity to take action to improve performance when needed?**			
A. Do you have processes to manage changes in policies, programs, or infrastructure?	❒	❒	❒
B. Do managers have the authority to make certain changes to improve performance?	❒	❒	❒
C. Does staff have the authority to make certain changes to improve performance?	❒	❒	❒
6. **Does the organization regularly develop performance improvement or quality improvement plans that specify timelines, actions, and responsible parties?**	❒	❒	❒
7. **Is there a process or mechanism to coordinate quality improvement efforts among programs, divisions, or organizations that share the same performance targets?**	❒	❒	❒
8. **Is quality improvement training available to managers and staff?**	❒	❒	❒
9. **Are personnel and financial resources allocated to your quality improvement process?**	❒	❒	❒

Tool 2C. Current Process Analysis

Background: Before beginning a quality improvement initiative, it is important to understand existing practices. This tool is intended for use in describing key processes in your organization where KPC infection prevention activities could/should be happening. Quality Improvement Organizations (QIOs) have developed this tool to provide a guide to identify and evaluate key processes of care.

Instructions: Have the implementation team identify and define every step in the current process for pressure ulcer prevention.

- When defining a process, think about staff roles in the process, the tools or materials staff use, and the flow of activities.
- Everything is a process, whether it is admitting a resident, serving meals, assessing pain, or managing a nursing unit. The ultimate goal of defining a process is identifying problems in the current process.

Use: Determine if there are gaps and problems in your current processes, and use the results of this analysis to systematically change these processes.

Tips:

- Take time to brainstorm and listen to every team member.
- The process must be understood and documented.
- Make each step in process very specific.
- Use one Post-It Note, index card, or piece of scrap paper for each step in the process.
- Lay out each step, move steps, and add and remove steps until the team agrees on final process.
- If the problem is that a process does not exist (for example, there is no current process to screen for pain upon admission and readmission), then identify the related processes (for example, the process for admission and readmission)
- If process is different for different shifts, identify each individual process.

Example: Process for making buttered toast

Step	Define
1	Check to see if there is bread, butter, knife, and toaster.
2	If supplies are missing, go to the store and purchase them.
3	Check to see if the toaster is plugged in.If not, plug in the toaster.
4	Check setting on toaster and adjust to darker or lighter as preferred.
5	Put a slice of bread in toaster.
6	Turn toaster on.
7	Wait for bread to toast.
8	When toast is ready, remove from toaster and put on plate.
9	Use knife to cut pat of butter.
10	Use knife to spread butter on toast.

1. Identify the steps of your defined process

Press for details. At the end of the gap analysis, compile the results in a document that displays each step so that team members have the map of the current process in front of them during the team discussion.

2. Team discussion

Evaluate your current process as you define it:

- What policies and procedures do we have in place for this process?
- What forms do we use?
- How does our physical environment support or hinder this process?
- What staff is involved in this process?
- What part of this process does not work?
- Do we duplicate any work unnecessarily? Where?
- Are there any delays in the process? Why?

Continue asking questions that are important in learning more about this process.

Tool 2D. Plan of Action

Background: The purpose of this tool is to provide a framework for outlining steps needed to design and implement the KPC initiative. The form was adapted from material produced by the Quality Improvement Organization program for the Centers for Medicare & Medicaid Services.

Instructions: The form lists six key tasks. For each, list in the second column the steps that will be taken to address the task, including tools to be used. The form gives examples of steps or activities for each task. In developing the plan, it is not expected that you will provide results but only that you lay out what will need to be done. In the last two columns, determine who will have lead responsibility for completing each task, and estimate an appropriate time frame for completing the activities. Use the plan as a working document that can be revised. As you begin to carry out the plan, you may need to make adjustments and add details to the later tasks.

Use: Use the completed sheet to plan, manage, and carry out the identified tasks. The plan should guide the implementation process, and can be continually amended and updated.

Plan of Action

Improvement Aim: Reduce KPC transmission within the health care setting			
Key Interventions/Tasks	**How will this be done? What specific tools/activities can be used?**	**Which team member(s) will make sure this happens?**	**Target date for completion of task**
Analyze current state of KPC infection control in this organization.			
Identify the bundle of prevention practices to be used in redesigned system.			
Assign roles and responsibilities for implementing the redesigned practices.			
Put the redesigned practices into place.			
Monitor infection rates and practices.			
Sustain the redesigned prevention practices.			

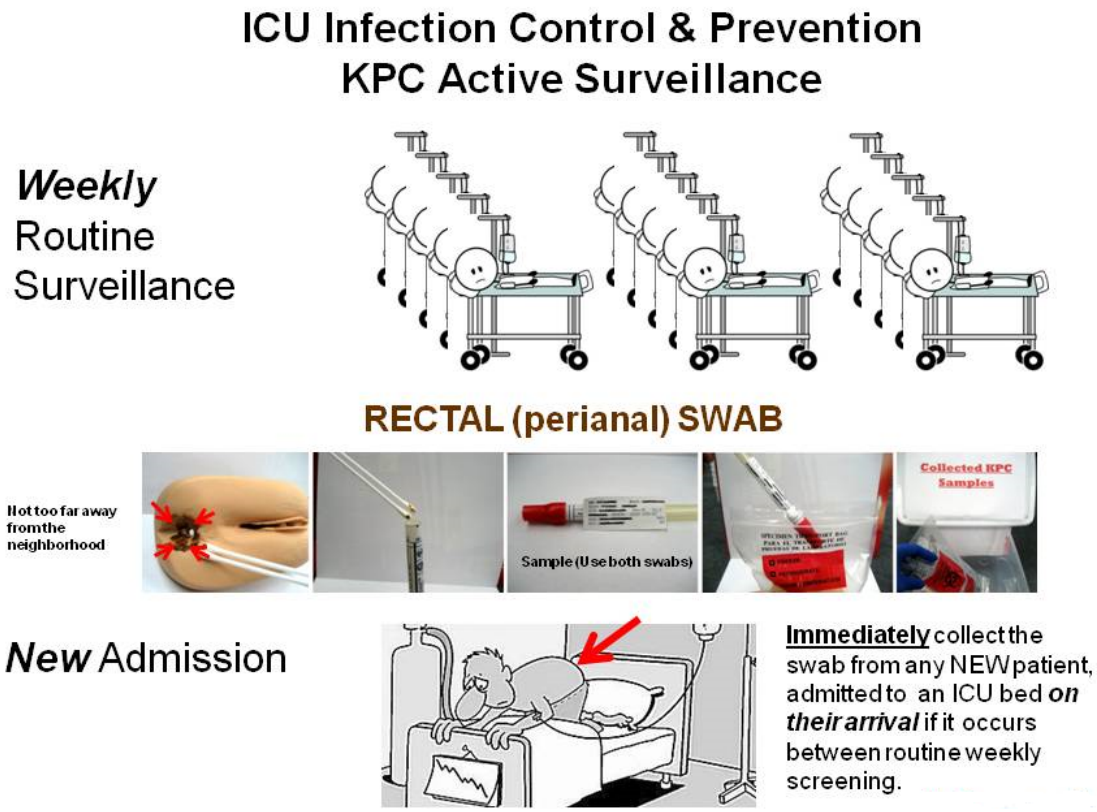
Tool 4A. Sampling Process Graphic

Background: The authors found that the details of the KPC surveillance program were easy for busy nurses to forget, and this graphic was developed as a quick reference card to explain how to do a rectal swab for a sample to test for the presence of KPC.

Instructions: Copies can be laminated and placed in areas where sampling materials are to be located, and where completed samples will be retrieved.

Use: This can also be used to train staff involved in implementing the surveillance program.

Sampling Process Graphic



Developed by Montefiore Medical Center for the Agency for Healthcare Research and Quality.

Tool 5A. Infection Control Observation Tool

Background: Efforts to prevent HAI often benefit from the collection, comparison, and sharing of data on fundamental infection control practices such as hand hygiene.

Instructions: This observation tool can be used to systematically collect data about hand hygiene compliance during multiple hand hygiene opportunities. The tool itself contains instructions about how to best carry out such observations.

Use: Data can be used to identify baseline hand hygiene practices, and then later to see how education and awareness activities may have changed behaviors.

Hand Hygiene Compliance Report

Instructions for Using the Hand Hygiene Observation Tool

1. This tool will be used for quality improvement purposes only. Not to be used for punitive purposes.
2. The purpose of this tool is to collect baseline data about current compliance with the CDC Hand Hygiene Guideline. Hand hygiene means using an alcohol-based antiseptic or soap before and after contact of any kind with a patient or his/her immediate environment. Under certain circumstances, the guideline calls for the use of nonsterile gloves. There is also a circumstance in which an alcohol-based antiseptic is not sufficient and actual hand washing must take place.
3. Data collection needs to be done discreetly, ideally by someone who would normally be in the unit, so that the person's presence is not thought to be unusual. Keep observation tools in a discreet location to minimize influence on current behaviors. It is important to have reliable baseline data.
4. Some suggestions for completing this tool:
   a. Identify your unit and date.
   b. Under staff category, identify the job category of the person you are observing.
   c. A key is listed at the bottom of the tool. For example, a staff physician code is MD, a nurse code is RN, chaplain is CHAP, and so on.
   d. Each category has a column for yes and no. Yes means the individual observed proper hand hygiene as specified on the left side of the tool, or no the individual did not. Make a hash mark for each yes or no. You may have multiple hash marks for each person you are observing in both columns and even within one category of patient contact. Each hash mark represents a discreet observation.
   e. Try to observe the behavior of every job category, not just nurses and doctors. This includes any employee who may have contact with the patient, including x-ray technicians, social workers, respiratory therapists, etc.
   f. Try to get a representative sample that reflects the true number of opportunities for hand hygiene in your unit. This means you could expect more hash marks for nurses than doctors and more for doctors than chaplains. One way to do this is to try to observe a single room for 5 minutes at a time.
   g. This tool can be completed at different times.

Send completed forms to the **Infection Control Unit.**

Hand Hygiene Compliance Report – Please Fax To (Fax number) (Infection Prevention Office) When Completed

INSTRUCTIONS: Observe practice. Include a variety of disciplines. NOTE: Hand Hygiene refers to use of alcohol foam hand rub or washing hands with soap and water for a least 15 seconds. Make a CHECK **(√)** for each hand hygiene opportunity. Please submit a minimum of **30** observations per month per unit.

Name of person completing observation sheet:
_____Date(s):_____

SPECIFY which campus i.e., for example: □ **Main Hospital** □ **Amb Site** **[specify site & address or unit]**: _____

Staff Title																		
HAND HYGIENE	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Before clean and aseptic procedures, including medication prep and prior to prep, gown, and glove for sterile procedures.																		
Before entering patient's room.																		
After contact with blood, body fluids, secretions or excretions, mucous membranes, non-intact skin.																		
After handling objects and devices such as soiled linen, trash, equipment.																		

After removing gloves or other personal protective equipment used for contact with body substances.																		
Before patient contact or equipment contact.																		
After and/or between patient contact and equipment contact.																		
After leaving patient's room.																		
GLOVE USE																		
Whenever potential for hand contact with blood/body substance.																		
Gloves removed immediately after use to avoid contaminating the environment.																		

GOWN AND GLOVES																		
Worn on entering a patient room on contact precautions																		

6. **Staff Titles**: **MD**=Attending/Resident/Fellow; **MS**=Medical Student; **RN =** Registered Nurse**; NA =** Nursing Assistant**; RT**=Respiratory Therapy; **XR**=X ray; **IVT**=IV Team; **DT**=Dietitian; **CHAP**=Chaplain; **SW**=Social Worker: Other=identify.

Developed by Montefiore Medical Center for the Agency for Healthcare Research and Quality.

Soap/Handrub Consumption Survey

Measuring the Consumption of Products in Association with the Implementation of WHO Multimodal Hand Hygiene Improvement Strategy

Purpose

This tool provides a simple template to measure the consumption of products (e.g. soap and alcohol-based handrubs) associated with implementing a hand hygiene improvement strategy.

Measuring the consumption of these products is an indirect method of monitoring hand hygiene performance. This indicator can help to assess the uptake of the intervention as a whole and provides an overall indication of its success. It also provides the opportunity to control stock levels over the short- and medium-term and to help estimate likely increases in requirements, particularly relating to alcohol-based handrub.

Method

In general, the data collection method and the area in which data are collected (selected wards or the entire health-care facility) should not be changed so as to obtain comparable data at different moments in time.

A simple way to collect data is through the central purchasing unit, if this exists, by regularly reviewing the order forms (monthly) for the selected product (e.g. alcohol-based handrub solutions). Alternatively, the information could be retrieved from the pharmacy or the service in charge of the distribution of the products to the wards. It is important to identify a method which fits the purchase/distribution procedure at the facility level and is optimal in terms of time investment and reliability of the information.

Measurement of consumption should be repeated at the end of each month; if this is not feasible, it should be undertaken at time intervals that are better suited to the purchase/distribution cycle in the hospital/ward. The grid for information collection included in this document offers the possibility to record data by month up to a period of 6 months. A new form should be filled in for every 6-month period. If monthly data are not available, cumulative data corresponding to longer periods (e.g. 3 or 6 months) should be entered. This measurement will contribute to the development of a plan for long-term procurement sustainability of products and monitoring of usage.

Calculations of consumption made on the basis of purchased or distributed products may be biased by the amount of product still in stock (i.e. not all products may have been used). Please ensure that the amount in stock is subtracted to calculate the real product consumption. It is important to indicate whether the amount reported corresponds to the purchased or to the used product.

If you use different products (e.g. different alcohol-based handrub formulations), please fill in one form for each product. A separate grid is used to register the use of soap.

Units of products may differ in volume and weight. Please indicate the number of units used (e.g. number of bottles) and the equivalent number of litres or total weight of the product.

Any variation in workforce or number of beds needs to be recorded; this also holds true for a sudden increase in beds (e.g., the opening of a new ward may drastically influence product consumption).

Feedback

- The attached protocol forms are for measurement of consumption over a 6-month period.
- The forms should be filled in monthly, preferably at the end of each month.
- At the end of the 6-month period, product consumption can be tabulated for the whole facility or the respective departments/wards.
- An increasing consumption trend indicates the success of the hand hygiene intervention.
- Static or declining trends post-implementation need to be examined closely. They may be linked to lack of product availability, distribution delays or interruptions, or other reasons.

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Revised August 2009

General Questions

Is there a central purchasing unit for the entire health-care facility? ☐ Yes ☐ No

(A central purchasing unit is one which makes all purchases on behalf of all units/departments of the health-care facility.)

How often are orders for hand hygiene products placed?

☐ Monthly ☐ 3-monthly ☐ 6-monthly ☐ irregular ☐ other

Please describe the process of purchase and distribution of product in your hospital, including the time intervals between purchase and actual distribution, staff responsible for each task in the process, etc.

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Protocol to Measure the Consumption of Products for the Hand Hygiene Intervention (Alcohol-based Handrubs and Soap)

Health-care facility name:

Name of implementation co-ordinator/lead:

6-month measurement period
(Please include specific dates for start month and end month, e.g. 30 June – 31 December)

Does the amount measured relate to ☐ whole facility ☐ a department ☐ a selected ward

Please indicate which ward (if applicable): _____

Please indicate which department (if applicable):

☐ Internal medicine ☐ Surgery ☐ Intensive care unit ☐ Mixed medical/surgical

☐ Emergency unit ☐ Obstetrics ☐ Paediatrics ☐ Long-term/rehabilitation

☐ Outpatient clinic ☐ Other

If the measured amount relates to a department, please describe the wards included:

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Alcohol-based Handrub Formulation

(measured in litres)

Product: ☐ Gel ☐ Liquid ☐ Other (please specify) _____

Information recorded is related to ☐ purchased/distributed product ☐ used product

Name/composition of product/s:

	Amount purchased/used		Number of patients admitted to the facility or department or ward	Number of patient-days related to the facility or department or ward
	Units used (bottles)	Units expressed as litres (l)		
Month 1 Date (month):				
Total facility or selected wards / areas (delete as applicable)				
Month 2 Date (month):				
Total facility or selected wards / areas (delete as applicable)				
Month 3 Date (month):				
Total facility or selected wards / areas (delete as applicable)				
Month 4 Date (month):				
Total facility or selected wards / areas (delete as applicable)				
Month 5 Date (month):				
Total facility or selected wards / areas (delete as applicable)				
Month 6 Date (month):				
Total facility or selected wards / areas (delete as applicable)				

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Soap
(measured in bars/litres)

Product ☐ Non-medicated soap bar ☐ Medicated soap bar ☐ Liquid soap

☐ Other (please specify, e.g. foam) _____

Information recorded is related to ☐ Purchased product ☐ Used product

Name/composition of product/s:

Important note: If different products are used simultaneously (e.g. bar or liquid soap on some units), it is advisable to log the consumption separately for each product in each period on a different form to avoid confusion.

	Amount purchased/used		Number of patients admitted to the facility or department or ward	Number of patient-days related to the facility or department or ward
	Units used (bottles or bars)	Units expressed as litres (l) or kilograms (kg)		
Month 1 Date (month):				
Total facility or selected wards / areas (delete as applicable)				
Month 2 Date (month):				
Total facility or selected wards / areas (delete as applicable)				
Month 3 Date (month):				
Total facility or selected wards / areas (delete as applicable)				
Month 4 Date (month):				
Total facility or selected wards / areas (delete as applicable)				
Month 5 Date (month):				
Total facility or selected wards / areas (delete as applicable)				
Month 6 Date (month):				
Total facility or selected wards / areas (delete as applicable)				

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Main Page

Jun 1, 2013 - May 31, 2014

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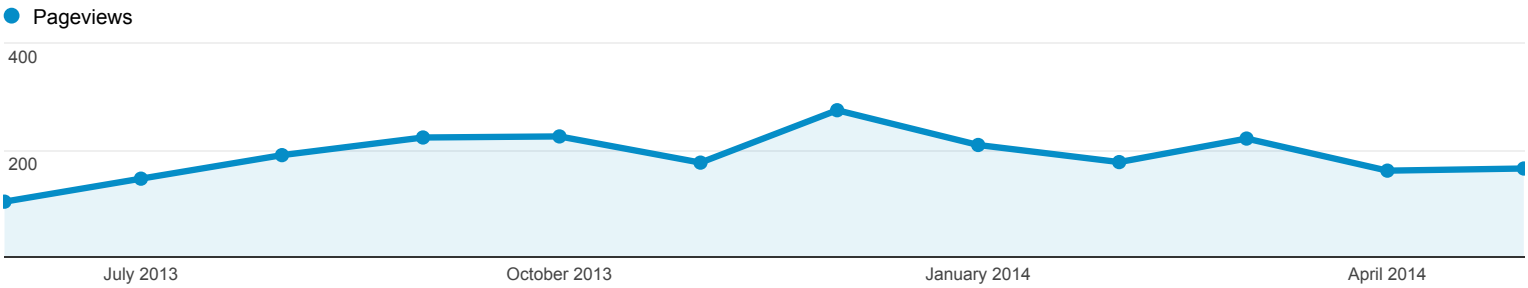
Report Tab



	Month of Year	Pageviews	Unique Pageviews	Avg. Time on Page	% Exit	Bounce Rate
		2,282 % of Total: 0.06% (3,688,708)	1,474 % of Total: 0.06% (2,499,068)	00:00:53 Site Avg: 00:01:48 (-50.65%)	23.23% Site Avg: 36.93% (-37.11%)	53.17% Site Avg: 50.09% (6.15%)
1.	**201306**	104 (4.56%)	70 (4.75%)	00:00:49	19.23%	33.33%
2.	**201307**	147 (6.44%)	99 (6.72%)	00:00:54	24.49%	66.67%
3.	**201308**	191 (8.37%)	121 (8.21%)	00:00:53	26.18%	56.25%
4.	**201309**	224 (9.82%)	122 (8.28%)	00:00:49	18.30%	38.64%
5.	**201310**	226 (9.90%)	149 (10.11%)	00:00:54	20.35%	36.17%
6.	**201311**	177 (7.76%)	110 (7.46%)	00:01:24	15.25%	31.03%
7.	**201312**	275 (12.05%)	195 (13.23%)	00:00:50	44.00%	77.42%
8.	**201401**	210 (9.20%)	135 (9.16%)	00:01:02	17.62%	35.14%
9.	**201402**	178 (7.80%)	107 (7.26%)	00:00:41	16.85%	34.29%
10.	**201403**	222 (9.73%)	138 (9.36%)	00:00:39	21.62%	54.55%
11.	**201404**	162 (7.10%)	108 (7.33%)	00:00:31	20.37%	47.37%
12.	**201405**	166 (7.27%)	120 (8.14%)	00:01:14	24.70%	61.54%

Rows 1 - 12 of 12

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Hospital Reports

Jun 1, 2013 - May 31, 2014

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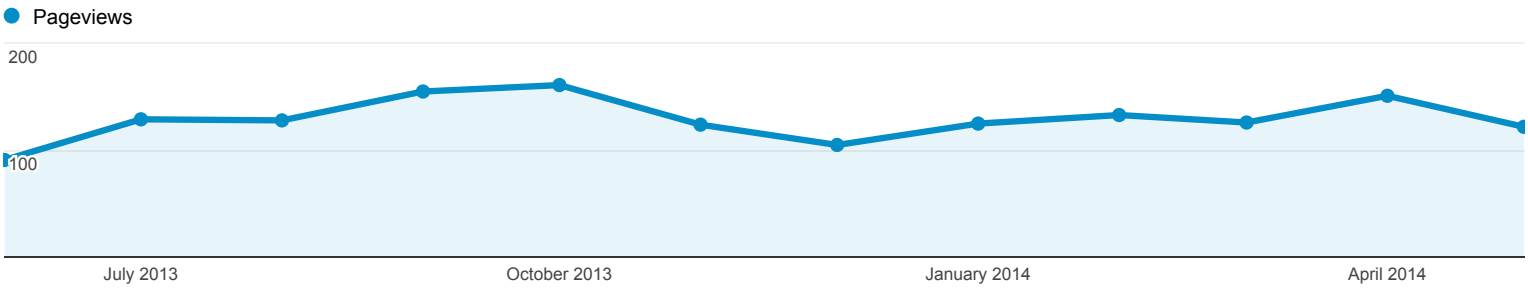

	Month of Year	Pageviews	Unique Pageviews	Avg. Time on Page	% Exit	Bounce Rate
		1,550 % of Total: 0.04% (3,688,708)	1,081 % of Total: 0.04% (2,499,068)	00:01:04 Site Avg: 00:01:48 (-40.53%)	36.84% Site Avg: 36.93% (-0.25%)	64.17% Site Avg: 50.09% (28.10%)
1.	**201306**	91 (5.87%)	65 (6.01%)	00:00:45	35.16%	65.79%
2.	**201307**	129 (8.32%)	97 (8.97%)	00:00:59	42.64%	68.00%
3.	**201308**	128 (8.26%)	93 (8.60%)	00:00:31	46.88%	66.67%
4.	**201309**	155 (10.00%)	101 (9.34%)	00:00:52	29.03%	72.97%
5.	**201310**	161 (10.39%)	106 (9.81%)	00:01:01	32.92%	54.17%
6.	**201311**	124 (8.00%)	87 (8.05%)	00:01:43	37.10%	63.41%
7.	**201312**	105 (6.77%)	80 (7.40%)	00:01:42	42.86%	65.12%
8.	**201401**	125 (8.06%)	86 (7.96%)	00:00:48	32.80%	56.76%
9.	**201402**	133 (8.58%)	87 (8.05%)	00:01:28	33.83%	66.67%
10.	**201403**	126 (8.13%)	89 (8.23%)	00:00:54	38.89%	58.33%
11.	**201404**	151 (9.74%)	104 (9.62%)	00:01:08	40.40%	71.15%
12.	**201405**	122 (7.87%)	86 (7.96%)	00:01:02	31.97%	59.46%

Rows 1 - 12 of 12

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