Supplementary Online Content

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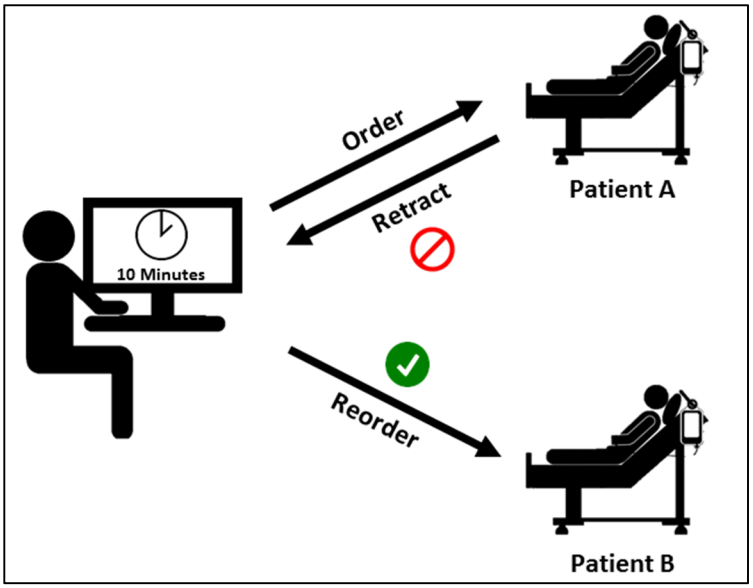
This supplementary material has been provided by the authors to give readers additional information about their work.

eMethods 1. Retract-and-Reorder Methodology

The Retract-and-Reorder methodology is based on the premise that the majority of orders placed and then cancelled by the same clinician represent an order error, and that the subsequent action taken by the clinician is indicative of the type of error.[1] The Wrong-Patient Retract-and-Reorder (RAR) measure was the first Health Information Technology (IT) Safety measure endorsed by National Quality Forum (NQF Measure #2723).[2,3] The measure detects RAR events, defined as one or more orders placed for a patient that are retracted within 10 minutes, and then placed by the same clinician for a different patient within the next 10 minutes (**eFigure 1**). In a validation study, real-time confirmatory telephone interviews with clinicians who placed and retracted orders demonstrated that the RAR measure correctly identified near-miss, wrong-patient orders in 170 of 223 cases, yielding a positive predictive value of 76.2% (95% CI 70.6% to 81.9%).[4] Extending the interval beyond 10 minutes revealed few additional RAR events. The mean time from placing the initial order for the wrong patient to retraction was 1 minute, 18 seconds, and the mean time from retraction to placing the order for the correct patient was 2 minutes, 17 seconds.



eFigure 1. Wrong-Patient Retract-and-Reorder Measure.

In the initial epidemiological study, the measure identified 5246 orders placed on the wrong patient over a 1-year period in a large academic medical center, which translates to 58 wrong-patient orders per 100 000 orders.[4] This volume of near-miss, wrong-patient orders is vastly greater than estimates reported in studies using voluntarily reported errors as the outcome,[5-7] enabling researchers to test interventions to prevent these errors in a range of systems and settings. Subsequently, the measure has been used to test the effectiveness of several systems-level interventions to reduce the frequency of wrong-patient order errors.[8-12]

Near-Miss Errors for Patient Safety Surveillance and Research

The Retract-and-Reorder automated detection method identifies near-miss errors rather than errors that reach the patient and cause harm. Near-miss errors are also referred to as “close calls” by the Department of Veterans Affairs,[13] “good catches” by the National Association for Healthcare Quality,[14] and “free lessons” by the safety expert James Reason.[15] Near-miss errors are particularly valuable in patient safety research, as they have been shown to occur up to 100 times more frequently than errors that reach the patient and cause harm, and thus can provide a sufficient number of outcome events to power research studies evaluating the effect of safety interventions.[16]

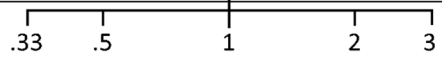
The Agency for Healthcare Research and Quality (AHRQ) National Resource Center for Health Information Technology developed the ***Health IT Evaluation Toolkit***, and identifies near-miss errors as a useful outcome measure for the evaluation of the effectiveness and safety of Health IT interventions.[17] AHRQ has coordinated the development and maintenance of the “Common Formats” for national reporting of patient safety events to Patient Safety

Organizations, and has included near-miss errors as important patient safety data to be collected and analyzed.[18]

The use of near-miss errors to test safety improvements in healthcare is encouraged by every major organization dedicated to improving patient safety including AHRQ, Institute of Medicine, World Health Organization, Institute for Healthcare Improvement, and The Joint Commission,[16,19-22] because they have been shown by safety experts to have the same causal pathway as errors that cause harm. The key distinction between an adverse event and a near-miss error is that in the latter a human recovery occurs before the error reaches the patient and causes harm. This principle is the foundation for the RAR automated detection method.

eFigure 2. Primary Results Comparing Wrong-Patient Order Sessions in the Restricted vs Unrestricted Group (As-Treated Analysis)

	No. of Order Sessions					
	Restricted[a]	Unrestricted[b]	Odds Ratio[c] (95% CI)	Restricted Better	Unrestricted Better	*P* value
Overall						
Wrong-patient order sessions per 100,000	**90.9**	**87.8**	1.03 (0.89 to 1.19)			.68
Wrong-patient order sessions	1934	2072				
Total order sessions	2,127,162	2,359,469				
Emergency department						
Wrong-patient order sessions per 100,000	**162.1**	**157.2**	1.05 (0.87 to 1.25)			.62
Wrong-patient order sessions	547	589				
Total order sessions	337,364	374,565				
Inpatient						
Wrong-patient order sessions per 100,000	**183.6**	**187.1**	0.97 (0.86 to 1.08)			.57
Wrong-patient order sessions	1295	1369				
Total order sessions	705,368	731,795				
Medical/Surgical						
Wrong-patient order sessions per 100,000	**189.8**	**185.8**	1.01 (0.89 to 1.16)			.83
Wrong-patient order sessions	942	877				
Total order sessions	496,254	472,025				
Critical care						
Wrong-patient order sessions per 100,000	**225.6**	**275.0**	0.87 (0.66 to 1.14)			.32
Wrong-patient order sessions	145	232				
Total order sessions	64,279	84,362				
Pediatrics						
Wrong-patient order sessions per 100,000	**112.2**	**150.5**	0.73 (0.50 to 1.06)			.10
Wrong-patient order sessions	70	106				
Total order sessions	62,373	70,427				
Obstetrics						
Wrong-patient order sessions per 100,000	**208.0**	**192.7**	1.04 (0.69 to 1.57)			.85
Wrong-patient order sessions	72	91				
Total order sessions	34,617	47,230				
Outpatient						
Wrong-patient order sessions per 100,000	**8.2**	**8.1**	0.98 (0.72 to 1.33)			.90
Wrong-patient order sessions	86	97				
Total order sessions	1,054,519	1,204,680				



[a] Restricted, configuration limited to one record open at a time.
[b] Unrestricted, configuration allowed up to four records open concurrently.

[c] Random-effects logistic regression models were constructed, using the order session as the unit of analysis and the clinician as the random intercept. The order session, a series of orders placed consecutively by a single clinician for a single patient, represents an independent opportunity for an error to occur. Wrong-patient order sessions were defined as order sessions that included at least one wrong-patient Retract-and-Reorder event. In as-treated analysis, each order was characterized according to the clinician's configuration at the time the order was placed.

eTable 1. Order Characteristics

Characteristic	No. (%) of Orders	
	Restricted[a]	**Unrestricted[b]**
Total orders	5,856,992	6,283,306
Order Type		
Medications	2,630,170 (44.9)	2,888,009 (46.0)
Labs	1,836,048 (31.4)	1,911,116 (30.4)
Imaging	253,922 (4.3)	253,732 (4.0)
Other	1,136,852 (19.4)	1,230,449 (19.6)

[a] Restricted, configuration limited to one record open at a time.
[b] Unrestricted, configuration allowed up to four records open concurrently.

eTable 2. Wrong-Patient Orders in the Restricted vs Unrestricted Group (As-Randomized Analysis)[a]

	No. of Orders	
	Restricted[b]	**Unrestricted[c]**
Overall		
Wrong-patient orders per 100,000	**52.2**	**48.0**
Wrong-patient orders	3058	3015
Total orders	5,856,992	6,283,306
Emergency department		
Wrong-patient orders per 100,000	**88.6**	**86.0**
Wrong-patient orders	980	978
Total orders	1,106,168	1,137,774
Inpatient		
Wrong-patient orders per 100,000	**89.5**	**86.7**
Wrong-patient orders	1940	1896
Total orders	2,166,764	2,186,305
Medical/Surgical		
Wrong-patient orders per 100,000	**91.6**	**87.5**
Wrong-patient orders	1387	1228
Total orders	1,513,368	1,403,712
Critical care		
Wrong-patient orders per 100,000	**117.7**	**120.8**
Wrong-patient orders	215	301
Total orders	182,698	249,252
Pediatrics		
Wrong-patient orders per 100,000	**54.4**	**58.6**
Wrong-patient orders	96	143
Total orders	176,601	243,890
Obstetrics		
Wrong-patient orders per 100,000	**103.1**	**115.3**
Wrong-patient orders	143	149
Total orders	138,681	129,270
Outpatient		
Wrong-patient orders per 100,000	**4.8**	**4.5**
Wrong-patient orders	119	128
Total orders	2,493,182	2,820,934

[a] Wrong-patient orders were analyzed using the order as the unit of analysis, with analysis conducted according to clinicians' assigned randomization group (as-randomized analysis).
[b] Restricted, configuration limited to one record open at a time.
[c] Unrestricted, configuration allowed up to four records open concurrently.

eTable 3. Baseline Clinician Characteristics (As-Treated Analysis)[a]

Characteristic	No. (%) of Clinicians		
	Restricted[b] (n = 1520)	Unrestricted[c] (n = 1741)	Varied[d] (n = 95)
Age, mean (SD), y	42.9 (12.7)	43.4 (12.4)	41.2 (10.5)
Experience at study site, mean (SD), y	6.5 (6.0)	6.7 (6.0)	4.5 (5.5)
Sex			
Female	863 (56.8)	979 (56.2)	52 (54.7)
Male	657 (43.2)	762 (43.8)	43 (45.3)
Clinician type			
Attending physician	728 (47.9)	844 (48.5)	48 (50.5)
House staff	485 (31.9)	562 (32.3)	24 (25.3)
Mid-level[e]	307 (20.2)	335 (19.2)	23 (24.2)
Primary practice area			
Outpatient	764 (50.3)	895 (51.4)	52 (54.7)
Inpatient			
Medical/surgical	327 (21.5)	310 (17.8)	10 (10.5)
Pediatrics	59 (3.9)	63 (3.6)	0 (0)
Obstetrics	25 (1.6)	39 (2.2)	3 (3.2)
Critical care	25 (1.6)	20 (1.1)	1 (1.1)
Other	105 (6.9)	107 (6.1)	9 (9.5)
Emergency department	126 (8.3)	149 (8.6)	11 (11.6)
Unclassified	89 (5.9)	158 (9.1)	9 (9.5)

[a] In as-treated analysis, each order was characterized according to the clinician's configuration at the time the order was placed.
[b] Restricted, configuration limited to one record open at a time.
[c] Unrestricted, configuration allowed up to four records open concurrently.
[d] These clinicians switched between arms at least once during the course of the trial period.
[e] Mid-level clinicians include nurse practitioners and physician assistants.

eTable 4. Wrong-Patient Orders in the Restricted vs Unrestricted Group (As-Treated Analysis)[a]

	No. of Orders	
	Restricted[b]	**Unrestricted[c]**
Overall		
Wrong-patient orders per 100,000	**52.1**	**48.2**
Wrong-patient orders	2982	3091
Total orders	5,724,389	6,415,909
Emergency department		
Wrong-patient orders per 100,000	**90.7**	**84.1**
Wrong-patient orders	966	992
Total orders	1,064,611	1,179,331
Inpatient		
Wrong-patient orders per 100,000	**88.2**	**88.1**
Wrong-patient orders	1884	1952
Total orders	2,137,109	2,215,960
Medical/Surgical		
Wrong-patient orders per 100,000	**93.7**	**85.3**
Wrong-patient orders	1408	1207
Total orders	1,502,711	1,414,369
Critical care		
Wrong-patient orders per 100,000	**99.2**	**134.3**
Wrong-patient orders	181	335
Total orders	182,506	249,444
Pediatrics		
Wrong-patient orders per 100,000	**45.8**	**66.9**
Wrong-patient orders	92	147
Total orders	200,712	219,779
Obstetrics		
Wrong-patient orders per 100,000	**106.0**	**111.2**
Wrong-patient orders	121	171
Total orders	153,767	114,184
Outpatient		
Wrong-patient orders per 100,000	**4.8**	**4.5**
Wrong-patient orders	118	129
Total orders	2,435,340	2,878,776

[a] Wrong-patient orders were analyzed using the order as the unit of analysis. In as-treated analysis, each order was characterized according to the clinician's configuration at the time the order was placed.
[b] Restricted, configuration limited to one record open at a time.
[c] Unrestricted, configuration allowed up to four records open concurrently.

eTable 5. Utilization and Wrong-Patient Orders by Number of Records Open in the Unrestricted Group[a]

				Wrong-Patient Orders per 100,000 orders			
					95% CI		
	Open Records	No. of Orders	Percent of Orders Placed[b]	Rate	Lower	Upper	*P* value[c]
Overall	1	4,173,579	66.4%	29.2	27.6	30.9	<.001
	2	844,319	13.4%	68.3	62.9	74.1	
	3	481,014	7.7%	86.1	78.0	94.8	
	4	784,290	12.5%	102.5	95.5	109.8	
ED	1	429,671	37.8%	65.6	58.2	73.8	<.001
	2	188,194	16.5%	93.5	80.2	108.4	
	3	151,431	13.3%	111.6	95.4	129.7	
	4	368,478	32.4%	95.3	85.6	105.8	
Inpatient	1	1,270,318	58.1%	65.2	60.8	69.8	<.001
	2	354,371	16.2%	106.1	95.7	117.4	
	3	220,851	10.1%	108.7	95.4	123.3	
	4	340,765	15.6%	132.6	120.7	145.4	
Outpatient	1	2,389,203	84.7%	4.2	3.4	5.1	.02
	2	282,354	10.0%	8.1	5.2	12.2	
	3	95,200	3.4%	4.2	1.1	10.8	
	4	54,177	1.9%	1.8	0.0	10.3	

[a] Unrestricted, configuration allowed up to 4 records open concurrently.
[b] Percentage of orders placed with 1, 2, 3, or 4 records open, overall and stratified by clinical setting.
[c] Calculated using chi-square test.

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