Characteristics of Inpatient Units Associated With Sustained Hand Hygiene Compliance

Jonathan D. Wolfe, MD, Henry J. Domenico, MS,† Gerald B. Hickson, MD,‡§ Deede Wang, MS MBA,§ Marilyn Dubree, MSN, RN,|| Nancye Feistritzer, DNP, RN,|| Nancy Wells, DNSc, RN,¶ and Thomas R. Talbot, MD, MPH*#*

Objectives: Following institution of a hand hygiene (HH) program at an academic medical center, HH compliance increased from 58% to 92% for 3 years. Some inpatient units modeled early, sustained increases, and others exhibited protracted improvement rates. We examined the association between patterns of HH compliance improvement and unit characteristics.

Methods: Adult inpatient units (N = 35) were categorized into the following three tiers based on their pattern of HH compliance: early adopters, nonsustained and late adopters, and laggards. Unit-based culture measures were collected, including nursing practice environment scores (National Database of Nursing Quality Indicators [NDNQI]), patient rated quality and teamwork (Hospital Consumer Assessment of Healthcare Provider and Systems), patient complaint rates, case mix index, staff turnover rates, and patient volume. Associations between variables and the binary outcome of laggard (n = 18) versus nonlaggard (n = 17) were tested using a Mann-Whitney *U* test. Multivariate analysis was performed using an ordinal regression model.

Results: In direct comparison, laggard units had clinically relevant differences in NDNQI scores, Hospital Consumer Assessment of Healthcare Provider and Systems scores, case mix index, patient complaints, patient volume, and staff turnover. The results were not statistically significant. In the multivariate model, the predictor variables explained a significant proportion of the variability associated with laggard status, (R^2 = 0.35, P = 0.0481) and identified NDNQI scores and patient complaints as statistically significant.

Conclusions: Uptake of an HH program was associated with factors related to a unit's safety culture. In particular, NDNQI scores and patient complaint rates might be used to assist in identifying units that may require additional attention during implementation of an HH quality improvement program.

Key Words: quality improvement, hand hygiene, safety culture, quality, outcomes

(*J Patient Saf* 2021;17: e1272–e1277)

There has been an increased focus on the use of quality improvement programs (QIPs) to improve patient safety in healthcare facilities across the country.[1,2] However, a growing body of evidence suggests that many QIPs are based on limited data and have a varying effect on patient safety processes and outcomes.[3–6] The inherent "culture" of an institution conducting a given QIP has been suggested as an important factor in predicting the program's ultimate success or failure.[7–12] Accurate measurement of patient safety culture is restricted by the ability to easily define objective components of culture. In addition, culture varies from unit to unit within a given institution, creating the potential for heterogeneous uptake of QIPs. Given the difficulty of identifying variables that correlate with successful implementation of QIPs, it is essential to closely study determinants of success or failure of these important programs.[4]

The Vanderbilt University Hospital (VUH) Hand Hygiene Program has been successful at increasing hand hygiene (HH) compliance as well as promoting a culture of shared accountability.[13] Although most inpatient units and clinics responded positively after this program's launch in 2009 with overall compliance rising from 58% to 92%, the rate of improvement varied by unit, with some units achieving early and sustained compliance whereas others were slower to improve. This study aimed to examine the association between unit uptake of the HH QIP and patient- and culture-specific measures on a unit level that may serve as proxies for teamwork, accountability, and the presence of a robust safety culture. The study also aimed to understand why units differed in the uptake of this QIP and to suggest potential predictors for successful implementation of other QIPs.

METHODS

This study was conducted at VUH, an 834-bed academic hospital with a catchment area throughout middle Tennessee. A comprehensive HH initiative was implemented at VUH in two major phases, starting in July 2009, as described previously.[13] Key facets of the initiative included leadership buy-in and goal setting, financial incentives linked to performance, and the use of a system-wide, shared accountability model. Throughout the first 3 years of the program, HH compliance improved consistently in association with the development and launch of an expanded direct observation program combined with evolving goals and incentives promoting individual and group accountability. Improvements were supported using the Vanderbilt Professional Accountability Pyramid to share individual and unit data with tiered interventions for units noted to have a pattern of consistent below-goal compliance.[14] High HH compliance was sustained and was inversely correlated with device-associated infection rates.[13]

To examine factors associated with unit uptake and use of the HH QIP, we focused on the inpatient and procedural units within the adult hospital. The study period comprised the first three fiscal years (FYs) of the program (FY10 [July 1, 2009–June 30, 2010], FY11, and FY12). Units were excluded from the analysis if there were fewer than 50 total HH observations performed on the unit during any FY or if there were greater than 6 months of missing data during 3-year period.

From the Departments of *Medicine, †Biostatistics, and ‡Pediatrics, Vanderbilt University School of Medicine; §Quality, Safety and Risk Prevention, ||Medical Center Administration, and ¶Nursing Research, Vanderbilt University Medical Center; #Health Policy, Vanderbilt University School of Medicine, Nashville, Tennessee.

Correspondence: Thomas R. Talbot, MD, MPH, A-2200 Medical Center North, 1161 21st Ave S, Vanderbilt University Medical Center, Nashville, TN 37232 (e-mail: tom.talbot@vanderbilt.edu).

The authors disclose no conflict of interest.

This study was supported by institutional funds.

Presented as a poster presentation at the ID Week Scientific Meeting, Philadelphia, PA, October 10, 2014 (abstract # 1501).

J.D.W. is currently affiliated with Department of Medicine, Missouri Baptist Hospital, St. Louis, MO, and NF is affiliated with Emory University Hospital, Atlanta, GA.

TABLE 1. Categorization of Units Based on Adoption of Hand Hygiene QIP

Unit Category:	Defined as Hand Hygiene Compliance by Year Noted:
Early-sustained adopters	≥80% by end of year 1; ≥80% for years 2 and 3
Nonsustained adopters	≥80% by end of year 1; did not maintain ≥80% for years 2 and 3
Late adopters	≥90% compliance by end of year 3 and were not early adopter
Laggards	Did not achieve 90% compliance by the end of year three and were not early adopters

Compliance based on the cumulative compliance for the entire fiscal year.

The included units were classified according to their attainment of FY HH program goals and the rapidity and stability of these improvements (Table 1). Specifically, a categorization framework was developed using Everett Rogers' diffusion of innovation categories of adopters.[15] "Early-sustained adopters" were modeled from Rogers' categories of innovators and early adopters, groups who are among the first to try an innovation and who readily embrace change opportunities. These units achieved 80% HH compliance (the institutional goal for the first 2 years of the program) by the end of year 1 and had more than 80% compliance for years 2 and 3. "Nonsustained or late adopters" represented groups that either readily embraced the innovation yet exhibited lack of sustainment during the study period or did not adopt the innovation initially but met the institutional goal by year 3 of the program. This group contained units that either achieved 80% compliance by the end of year 1 but did not maintain at least 80% compliance for either year 2 or year 3, or alternatively did not adopt the innovation initially but achieved 90% compliance (the institutional goal for year 3 of that program) by the end of year 3. Finally, "laggards," similar to Rogers' adopter group of the same name, were skeptical of change and often resistant to adoption of innovations. This group never achieved 90% compliance by the end of year 3. Graphic examples of these groups are illustrated in Figures 1A to D.

Specific variables were chosen that were hypothesized to be predictive of a unit's teamwork and safety culture or to influence unit uptake of a QIP (Table 2). The units were classified as intensive care units and nonintensive care units as well as procedural units and nonprocedural units. The number of unsolicited patient complaints per 1000 admissions was included for each unit.[16] In addition, the clinical complexity of the patients on each unit, as measured by the average case mix index (CMI), was included and thought to influence the behavior of unit personnel, with higher patient complexity hypothesized to be associated with lower HH compliance. Next, personnel turnover, or "churn," was calculated for each unit according to the formula (number of terminations + number of transfers)/average headcount per year. In addition, the total patient census per unit per year was included.

Additional variables were taken from validated national quality survey data collected as part of external quality programs, namely Press Ganey's National Database of Nursing Quality Indicators (NDNQI)[17] and the Hospital Consumer Assessment of Healthcare Provider and Systems (HCAHPS).[18] The NDNQI Practice Environment Scale (PES) score encompasses the following key areas as rated by nursing personnel: nurse participation in hospital affairs; nursing foundations for quality of care; nurse manager

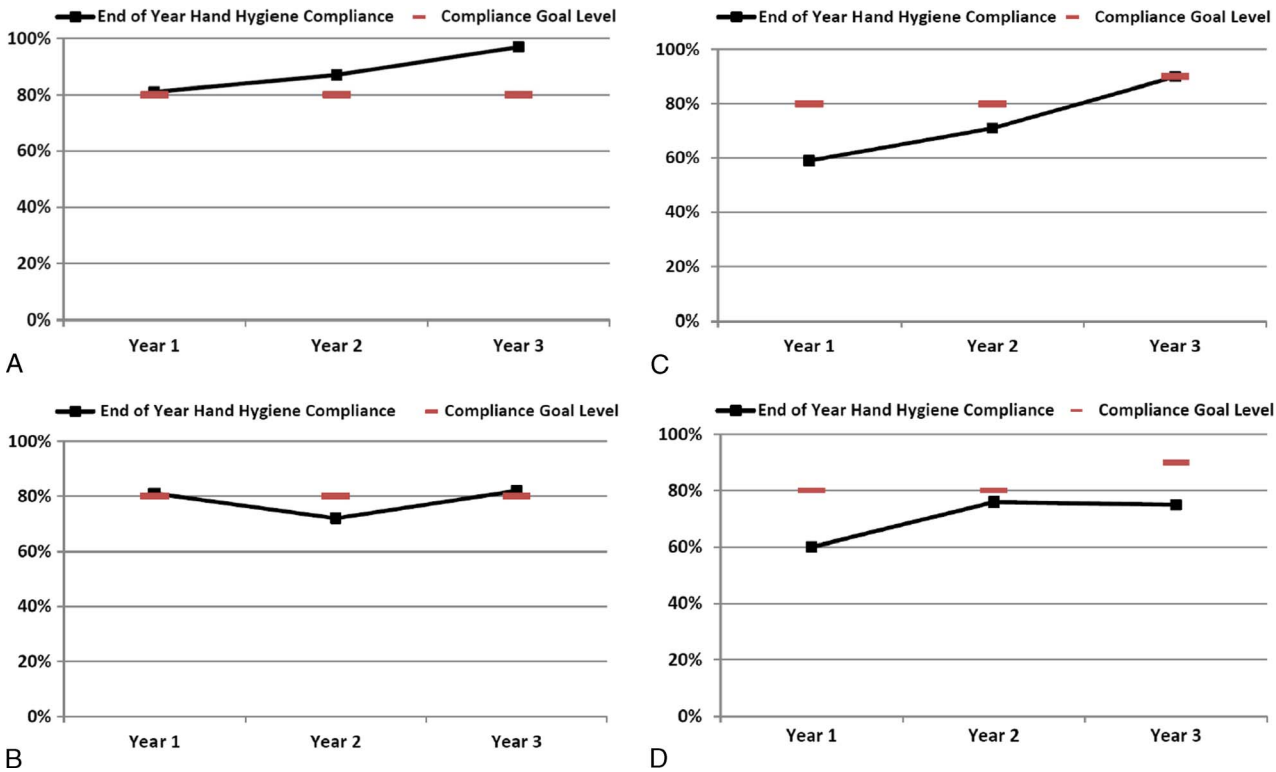

FIGURE 1. Graphical examples of the four unit categories based on uptake and sustained improvement in HH compliance. A, Early-sustained adopter unit. B, Nonsustained adopter unit. C, Late adopter unit. D, Laggard unit.

TABLE 2. Variables Chosen to Assess Reasons for Different Patterns of Uptake and Sustained Improvement of the VUH Hand Hygiene QIP

Variable	Source	Definition	Data Description	Collection Frequency
Medical staff turnover "churn" rate	Institutional data: (number of terminations + number of transfers)/average yearly headcount	Percentage of the people in a unit that leave during a fiscal year; intended to give an idea of unit turnover	Percentage of personnel	Annual
Patient volume	Institutional data	The total patient volume per unit per year	Patient volume per year	Annual
Patient complaint rate	Institutional data: number of complaints per unit/1000 patients per unit	The number of patient complaints related to patient care per 1000 hospitalized patients	Number of complaints per 1000 hospitalized patients	Annual
Nursing PES	NDNQI	Provides a series of standardized nursing specific metrics evaluating nursing participation, quality, leadership, staffing and resources, and nurse-physician relations. Used as a comparison of nursing quality across different institutions	The mean PES score is the mean of the 5 subsections of the NDNQI assessment intended to be an overall composite score with higher scores being indicative of better performance	Biennially
Quality score	HCAHPS	Survey administered to patients in order to assess multiple domains of hospital quality. The Quality Score is representative of the overall quality of care received	Percentage of respondents that responded "excellent" to the questions in the survey regarding quality of care	Annual aggregate
Teamwork score	HCAHPS	Survey administered to patients in order to assess multiple domains of hospital quality. The Teamwork Score is representative of the observed teamwork between doctors, nurses, and staff	Percentage of respondents that responded "excellent" to the questions in the survey regarding teamwork among faculty and staff	Annual aggregate
Patient complexity	CMI	National index meant to reflect the diversity, clinical complexity, and resource needs for a particular group of patients	A higher score represents increasing patient complexity	Annual aggregate

ability, leadership, and support of nurses; staffing and resource adequacy; and collegial nurse-physician relations. The HCAHPS survey contains 25 questions for patients related to their hospital stay. Two different categories felt to be best representative of the quality of care and teamwork within a unit (i.e., "overall quality of care" and "teamwork between doctors, nurses, and staff") were included for the analysis. Participants in HCAHPS surveys responded "never," "sometimes," "usually," or "always" to questions in nine key topics including the following: communication with physicians, communication with nurses, responsiveness of hospital staff, pain management, communication about medicines, discharge information, cleanliness of the hospital environment, quietness of the hospital environment, and transitions of care. The variable used in the analysis was the percentage of participants that responded to all of the questions in the domain with the best rating (i.e., "always" for questions with positive implications or "never" for questions with negative implications).

A Mann-Whitney *U* test was used to test for differences in the baseline unit culture variables from FY10 between units classified as laggards and those classified in other categories ("nonlaggard"). To examine effects of these variables on adoption status while controlling for differences in CMI, a multivariate, three-level ordinal regression model was used. The outcomes used in this model was early-sustained adopter (best performance), nonsustained or late adopter (mid-tier performance), or laggard (worst performance). This model was selected over a binary logistic model to increase power given the low unit count. Variables were selected for inclusion based on completeness and plausibility of association with adoption status. Baseline measurements were used to predict the ordinal outcome, and mean-value imputation was used for missing data values before fitting the model. Patient census was removed from the regression model to increase power given the sample size. The six variables included in the regression model were nursing satisfaction (PES score), CMI, patient complaint rate, patient ratings of quality and teamwork, and staff turnover rate. The *P* values for the ordinal regression model were calculated using a likelihood ratio χ^2 test.

RESULTS

From the total available 51 units, 16 were excluded, either due to missing data (n = 9) or opening following the start of the study period (n = 7). The remaining 35 units were used in the analysis. When directly comparing variables between laggards (n = 18) and nonlaggards (n = 17), the nonlaggards performed better in several fields. Units classified as nonlaggards had higher median PES scores, higher HCAHPS quality and teamwork scores, and lower patient complaint rates. Nonlaggards also had a higher median CMI, lower patient volume, and decreased staff churn (Fig. 2, Table 3). However, none of the associations reached statistical significance. Performance between procedural and nonprocedural units was not demonstrably different. Intensive care units (ICUs) performed better than non-ICUs because none of the ICUs were laggards.

In the ordinal regression model, lower nursing satisfaction scores (odds ratio [OR] = 0.009, $P = 0.018$) and lower rates of patient

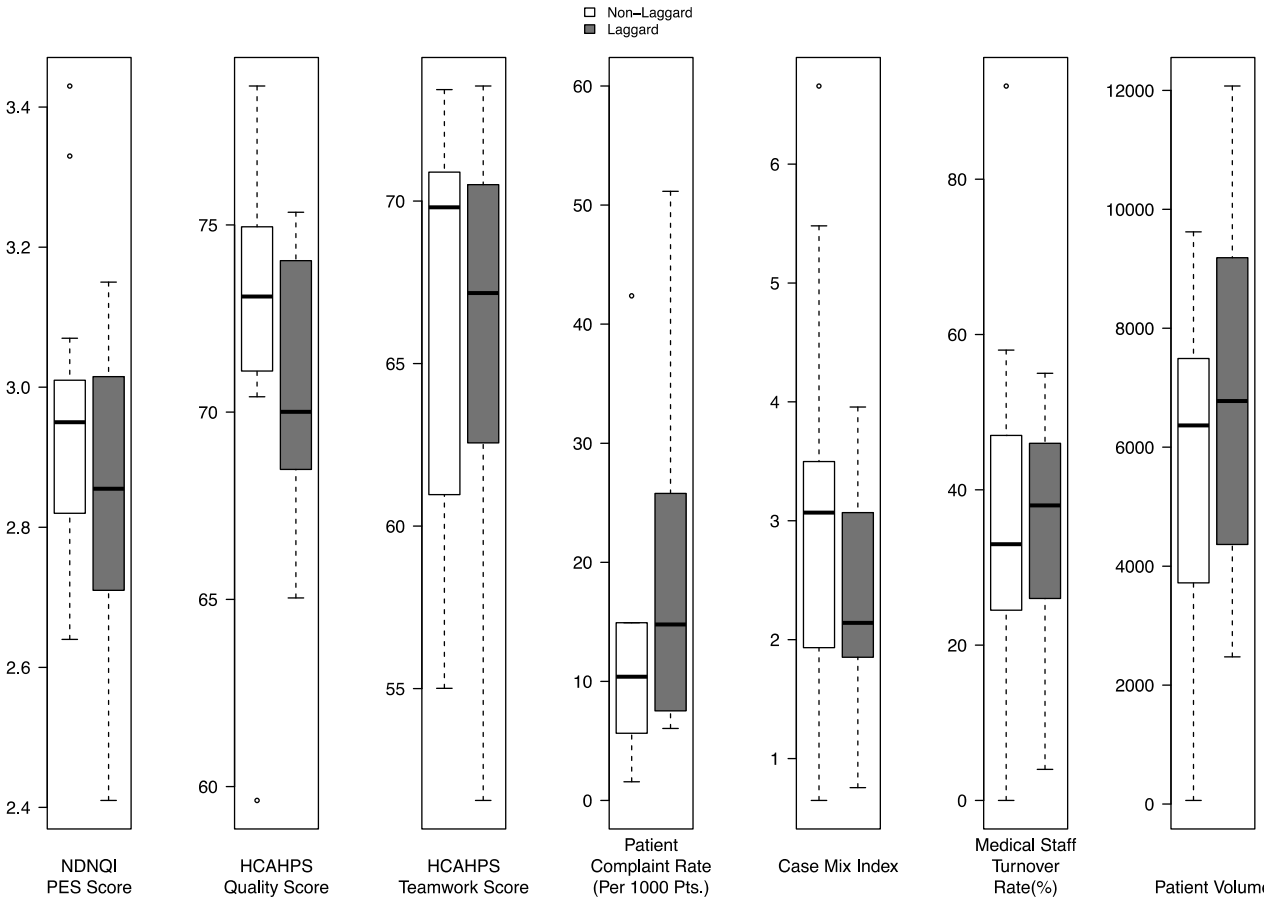

FIGURE 2. Unit-specific teamwork and safety culture metrics and relationship to unit categorization based on hand hygiene program uptake and sustainment.

complaints (OR = 0.982, $P = 0.019$) were statistically significantly associated with an increased laggard status. None of the other variables yielded statistically significant results. The model showed that the six predictor variables jointly accounted for a significant proportion of the variability between early-sustained, nonsustained or late, and laggard unit categories (model $R^2 = 0.35$, $P = 0.0481$).

DISCUSSION

Uptake and compliance with an HH quality improvement initiative was associated with multiple variables related to unit teamwork and safety culture. When directly comparing the median values of variables between nonlaggards and laggards, nonlaggards had higher nursing satisfaction scores, increased HCAHPS quality and teamwork scores, decreased personnel churn, decreased patient complaints, decreased patient census, and increased patient complexity. Many of these differences are clinically relevant. The trends were more notable for patient census, CMI, patient complaints, and HCAHPS quality scores and less so for the other variables. The NDNQI and HCAHPS variables give insight into multiple facets of unit teamwork and safety culture, and it was expected that units with higher performance according to these variables would be better equipped to effectively implement an HH QIP. Similarly, decreased patient complaints, decreased personnel churn, and decreased patient census were similarly hypothesized to be associated with nonlaggard status, and the trend was in the

TABLE 3. Direct Comparison of Laggard Versus Nonlaggard Units Using a Mann-Whitney *U* Test

Variable	Nonlaggard Units Median (1st Quartile/3rd Quartile)	Laggard Units Median (1st Quartile/3rd Quartile)	*P*
Census	6367.5 (3817.0–7288.8)	6777.0 (4365.0–9188.0)	0.20
PES (mean score)	2.95 (2.82–3.01)	2.86 (2.71–3.01)	0.49
Churn (proportion of personnel)	0.33 (0.25–0.46)	0.38 (0.26–0.46)	0.94
Quality (% responses excellent)	73.1 (71.1–75.0)	70.0 (68.5–74.1)	0.33
Teamwork (% responses excellent)	69.8 (61.0–70.9)	67.2 (62.7–69.8)	0.93
Patient complaints (No. complaints/1000 hospitalized patients)	10.39 (6.59–14.81)	14.78 (8.50–23.66)	0.38
CMI (a higher score represents increasing patient complexity)	3.07 (1.93–3.50)	2.14 (1.87–3.07)	0.16

expected direction consistent with previous literature.[15] Interestingly, increased patient complexity based on the CMI score was more associated with nonlaggard status. It may be that caring for more complex patients results in heightened awareness of HH or a more cohesive culture among staff members, which translated into improved uptake of the QIP.

These positive and negative associations suggest that certain metrics may be predictive of a unit's overall adherence with an HH QIP. Despite the interesting trends, none of the associations reached statistical significance in the initial comparison model. We suspect that this was in part due to low sample size and power to detect differences with such a sample, and additional studies will be needed to corroborate the utility of these variables.

To capture a concept as multifaceted as culture and how it relates to QIP uptake, it is reasonable to suggest that using multiple variables may be more successful than relying on single variables. This approach could account for variability seen in units that were particularly strong in one area but weak in others. The results of our ordinal regression analysis suggest that increased nursing satisfaction based on the NDNQI PES score and decreased patient complaint rates are jointly associated with a decrease in laggard status, suggesting a stronger role for these factors in QIP uptake and sustainment. The NDNQI PES score was associated with the lowest OR of units having laggard status. This strong association is expected in the context of previous literature highlighting the relationship between nursing satisfaction, healthy working environments, and quality of patient care.[19] Lower patient complaint rates were associated with greater likelihood of laggard status, which is contradictory to the results of the single-variable analysis previously discussed and less expected based on previous literature.[20,21] It may be that units with a stronger quality-focused culture may more actively encourage patients to report and concerns as opposed to a less focused unit that does not promote such reporting as a means of continual quality improvement.

Overall, the ordinal model was statistically significant and accounted for 35% of the variability seen in HH QIP uptake. Although this level of accountability is fairly good for the statistical method used and the selected variables may give insight into which units in a hospital may be more or less successful at implementing an HH QIP, they may not be accurate enough to have predicative value. Although additional studies will be necessary, the methodology and the variables used in the analysis may have utility in assessing other types of QIPs.

This study does have potential limitations. The quality improvement initiative could have overestimated the true HH compliance rate due to the Hawthorne effect (due to the recognition of being observed), although this effect would be expected to apply uniformly to all areas because of the use of multiple different observers for the areas during the study. As personnel from multiple departments were involved in the collection and accuracy of the safety culture variables chosen, there could be errors in the collected data, which could influence the results of the study. There were missing variables for some of the units, which could alter the final results of the analysis. Specifically, from the selected variables, there were missing data points from medical staff "churn," patient volume change, NDNQI PES scores, HCAHPS quality and teamwork scores, patient complaints, and CMI. In particular, HCAHPS quality and teamwork scores were not available for any procedural units as they are tied to the inpatient units that patients stayed on and not to all nonward locations where they may have received care. As such, they were only available for approximately half the units included in the analysis. However, most units had near-complete data sets and mean values were imputed for the missing data for the ordinal regression analysis. Finally, different determinations of patient volume were used for the procedural and nonprocedural areas (e.g., number of scheduled procedures versus patient admissions), which may not be comparable.

CONCLUSIONS

Given the relative ubiquity of QIPs in the past decade requiring extensive financial and administrative resources, understanding factors associated with the successful implementation of a QIP is essential. Such knowledge may help better prepare hospitals when initiating these programs by identifying units at the onset that may implement quickly or alternatively may require more resources or attention. In this study, uptake and compliance with an HH QIP was associated with several variables that may serve as a proxy for unit teamwork and safety culture. In particular, NDNQI PES scores and patient complaint rates might be used to gain insight into specifically which units in a hospital may be more or less successful at implementing an HH QIP. A similar methodology may demonstrate utility in analyzing other types of QIPs as well.

ACKNOWLEDGMENTS

The authors thank Sabrina Downs, Nik Zakrzewski, Jan Karrass, Jesse Ehrenfeld, Carl Jordan, Claudette Fergus, Leslie Wilkes, Leah Cannon, Daniel Kirby, and Sarah Hagovsky for their assistance with this study.

REFERENCES

1. Singer SJ, Falwell A, Gaba DM, et al. Identifying organizational cultures that promote patient safety. *Health Care Manage Rev*. 2009;34:300–311.
2. Berwick DM, Calkins DR, McCannon CJ, et al. The 100,000 lives campaign: setting a goal and a deadline for improving health care quality. *JAMA*. 2006;295:324–327.
3. Mittman BS. Creating the evidence base for quality improvement collaboratives. *Ann Intern Med*. 2004;140:897–901.
4. Schouten LM, Hulscher ME, van Everdingen JJ, et al. Evidence for the impact of quality improvement collaboratives: systematic review. *BMJ*. 2008;336:1491–1494.
5. McDonald KM, Schultz EM, Chang C. Evaluating the state of quality-improvement science through evidence synthesis: insights from the closing the quality gap series. *Perm J*. 2013;17:52–61.
6. Osborne NH, Nicholas LH, Ryan AM, et al. Association of hospital participation in a quality reporting program with surgical outcomes and expenditures for Medicare beneficiaries. *JAMA*. 2015;313:496–504.
7. Shortell SM, Marsteller JA, Lin M, et al. The role of perceived team effectiveness in improving chronic illness care. *Med Care*. 2004;42:1040–1048.
8. Solberg LI. If you've seen one quality improvement collaborative. *Ann Fam Med*. 2005;3:198–199.
9. Morello RT, Lowthian JA, Barker AL, et al. Strategies for improving patient safety culture in hospitals: a systematic review. *BMJ Qual Saf*. 2013;22:11–18.
10. Braithwaite J, Westbrook MT, Iedema R, et al. A tale of two hospitals: assessing cultural landscapes and compositions. *Soc Sci Med*. 2005;60:1149–1162.
11. Valentine MA, Nembhard IM, Edmondson AC. Measuring teamwork in health care settings: a review of survey instruments. *Med Care*. 2015;53:e16–e30.
12. Fan CJ, Pawlik TM, Daniels T, et al. Association of safety culture with surgical site infection outcomes. *J Am Coll Surg*. 2016;222:122–128.
13. Talbot TR, Johnson JG, Fergus C, et al. Sustained improvement in hand hygiene adherence: utilizing shared accountability and financial incentives. *Infect Control Hosp Epidemiol*. 2013;34:1129–1136.

14. Hickson GB, Pichert JW, Webb LE, et al. A complementary approach to promoting professionalism: identifying, measuring, and addressing unprofessional behaviors. *Acad Med*. 2007;82:1040–1048.
15. Behavioral Change Models: Diffusion of Innovation Theory. Available at: http://sphweb.bumc.bu.edu/otlt/MPH-Modules/SB/SB721-Models/SB721-Models4.html. Accessed February 23, 2016.
16. Pichert JW, Moore IN, Karrass J, et al. An intervention model that promotes accountability: peer messengers and patient/family complaints. *Jt Comm J Qual Patient Saf*. 2013;39:435–446.
17. Turn Nursing Quality Insights into Improved Patient Experiences. Available at: http://www.pressganey.com/ourSolutions/performance-and-advanced-analytics/clinical-business-performance/nursing-quality-ndnqi. Accessed September 9, 2015.
18. Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS). Accessed at: http://www.hcahpsonline.org/home.aspx. Accessed September 9, 2015.
19. Vaughan L, Slinger T. Building a healthy work environment: a nursing resource team perspective. *Nurs Leadersh (Tor Ont)*. 2013;2013:70–77.
20. Bismark MM, Brennan TA, Paterson RJ, et al. Relationship between complaints and quality of care in New Zealand: a descriptive analysis of complainants and non-complainants following adverse events. *Qual Saf Health Care*. 2006;15:17–22.
21. Reader TW, Gillespie A, Roberts J. Patient complaints in healthcare systems: a systematic review and coding taxonomy. *BMJ Qual Saf*. 2014;23:678–689.