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Original Article

Nudging to select single-lumen over multiple-lumen peripherally inserted central catheters (PICCs) in a large safety net system

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Abstract

Background: Peripherally inserted central catheters (PICCs) are increasingly used for vascular access in inpatient settings. Compared to multilumen PICCs, single-lumen PICCs carry a lower rate of complications, including central-line–associated bloodstream infection and thrombosis. Despite this, multilumen PICCs are still overused.

Methods: This quality improvement initiative was implemented across 11 hospitals at New York City Health + Hospitals safety net system. The electronic health record (EHR) interventional radiology or vascular access team consultation orders were modified to allow for lumen choice, with default selection to a single-lumen PICC.

Results: Average single-lumen PICC utilization increased by 25.5%, from 44.4% to 69.9% ($P < .001$). CLABSI rates had a nonsignificant reduction by 26.7% from 2.44 to 1.79 infections per month ($P = .255$). Among provider types in the postintervention period, single-lumen PICC utilization ranged from 67.7% for advanced practice providers to 82.4%–94.6% for physicians. Among provider specialties, utilization ranged from 31.8% for neurology to 97.7% for orthopedics. Additionally, there was large variation in pre- and postintervention differences in utilization by hospital.

Conclusions: We successfully increased single-lumen PICC utilization across all 11 safety net hospitals. This expands on previous work on improving single-lumen PICC use and use of default nudges in large, resource-limited settings. Further study is needed to examine variation among provider types, specialties, and hospitals.

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Multilumen peripherally inserted central catheters (PICCs) remain a common practice outside the critical care setting.[1,2] This practice may be due to lack of awareness of guidelines, resultant harms, or staff or patient convenience.[2,3] Additionally, multiple lumens may be requested in anticipation of future needs.[4] Although there are benefits relative to temporary central venous access catheters, a higher risk of complications remains relative to single-lumen PICCs, including central-line bloodstream infections (CLABSIs), thromboses, and occlusions.[5,6] These complications lead to prolonged length of stay and added healthcare costs.[7]

Previous interventions reduced unnecessary multilumen PICCs in academic centers.[4,8,9] Although successful, they were implemented within smaller settings such as units and single centers. Additionally, these interventions were labor intensive and relied on significant resource utilization. The electronic health record (EHR) can be an effective tool in implementing wide-scale change with limited resources. A "nudge" is an intervention that changes how choices are presented to the provider to account for predictable ordering patterns and to improve decision making.[10] The use of nudges, particularly within the EHR, allows for easier approval, implementation, and data collection across large, complex

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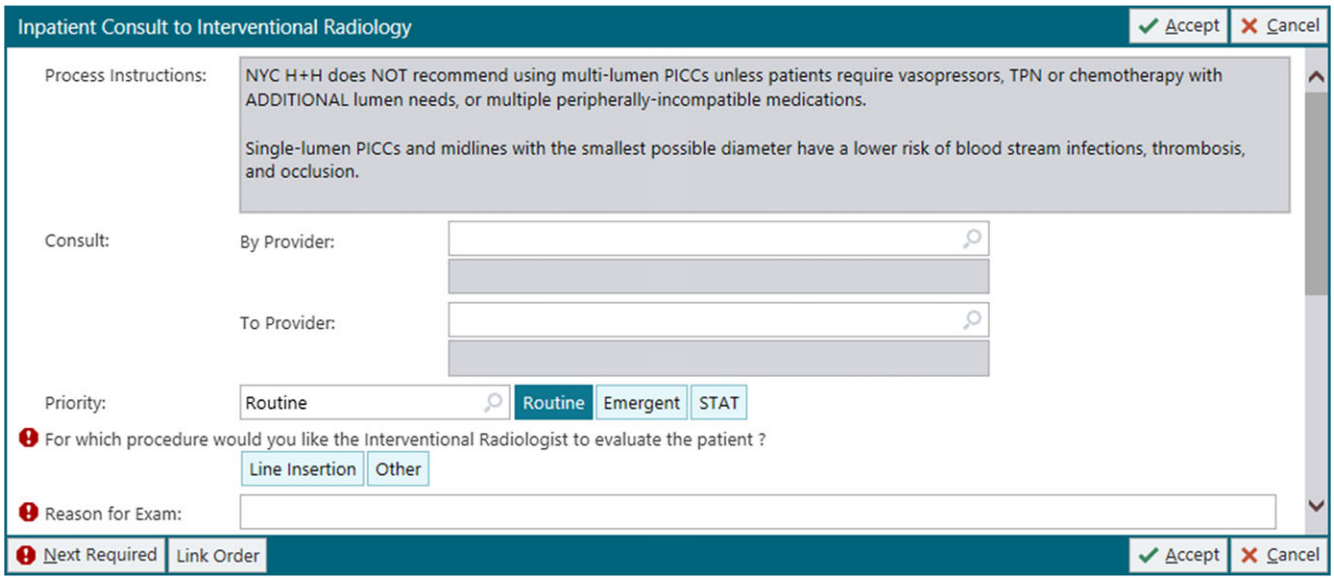

Fig. 1. Default nudge for single-lumen PICC insertion.

healthcare settings. Default nudges are often the most impactful and user friendly in that they do not add additional click burden.[10] Here we describe a nudge-focused EHR intervention aimed to improve single-lumen PICC use across a large safety net health system.

Methods

Study design and setting

This quality improvement initiative was developed at New York City Health + Hospitals (NYC H + H), the largest public health system in the United States, comprising 11 teaching hospitals and >70 ambulatory centers (Supplementary Table 1 online). Our project was deemed a quality improvement project by the NYC H + H central research office; thus, an institutional review board submission was not required.

Intervention

The intervention was led and designed by the System High Value Care Council at NYC H+H with interdisciplinary input from experts in infectious disease, internal medicine, critical care, infection control, quality and safety, interventional radiology, and nursing across the system.

Although the workflow regarding placement of a PICC line is different at each hospital, all hospitals use a consultation order as the first step. We therefore modified the EHR consultation order for interventional radiology (Fig. 1). In 2 hospitals with vascular access teams, the consultation orders for these vascular access teams were modified in the same way. If the PICC line is selected, the options for "single lumen" or "other" appear, with a default selection to single-lumen PICC. If the provider selected the "other" option, a cascading menu would appear with higher lumen counts (double or triple). Educational text was placed within the order stating the institutional guidelines for multiple lumens including vasopressors, total parenteral nutrition, chemotherapy with multiple-lumen needs, or multiple peripherally incompatible medications. The initiative was introduced in a one-time e-mail to clinical leadership across the system. No additional system-wide interventions targeted appropriate line placement.

Measures and Statistical Analysis

Our outcome measure was the proportion of single-lumen PICCs inserted out of the total number of PICCs. The preintervention period (January 2, 2020, to May 2, 2021, 16 months) was compared with the postintervention period (May 3, 2021, to July 31, 2022, 15 months). We measured the intervention's system-wide impact using 2 approaches. First, we performed a quasi-experimental interrupted time-series binomial regression. Individual data points consisted of weekly proportions of single-lumen PICC usage. Two separate regression lines were generated using the weekly proportions, one for the preintervention period and another for the postintervention period. The difference in the line intercepts at the intervention date allowed us to measure the immediate change in single-lumen PICC utilization (ie, level difference). The differences in the temporal slopes of the lines allowed us to compare longer-term trend changes (ie, slope difference). These differences were compared via multivariate *t* tests. Additionally, a counterfactual preintervention regression line was extended into the postintervention period to show predicted single-lumen PICC utilization in the absence of an intervention. The second approach compared average preintervention versus postintervention average single-lumen PICC utilization, without adjusting for temporal trends, using a binomial regression with a binary variable for the postintervention period. To ensure that the patient population was similar before and after the intervention, median age and length of stay were compared for patients with documented PICC placements. These were all statistically compared using an unpaired *t* test assuming unequal variance (ie, the Welch test).

Next, we compared the preintervention versus the postintervention monthly CLABSI counts, correlating PICC lines to CLABSIs. Statistical significance was measured using a Poisson regression. National Healthcare Safety Network definitions (2020–2022) for CLABSIs were used. We stratified preintervention versus postintervention PICC lumen counts by hospital. We also stratified postintervention PICC placement orders by lumen count

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Table 1. Preintervention Versus Postintervention Percentage of Single-Lumen PICC Use

	Regression With Time Trend				Regression Without Time Trend		
Lumen Type % All PICCs	Preintervention Intercept, %	PostinterventionIntercept, %	Level Difference[a]	Slope Difference	Preintervention Average, %	Postintervention Average, %	Difference, %
Single	46.7	68.9	22.2 ***	−0.001	44.4	69.9	25.5 ***
Double	51.1	28.4	−22.7 ***	−0.002	50.8	27.1	−23.7 ***
Triple	2.6	2.7	0.1	0.02	4.8	3.0	−1.8 ***

Note. PICC, peripherally inserted central catheter.
[a]Difference = postintervention minus preintervention.
* $P < .05$; ** $P < .01$; *** $P < .001$.

and provider type and specialty to better understand differences in utilization.

Data were abstracted through SQL queries on the Epic Clarity database and were analyzed statistically using R version 4.0.3 software (R Foundation for Statistical Computing, Vienna, Austria, 2020). Data for PICC lines were analyzed from lines, drains, and airway documentation updated by nursing staff. Data from clinician orders were also analyzed.

Results

Patient and hospital characteristics are presented in the Supplementary Material (online). Single-lumen PICC utilization significantly increased compared to the preintervention period (Table 1). When not adjusting for temporal trends, average single-lumen PICC utilization increased by 25.5%, from 44.4% to 69.9% ($P < .001$). When adjusting for temporal trends, there was no significant slope difference (Fig. 2). We detected a significant level difference, with utilization increasing by 22.2%, from 46.7% to 68.9% at the intervention date ($P < .001$). When examining CLABSI rates from PICC lines, the CLABSI rates had a nonsignificant reduction by 26.7% from 2.44 to 1.79 infections per month ($P = .255$). Median age was unchanged before the intervention versus after the intervention (61.0 vs 61.0 years; $P = .76$), as was length of stay (12.9 days vs 13.6 days; $P = .65$), along with other patient demographics including sex, race, and insurance status (Supplementary Table 2 online). Notably, total PICCs decreased from the preintervention to the postintervention period (Table 1); the average weekly PICC placement rate decreased from 46.7 to 42.2 ($P = .00169$).

We detected heterogeneity when stratifying postintervention PICC placement orders by provider type and by specialty type. When comparing provider types, fellows had the highest single-lumen PICC utilization at 94.6%, whereas physician associates (PAs) and nurse practitioners (NPs) had the lowest utilization at 67.7% (Table 2). When comparing specialty types, orthopedics had the highest single-lumen PICC utilization at 97.7%, whereas neurology had the lowest utilization at 31.8% (Table 2).

Increases in single-lumen PICC utilization stratified by hospital ranged from 3.7% at Woodhull Hospital to 63.0% at Lincoln Hospital (Table 3). Lower increases were observed at hospitals with high single-lumen PICC utilization before the intervention such as Woodhull Hospital (77.9%), Coney Island Hospital (78.9%), and Kings County Hospital (60.8%). Similarly, larger increases were observed in hospitals with the lowest preintervention single-lumen PICC utilization: Lincoln Hospital (18.0%), Jacobi/North Central Bronx (NCB) Hospital (23.1%), and Harlem Hospital (35.4%). Notably, hospital data for Jacobi and NCB were combined into a single entity based on their similar data-reporting structures.

Discussion

We successfully increased single-lumen PICC use and reduced potentially unnecessary multilumen use across 11 hospitals. This research expands on previous work that employed default nudges, with implementation across a larger, resource-limited setting.[4,9] Although it was not statistically significant, we noted a relative reduction in PICC-related CLABSI rates by 27%; thus, a longer postintervention study period may be needed.

Our 26% increase in single-lumen PICC use was less than the 48% increase reported by Lam et al.[9] This difference may be attributed to their concurrent local publicity campaign, as they announced within their meetings and rounds within units and teams. Education and awareness campaigns are more effective in smaller settings, possibly creating this significant additive effect.[11] Although we sent a mass e-mail to executive and clinical leadership, practically, we were unable to speak in person in each of the local units or services across 11 hospitals. Interestingly, when comparing our increase with Bozaan et al[4] (29%), our results were similar. Their intervention was more robust, including having their vascular-access service team review the appropriateness of indications and escalating to clinical pharmacists when inappropriate. However, their single-lumen PICC use likely reached a ceiling at 94%, and a larger increase may have manifested if their baseline use had been lower.

Significant variation was observed among provider types and provider specialties. Among provider types, we observed lower use of single-lumen PICCs after the intervention among advanced practice providers (APPs; 67.7%) compared to physicians (82.4%–94.6%). This novel finding warrants further study; there may be opportunities to investigate APP attitudes regarding vascular access that explain this difference from physicians. In broader context, previous research regarding overuse among APPs versus physicians is mixed.[12–14] Among provider specialties, there was a wide range of single-lumen PICC utilization (31.8%–97.7%), with neurology and neurosurgery having the lowest rates. Although there may be a higher need for multiple lumens among certain specialties, this variation may also reflect areas in which education and additional reinforcement could be beneficial. We were unable to obtain preintervention provider type and provider specialty data due to the lack of PICC lumen options on the previous consultation orders. Future investigation on the effect of nudge interventions for reducing overuse on these variables could be beneficial.

Significant variation was noted across individual hospitals. This finding may represent differences in clinician engagement and

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Table 2. Postintervention PICC Utilization by Provider Type and Provider Specialty

Category	All PICCs, No.	Total PICCs, %	Single-Lumen PICC, %
Provider type			
Resident physician	960	66.3	82.4
APP (NP and PA)	421	29.1	67.7
Fellow physician	37	2.6	94.6
Attending physician	31	2.1	87.1
Provider specialty			
General internal medicine	593	40.9	85.7
Critical care	175	12.1	70.3
General surgery	159	11.0	66.0
Cardiothoracic surgery	62	4.3	77.4
Neurosurgery	50	3.5	48.0
Neurology	44	3.0	31.8
Orthopedics	43	3.0	97.7
Obstetrics and gynecology	34	2.3	79.4
Vascular surgery	19	1.3	73.7
Plastic surgery	18	1.2	94.4
Other	252	17.4	85.7
All	1,449	100.0	78.5

Note. PICC, peripherally inserted central catheter; APP, advance practice practitioner; NP, nurse practitioner; PA, physician assistant.

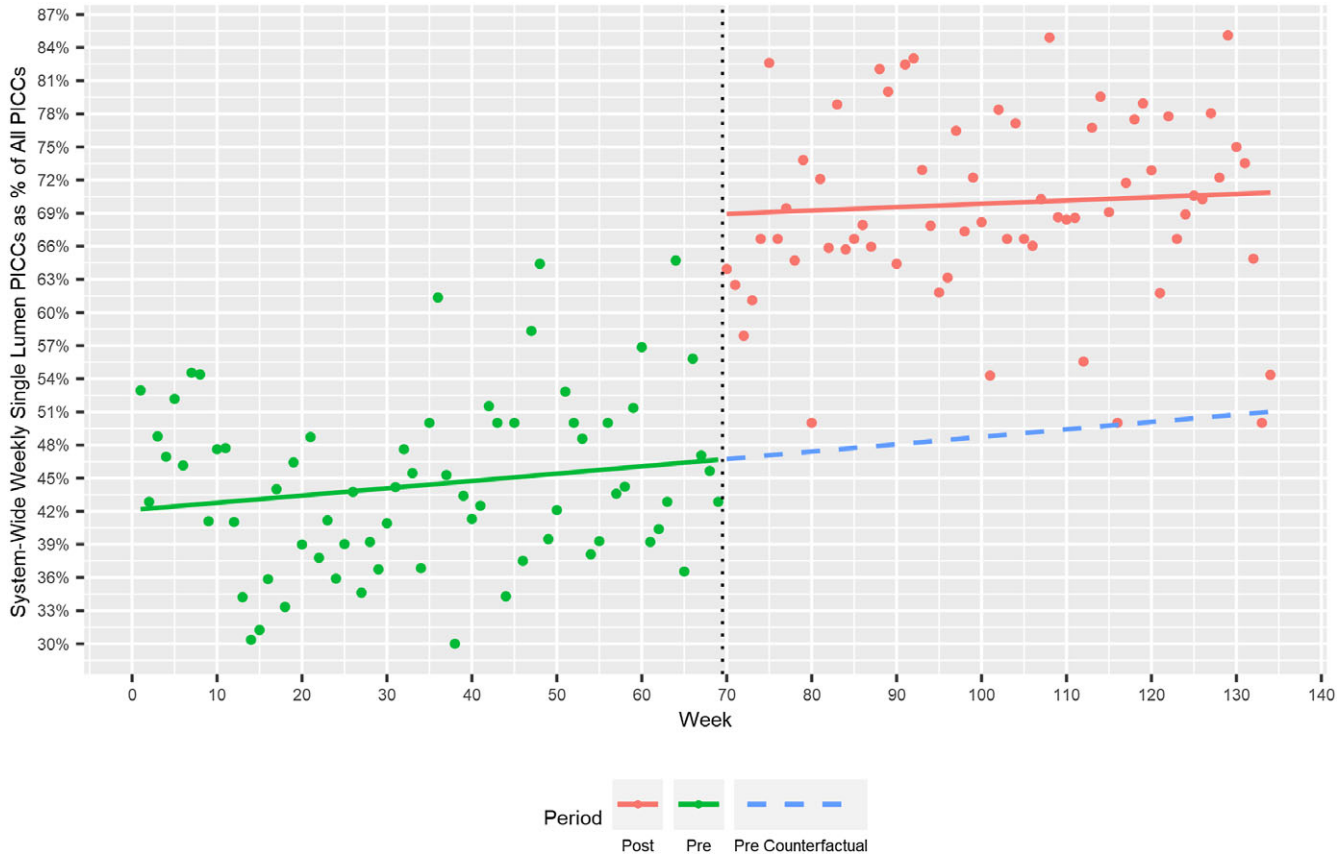

Fig. 2. Binomial regression of single-lumen PICC usage as a percentage of total PICCs.

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Table 3. Preintervention Versus Postintervention Single-Lumen PICC Use by Hospital[a]

Location	Before the Intervention, No. (%)	After the Intervention, No. (%)	Difference, %
Bellevue	365 of 719 (50.8)	509 of 813 (62.6)	11.8
Coney Island	164 of 208 (78.8)	147 of 173 (85.0)	6.1
Elmhurst	88 of 137 (64.2)	70 of 93 (75.3)	11.0
Harlem	104 of 293 (35.5)	161 of 208 (77.4)	41.9
Jacobi/NCB	102 of 459 (22.2)	272 of 375 (72.5)	50.3
Kings County	234 of 385 (60.8)	229 of 336 (68.2)	7.4
Lincoln	67 of 368 (18.2)	201 of 252 (79.8)	61.6
Metropolitan	22 of 161 (13.7)	27 of 108 (25.0)	11.3
Queens	185 of 364 (50.8)	228 of 294 (77.6)	26.7
Woodhull	100 of 129 (77.5)	72 of 89 (80.9)	3.4
Systemwide	1,431 of 3,223 (44.4)	1,916 of 2,741 (69.9)	25.5

Note. PICC, peripherally inserted central catheter; NCB, North Central Bronx Hospital.
[a]Percentage based on total PICCs (single, double, and triple lumen).

willingness to change their practice to placing single-lumen PICCs. Larger increases were observed in hospitals with the lowest preintervention single-lumen utilization: Lincoln (18.0%), Jacobi/NCB (16.8%), and Harlem (35.4%). This finding suggests that with appropriate nudging, providers are open to changing their clinical practice.

Implementation within safety net systems remains challenging. Understaffing and high staff turnover are mentioned nearly universally in literature, along with "self-siloing" and delayed uptake of newer practices.[15] Thus, low-effort, high-impact interventions are critical to improving value within resource-limited settings. Models for prioritization of projects, such as those used by Stinnett-Donnelly et al,[16] may prove more useful in safety net systems. Our intervention may provide an additional framework for improving value with limited resources.

This study had several limitations. First, this intervention lacked randomization or concurrent control. Second, our analysis did not include other complications of PICCs (eg, thrombosis or occlusion) or alternative intravenous access usage. We also suspect that in rare instances, PICC lines were placed outside of the EHR workflow, with a potentially marginal effect on this intervention. Additionally, our initiative does not address or assess the appropriateness of PICC placement over alternative IV access. Notably, our data relied on accurate documentation in the Lines, Drains, Airways (LDA) section of the chart, and though documentation patterns likely did not change before versus after the intervention, there may be some inaccuracies in the data. Lastly, this intervention occurred during the coronavirus disease 2019 (COVID-19) pandemic, including during surges. Hospital-acquired conditions, such as CLABSIs, increased significantly during this period, which may limit generalizability of our findings to nonpandemic periods.[17] However, the positive effect of this intervention across the hospitals remains intact.

This initiative successfully improved single-lumen PICC line usage across a 11-hospital safety net health system. Further study is needed to understand effectiveness of default nudge interventions among different provider types and specialties.

Supplementary material. For supplementary material accompanying this paper visit https://doi.org/10.1017/ice.2022.306

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