Reducing Overuse of 3-Day Repeat Type and Screen Testing across an 11-Hospital Safety Net System

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ABSTRACT

BACKGROUND: According to the American Association of Blood Banks, a Type and Screen (T&S) is valid for up to three calendar days. Beyond a limited number of clinical indications such as a transfusion reaction, repeat T&S testing within 3 days is not warranted. Inappropriate repeat T&S testing is a costly medical waste and can lead to patient harm.

OBJECTIVE: To reduce inappropriate duplicate T&S testing across a large, multihospital setting.

SETTING: The largest urban safety net health system in the USA, with 11 acute care hospitals.

INTERVENTIONS: Our first intervention involved adding the time elapsed since the last T&S order into the order and the process instructions that described when a T&S was indicated. The second intervention was a best practice advisory that triggered when T&S was ordered before the expiration of an active T&S.

MAIN MEASURES: The primary outcome measure was the number of duplicate inpatient T&S per 1000 patient days.

KEY RESULTS: Across all hospitals, the weekly average rate of duplicate T&S ordering decreased from 8.42 to 7.37 per 1000 patient days (12.5% reduction, $p<0.001$) after the first intervention and to 4.32 per 1000 patient days (48.7% reduction, $p<0.001$) after the second intervention. Using linear regression to compare pre-intervention to post-intervention 1, the level difference was −2.46 (9.17 to 6.70, $p<0.001$) and slope difference was 0.0001 (0.0282 to 0.0283, $p=1$). For post-intervention 1 to post-intervention 2, the level difference was −3.49 (8.06 to 4.58, $p<0.001$) and slope difference was −0.0428 (0.0283 to −0.0145, $p<0.05$).

CONCLUSIONS: Our intervention successfully reduced duplicate T&S testing using a two-pronged electronic health record intervention. The success of this low effort intervention across a diverse health system provides a framework for similar interventions in various clinical settings.

KEY WORDS: quality improvement; overuse; type and screen; patient safety; medical waste

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INTRODUCTION

A type and screen (T&S) determines ABO blood group and Rh type for clinically significant allo-antibodies in the event a patient requires a blood transfusion.[1] According to the American Association of Blood Banks, a T&S is valid for up to three calendar days.[2] Beyond a limited number of clinical indications such as a transfusion reaction, repeat T&S testing within 3 days is not warranted.[3]

Repetitive testing within 3 days, although valid in some instances, is often unnecessary. Duplications occur for a variety of reasons including the lack of awareness of the existing active order by the ordering clinician, difficulty with locating previous test results, and routine ordering without considering its appropriateness.[4,5] Additionally, clinicians order T&S to prevent any possible delays for blood products. A study showed 5.1% of Type and Screen samples during a 24-month study period were duplicate orders received within 3 days of a previous T&S.[3] Clinically inappropriate repeat T&S testing represents a costly medical waste for the hospital system. Additionally, unnecessary blood draws may lead to patient harm such as pain and iatrogenic anemia.[6] In safety net settings where healthcare is provided to medically underserved individuals who have limited access to healthcare resources due to socioeconomic, cultural, or geographic barriers, the impact of waste is particularly significant.

To date, there is sparse literature on reducing duplicate T&S. In a single-center study, duplicate T&S were reduced via an electronic health record (EHR) intervention that added the test order date and expiration in the T&S order.[7] However, successful implementation across larger, multihospital settings is lacking. We expand on previous literature and present a more robust EHR intervention to reduce testing across a large safety net system.

METHODS

Project Setting

This quality improvement initiative was implemented at New York City Health + Hospitals (NYC H + H), the largest municipal health system in the USA, with 11 acute care hospitals. All hospitals are urban, teaching centers with 6 of the 11 hospitals serving as trauma centers. Our project was deemed a quality improvement project by the NYC H + H Central Research Office, and thus an Institutional Review Board submission was not required. The intervention was led and designed by the System High Value Care Council with input from subject matter experts from patient safety, anesthesia, emergency medicine, internal medicine, pathology, and laboratory.

Intervention

Our staggered approach involved two changes to the electronic health record (Epic Systems Corporation, Verona, Wisconsin). Our first intervention, implemented in May 2021, involved adding the time elapsed since the last T&S order into the order (Fig. 1a). Additionally, there were process instructions that described when a T&S was indicated: (1) order both a T&S and an ABO/Rh Confirmation test for patients without history of T&S on file at the current facility, (2) order only a T&S if there is a T&S on file at the current facility, (3) send a new T&S sample every 3 days/72 h for the Blood bank to issue blood. Because there were no mandatory prompts in the T&S order, a user could sign a T&S order without the order screen displaying, which would limit the effect of our intervention. To increase the visibility of both the time elapsed and the process instructions, we added a mandatory prompt to existing questions within the T&S order so that the user would see the order screen.

Our second intervention, implemented in April 2022, was a best practice advisory (BPA) that triggered when T&S was ordered before the expiration of an active T&S. The alert states "A Type & Screen lasts 3 calendar days. Please avoid reordering earlier than needed." The removal of the order was defaulted on the BPA (Fig. 1b). The previous collection date and remaining time until expiration were shown. The 3-day expiration period was defined as the end of the second calendar day at 11:59 PM, with the initial result (at any time) as day 0. Users could override the BPA and place the T&S order if necessary.

Measures and Statistical Analysis

The pre-intervention period was May 25, 2020, to May 23, 2021 (12 months). The first post-intervention period was May 24, 2021, to April 24, 2022 (10 months). The second

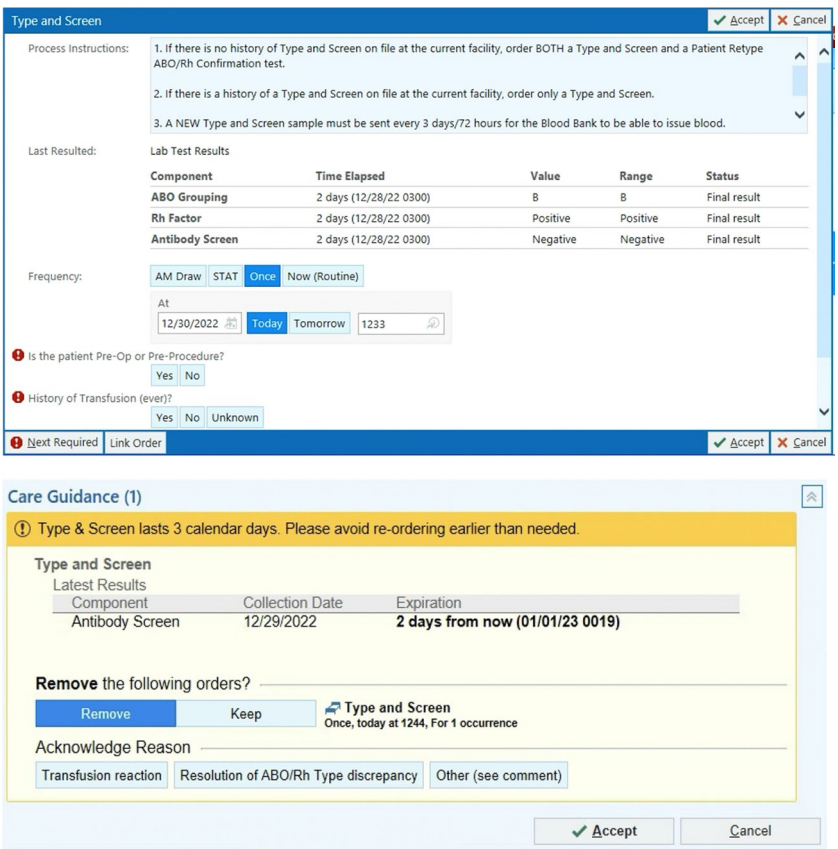

Figure 1 a New process instructions with advisory statement within the Type and Screen order. b Duplicate Type and Screen Best Practice Advisory.

post-intervention period was April 25, 2022, to January 1, 2023 (9 months).

The outcome measure was the number of duplicate inpatient T&S per 1000 patient days. A duplicate T&S was defined as a new T&S sample that was collected within two calendar days of the previously resulted T&S. We excluded the third calendar day from the BPA trigger as well as the outcome measure to avoid any unwanted delays in blood transfusions. Of note, NYC H + H requires two T&Ss (or one T&S and one ABO/Rh test) for a patient without a prior sample at the local blood bank. To account for this unique circumstance where duplicate T&S orders are clinically appropriate, we further defined a duplicate T&S as any T&S ordered within two calendar days of the initial two T&S or a T&S and an ABO/Rh in all patient encounters. The outcome measure was also stratified by individual hospitals. Of note, Jacobi and North Central Bronx are two different hospitals under the same operating certificate and a singular data entity.

The outcome measure was analyzed via two methods. The first method utilized a *t*-test assuming unequal variance (Welch test). This method was used to compare the weekly average of duplicate tests pre-intervention to post-intervention 1 and post-intervention 2. Linear regression for weekly averages of duplicate T&S for all hospitals combined was then used to compare pre-intervention duplicate T&S to post-interventions 1 and 2. Intercepts at the second intervention date were compared to detect an immediate change in ordering rates (level difference). The slopes were also compared to detect changes in ordering rates (slope difference).

The process measure was the acceptance rate of the BPA, defined as the number of times the T&S order was removed through the BPA divided by the total number of times the BPA triggered. This acceptance rate was stratified by clinician type and specialty.

As a balance measure, we compared the number of T&S ordered within 2 h after the placement of a blood transfusion order pre- and post-intervention. We used this measure as a surrogate marker to identify potential patients without an active T&S for a blood transfusion order. Pre- and post-intervention age and length of stay (LOS) were statistically compared to measure changes in the patient population. These variables were compared using a Welch *t*-test.

Data were abstracted through SQL query. All analyses were performed with version 4.0.3 of the R programming language (R Core Team, 2020).

RESULTS

The pre-intervention average age was 59.7 years and 59.4 years post-intervention 2 ($p = 0.6$). The pre-intervention average LOS was 11.9 days and 12.2 days post-intervention 2 ($p = 0.07$).

Across all hospitals, without accounting for temporal trends, the weekly average rate of duplicate T&S ordering decreased from 8.42 to 7.37 per 1000 patient days (12.5% reduction, $p < 0.001$) after the first intervention and to 4.32 per 1000 patient days (48.7% reduction, $p < 0.001$) after the second intervention. Using linear regression to compare pre-intervention to post-intervention 1 (Fig. 2), the level difference was − 2.46 (9.17 to 6.70, $p < 0.001$) and slope difference was 0.0001 (0.0282 to 0.0283, $p = 1$). For post-intervention 1 to post-intervention 2, the level difference was − 3.49 (8.06 to 4.58, $p < 0.001$) and slope difference was − 0.0428 (0.0283 to − 0.0145, $p < 0.05$). A comparison of duplicate T&S relative reductions in individual hospitals is shown in Table 1. All eleven hospitals had a significant reduction in duplicate T&S. Both Elmhurst Hospital and Queens Hospital had the highest reduction of 68.1% ($p < 0.001$) for both interventions combined.

The overall BPA acceptance rate was 30.9% (2602 of 8423) (Table 2). Attending physicians had the highest acceptance rate of 42.6% (46 of 108), followed by

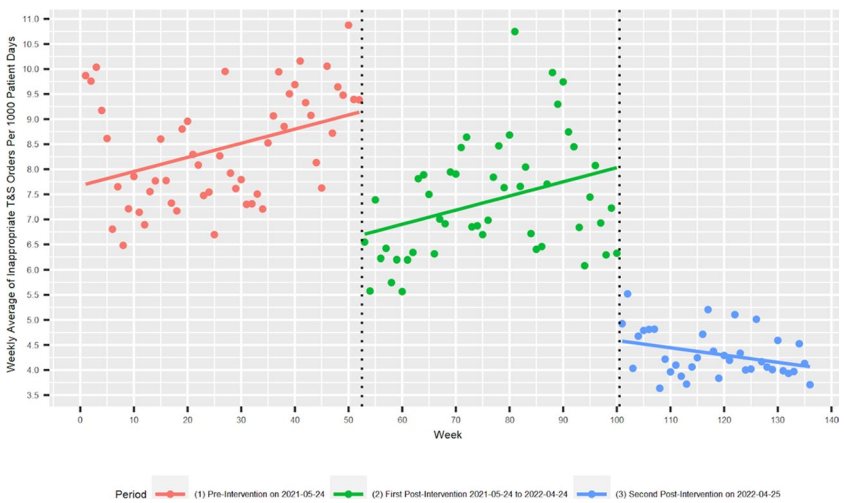

Figure 2 Interrupted time series regression comparing the weekly average rate of duplicate T&S preintervention to postintervention 1 and 2.

Table 1 Individual hospital duplicate Type and Screen testing rates per 1000 patient days pre-intervention and post-intervention 2

Location	Duplicate T&S testing rates per 1000 patient days		Difference
	Pre-intervention	Post-intervention 2	
BELLEVUE	10.4	6.26	−4.14 (−39.8%)***
CONEY ISLAND	20.55	10.8	−9.75 (−47.4%)***
ELMHURST	11.34	3.62	−7.72 (−68.1%)***
HARLEM	3.42	2.06	−1.36 (−39.8%)***
JACOBI/NORTH CENTRAL BRONX	3.86	3.12	−0.74 (−19.2%)*
KINGS COUNTY	9.98	5.57	−4.41 (−44.2%)***
LINCOLN	5.52	1.95	−3.57 (−64.7%)***
METROPOLITAN	2.5	2.02	−0.48 (−19.2%)
QUEENS	9.89	3.15	−6.74 (−68.1%)***
WOODHULL	2.45	1.43	−1.02 (−41.6%)***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

resident physicians with 31.6% (2144 of 6786). Nurse practitioners had the lowest acceptance rate of 23.3% (42 of 180). Among clinician specialties, the BPA triggered most frequently for Internal Medicine (4524 of 8423). Anesthesiology had the highest BPA acceptance rate of 37.9% (36 of 95) and orthopedic surgery had the lowest BPA acceptance rate of 18.9% (41 of 217) (Table 3).

For the balancing measure, the rate of T&S within 2 h of a blood transfusion pre-intervention was 3.37 per 1000 patient days, and 3.27 per 1000 patient days post-intervention 1 (3.0% reduction, $p < 0.01$), and 2.80 per 1000 patient days post-intervention 2 (11.5% reduction, $p < 0.001$).

DISCUSSION

Our initiative successfully reduced duplicate T&S testing across our 11-hospital safety net system. There is a paucity of interventions aimed at reducing unnecessary T&S. Stockbine et al. investigated the effectiveness of an EHR intervention in significantly reducing duplicate T&S orders by 12.8% at a large academic medical center. Their intervention involved redesigning the T&S order screen to inform clinicians of the date and time the current test expires as well as the date and time of the most recent test.[7] In our study, the first intervention, which also involved order screen changes, demonstrated a similar reduction of 12.5%. The novelty of our initiative lies in the combination of the order screen changes with a BPA intervention that achieved a 48.7% relative reduction without compromising timely blood transfusions.

Table 2 Best Practice Advisory action rate by clinician type

Clinician type	Count BPAs (% total)	Action rate (%)
Resident physician	6786 (80.6%)	31.6%
Physician associate	1304 (15.5%)	27.5%
Nurse practitioner	180 (2.1%)	23.3%
Attending physician	108 (1.3%)	42.6%
Fellow physician	45 (0.5%)	26.7%
Overall	7148 (100%)	30.6%

Table 3 Best Practice Advisory action rate by clinician specialty

Clinician specialty	Count BPAs (% total)	Action rate
Internal medicine	4524 (53.7%)	34.9%
General surgery	1343 (15.9%)	25.8%
Emergency medicine	559 (6.6%)	26.8%
Orthopedics/orthopedic surgery	217 (2.6%)	18.9%
Obstetrics and gynecology	175 (2.1%)	27.4%
Neurology/neurosurgery	163 (1.9%)	20.2%
Cardiology	197 (2.3%)	28.9%
Anesthesiology	95 (1.1%)	37.9%
Urology	42 (0.5%)	21.4%
Otolaryngology	55 (0.7%)	36.4%
Other	1053 (12.5%)	26.9%
Overall	8423 (100.0%)	30.9%

Successful quality improvement implementation in resource-limited settings has its unique challenges. In well-resourced, academic settings, high effort multifaceted interventions or stewardship from clinical experts are shown to be effective. These may not be feasible in safety net settings with limited resources. Implementation across multiple hospitals is an additional level of challenge. Through two EHR interventions alone, our initiative demonstrated novel success at decreasing duplicate T&S orders in this type of setting. We believe that the success achieved through our interventions, particularly in reducing duplicate orders, can be generalizable to other institutions using a similar EHR system, regardless of whether they are safety net or academic settings. The principles and strategies employed in our study can serve as a foundation for implementing similar interventions in different healthcare settings.

The EHR interventions relied on different principles of nudge, defined as any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives.[8] First, the informational nudges within our initial intervention, which are often cited as the weakest types of nudges[9], produced modest effects as expected. The addition of two mandatory prompts within the T&S order disenabled clinicians to place an order without seeing the order screen that displays the process instructions and the time elapsed since the last T&S order. With the BPA, we used simplification, or narrowing down the numerous complex appropriateness guidelines to just one idea: reducing unnecessary 3-day repeats. Second, we utilized defaults, the most powerful nudge, within the BPA by defaulting on the intended action, or removal of the order.[9] Both interventions appropriately addressed the factors contributing to duplicate testing by providing timely information at the moment in the workflow where it would be most useful. Moreover, the BPA serves to help clinicians be

aware that an active T&S exists, as it may be a different clinician than the one who ordered the existing T&S, or it may be difficult to know if the T&S is active in the EHR.

We observed a discrepancy between the acceptance rate of the BPA (30.9%) and the higher relative reduction of duplicate T&S (48.7%), which may partially reflect the combined effectiveness of both interventions in this study. It may also be understood as the cumulative learning effect by clinicians. As studies have shown, the simple trigger and actionable message of the BPA encourage future behavioral changes without the need for this reminder.[10,11]

An interesting phenomenon was the significant reduction of the balance measure of our study in post-interventions 1 and 2. The number of T&S ordered within 2 h after the placement of a blood transfusion order was chosen as a surrogate marker of delayed blood transfusions, as if there was not an active T&S at the time of blood transfusion order, then a clinician would need to order a new T&S and wait for the result prior to transfusion. We can speculate the decrease may have been attributed to clinicians who previously signed orders for both transfusion and T&S in emergency settings were now removing the T&S order.

High variability was seen when comparing the individual hospitals. For example, the relative reduction in the second post-intervention period ranged from 19.2 to 68.1%. Consistent findings were not found when comparing the size of the hospitals (large vs small), or trauma vs nontrauma centers. There may be different local workflows that we are not aware of that go against our intervention and considerable variability in high value care culture between institutions.[12] Furthermore, this confirms our previous findings that considerable variability in overuse can exist among hospitals within the same health system.[10,11,13,14]

We also noted variability among clinician types as well as ordering physician specialties. Attending physicians had the highest BPA acceptance rate (42.6%) and nurse practitioners had the lowest (23.3%). This pattern was also seen in previous studies[10,13] and previous studies demonstrated that attendings have more comfort with less testing compared with advanced practice providers.[15] Among specialties, more than half the total BPA counts were triggered by Internal Medicine (53.7%), more than all surgical specialties combined. Internal medicine also had the highest BPA acceptance rate, with orthopedic surgery having the lowest acceptance rate. We suspect that specialty-specific workflows and culture underline these findings, and this data may help hone in additional interventions in the future.

Several limitations exist with this study. First, this study did not include chart reviews for appropriateness of reduced duplicate T&S. Second, we chose to only focus on duplicate T&S after the initial 2 T&S or 1 T&S and ABO/Rh. If a patient already has an existing T&S in the system, then they only need 1 T&S. However, it is difficult to identify if a patient has a prior sample at each local blood bank. In defining the outcome measure, we chose to exclude the second T&S in all patient encounters to underestimate, rather than overestimate, the prevalence of inappropriate duplicates. Third, the balance measure used in this study is a surrogate marker, not an actual indicator of blood transfusion delays. The significant reductions of the balance measure may indicate that the occurrences of delayed transfusions could have been masked by the effect of our interventions. Finally, this quality improvement initiative was not randomized and lacked a control; thus, we are not able to say our intervention directly caused the decrease in T&S.

CONCLUSION

Our intervention successfully reduced duplicate T&S testing using a two-pronged EHR intervention. The success of this low effort intervention across a diverse health system provides a framework for similar interventions in various clinical settings. Future studies may investigate the potential correlation between these reductions and negative patient experiences such as iatrogenic anemia. Exploring this relationship will yield valuable insights into the impact of unwarranted testing on patient outcomes, thereby facilitating the development of evidence-based interventions to mitigate harm.

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Data Availability *All data can be made available upon request.*

Declarations:

Conflict of Interest: *No Conflicts of Interest from any of the authors.*

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