Operations Management

Using the Red/Yellow/Green Discharge Tool to Improve the Timeliness of Hospital Discharges

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Overall trends in inpatient volume and lengths of stay have decreased, but the number of emergency department (ED) visits and length of stay (LOS) have increased and are only expected to worsen.[1] With an aging population, the number of patients requiring hospital admission is expected to outstrip the availability of beds.[2] Although increasing bed capacity has addressed some of this need, discharge delays in particular have been linked to decreased bed availability, lower rates of possible admissions, and lower patient satisfaction.[3–8] Attention has been given to hospitalwide patient flow,[9–17] reflecting in part the impact of Joint Commission standards on managing patient flow, first created in 2004.*[18]

Other institutions have used chart alerts, communication boards (for example, whiteboards), computer applications to manage the discharge process, and designated discharge planning personnel to facilitate timely discharges.[19–25] Studies also suggest that both estimation of the date of discharge and communication of this information to a multidisciplinary team need to be done early during patient stays to facilitate throughput.[15,26–31] Although predicting the timing of discharge can facilitate flow, it also needs to be accurate to improve and maintain process efficiency.[32–34]

At Yale-New Haven Hospital (YNHH; Connecticut), growth in inpatient admissions caused the hospital to operate at near-capacity, delaying care and straining resources. Before the implementation of the Red/Yellow/Green (RYG) Discharge Tool in February 2009, the process around discharge was nonstandardized among the medicine units, and there were no visual cues to communicate a patient's readiness for discharge to the team. Practitioners would inconsistently communicate decisions determined on work rounds with nursing and care coordination. With the discharge decision often occurring on

* Leadership (LD) Standard LD.04.03.11, "The hospital manages the flow of patients throughout the hospital," includes Element of Performance (EP) 1 ("The hospital has processes that support the flow of patients throughout the hospital") and EP 5 ("The hospital measures and sets goals for the components of the patient flow process . . .").

Article-at-a-Glance

Background: As part of Yale-New Haven Hospital (Connecticut)'s Safe Patient Flow Initiative, the physician leadership developed the Red/Yellow/Green (RYG) Discharge Tool, an electronic medical record–based prompt to identify likelihood of patients' next-day discharge: green (very likely), yellow (possibly), and red (unlikely). The tool's purpose was to enhance communication with nursing/care coordination and trigger earlier discharge steps for patients identified as "green" or "yellow."

Methods: Data on discharge assignments, discharge dates/times, and team designation were collected for all adult medicine patients discharged in October–December 2009 (Study Period 1) and October–December 2011 (Study Period 2), between which the tool's placement changed from the sign-out note to the daily progress note.

Results: In Study Period 1, 75.9% of the patients had discharge assignments, compared with 90.8% in Period 2 ($p < .001$). The overall 11 A.M. discharge rate improved from 10.4% to 21.2% from 2007 to 2011. "Green" patients were more likely to be discharged before 11 A.M. than "yellow" or "red" patients ($p < .001$). Patients with RYG assignments discharged by 11 A.M. had a lower length of stay than those without assignments and did not have an associated increased risk of readmission. Discharge prediction accuracy worsened after the change in placement, decreasing from 75.1% to 59.1% for "green" patients ($p < .001$), and from 34.5% to 29.2% ($p < .001$) for "yellow" patients. In both periods, hospitalists were more accurate than house staff in discharge predictions, suggesting that education and/or experience may contribute to discharge assignment.

Conclusions: The RYG Discharge Tool helped facilitate earlier discharges, but accuracy depends on placement in daily work flow and experience.

the day of actual discharge, the lack of advance planning created a bottleneck of patients requiring discharge preparation, particularly by house staff services. Communication between the patients' medical providers, who usually had rounds and other educational activities throughout the morning, and with other key players (for example, ward clerks, who were responsible for arranging posthospitalization appointments and transportation, and environmental services, who were in charge of cleaning rooms for admissions) was also disjointed, resulting in further delays. The 11 A.M. discharge rate for medicine patients, a timeliness goal used by many to improve flow, was 10.4% at YNHH in 2007.

In fiscal year (FY) 2008 (October 1, 2007–September 30, 2008), YNHH developed the Safe Patient Flow Initiative, an institutionwide endeavor to streamline throughput, as described in detail elsewhere.[35] The effort involved hospitalwide education on patient throughput, physician and nursing leadership engagement, financial incentives, and other structural changes to promote expedited discharges, and successes were seen in overall 11 A.M. discharge rates.[35] As part of the initiative, communication around planned discharges was targeted as one area for improvement. Physicians used the RYG Discharge Tool—a color-alert prompt within the electronic medical record (EMR)—to facilitate multidisciplinary communication about predicted next-day discharges. In this article, we describe the tool's development, process improvements, and evaluation of the tool's effectiveness in increasing the likelihood of earlier discharges, particularly on medicine services.

Methods

Setting

YNHH is an academic/community hospital located in New Haven, Connecticut. From FYs 2008 through 2012, YNHH experienced an increase in ED visits from 128,777 to 136,088 patients and in inpatient volume from 52,144 to 57,626 discharges. This high volume and delays in patient throughput created an overcrowded ED, straining capacity and increasing workload. A lack of available medicine service beds during high ED service times contributed to inefficient patient flow, which was exacerbated by delayed discharges of clinically ready patients.

Intervention: Initial Development

In the Safe Patient Flow Initiative, an internal consultation team (YNHH Operations Support) partnered with an implementation-based management consulting firm to target areas for improvement through process analysis of hospital departments, including medicine, emergency medicine, nursing, environmental services, and transport. Through a four-week series of observations of discharge-related work flow, along with discussions with nursing and medical practitioners about barriers to efficient discharge, we determined that lack of timely communication about anticipated next-day discharges significantly contributed to delays in patient throughput.[35]

An interdisciplinary team, including representatives from medical staff, nursing, care coordination, business associates (ward clerks), operations support, corporate decision support, and information technology services, developed the RYG Discharge Tool to specifically differentiate which patients had a high likelihood of leaving the next day. The desired outcome of this intervention was to facilitate earlier discharge times and achieve more discharges by 11 A.M.

Practitioners "tagged" each patient's EMR with a red (unlikely), yellow (possibly), or green (very likely) label, indicating probability of next-day discharge. The three levels were modeled after a recognizable color alert system for ease of understanding and quick adoption. The tool was initially built into the medical team sign-out, an electronic document used for patient handoffs located within each patient's EMR. The prompt was structured as a forced toggle field, in which house staff or hospitalist practitioners were required to update the RYG prediction each time that they made changes to the sign-out. If the prompt had not been updated on each day by midnight, the EMR would default that field to "Missing."

Intervention: Implementation and Work Flow

Assessment of discharge readiness was based primarily on the overall clinical impression of the patient's primary team, with input from the patient's nursing team and care coordination. No other specific criteria were given to practitioners for each RYG category. Practitioners were introduced to this prompt during their hospital orientation, in which the tool's daily completion was delineated as a required step in the discharge process. Patients' discharge probabilities were displayed as color-coded data on each unit's centrally located liquid crystal display (LCD) screen Facility Board (Appendix 1, available in online article). The RYG Discharge Tool required the nursing staff, physicians, business associates, and care coordinators to redesign their work flow and prioritize patients with the potential to be discharged. Nursing and medical staff on the evening/night shift were expected to begin discharge paperwork for patients identified as "green" or "yellow" to be discharged the next day. Care coordinators also prioritized efforts for placement/transportation on the basis of RYG assignment. The following

morning, nurses, practitioners, and the care coordinators met formally in 7 A.M "huddles" to target "green," clinically ready patients for discharge by 11 A.M. Practitioners also restructured morning work rounds to begin with examining patients designated as "green." On days when there was a high patient volume in the ED and/or the operating room, hospital leadership used the RYG assignment to plan for bed availability. This cascade of discharge processes began simultaneously with the rollout of the RYG tool.

Intervention: Process Improvement

Initially, the business associates on the evening shift printed reports including patients' RYG status and posted the color-coded data to each unit's centrally located LCD screen Facility Board, which displayed patient and throughput information.[35] By July 2010, we had improved the functionality so that the RYG assignments automatically populated the Facility Board in real time, eliminating the need for any manual input.

After it was determined that tool use was lower than optimal, focused interviews revealed that house staff were not updating sign-outs daily, as they were often caring for the patients overnight, resulting in missing values for the RYG prompt. In contrast, hospitalist practitioners more consistently updated sign-outs daily as part of day-to-night shift change. In addition, patients admitted for < 24-hour stays often did not have sign-outs created in their chart and therefore also lacked RYG assignment. As a result, in April 2010, in a placement change, the RYG tool was incorporated into house staff and hospitalist daily progress notes, as a forced prompt to be completed on initiation of the note. The sign-out's RYG field remained as an optional update.

To provide ongoing feedback to providers and ensure consistent integration into daily work flow, ongoing behavioral audits of the discharge process were performed. Reasons for not leaving by 11 A.M. were categorized and trended on a unit-by-unit basis as part of a Pareto chart (Figure 1, page 246). The reasons included items such as missing practitioners' entry of the RYG status, delays in nursing and medical staff initiation of discharge paperwork, the frequency of morning "huddles," and delays in practitioner work rounds. These results were reviewed by unit-level management, as well as the nursing and medical directors of inpatient medicine. Variances in completing the discharge steps, particularly for patients who did not leave by 11 A.M. despite a "green" designation, were reviewed on a weekly basis by the unit nurse managers and physician leaders, who provided immediate feedback to the frontline staff involved.

Evaluation

After implementation and process improvement steps were completed, we evaluated the RYG tool in terms of the primary outcomes of effectiveness in increasing the percentage of discharges by 11 A.M. and achieving earlier discharge times overall on the adult medicine services at YNHH. Discharges were measured at the time stamp that patients physically vacated their rooms. We compared these metrics pre- and postintervention, as well as for those with and without RYG assignment during the intervention period, to measure the impact of our process improvement steps. Countermeasures of LOS (that is, hospital days counted by midnight stays) and readmission rates were also compared for those with and without RYG labels.

We also measured the secondary outcomes of tool use and prediction accuracy, by provider type (house staff versus hospitalist). Although the tool was updated throughout patient hospitalizations, our measure of use was defined as the presence of any RYG assignment on the day before patient discharge. To capture the tool's effect on overall work flow, we measured prediction accuracy as the rate of patients' next-day discharge based on the daily RYG assignment throughout the hospitalization (for example, the percentage of "green" assignments who achieved discharge the next day).

To explore our secondary metrics, two study periods were selected to occur approximately six months after the RYG tool initiation (Study Period 1, October–December 2009) and change in tool placement from sign-out to progress notes (Study Period 2, October–December 2011),* allowing for orientation of new staff hired in July of each year to the discharge process, and if applicable, the RYG tool.

A general comparison group was also identified from a similar time frame in the preintervention period (October–December 2007) before the start of the entire Safe Patient Flow Initiative in July 2008. Discharge assignments, timing of the assessment, discharge dates/times, and service team, as well as patient demographics, throughput data, and disposition, were collected for all subjects. Patients who were admitted under observation status, died during their hospitalization, or who left against medical advice were excluded from this study. In addition, as discharge work flow is substantially different for patients admitted for less than 24 hours, these patients were excluded from study analysis.

Primary data were collected via an automated query from the hospital EMR. Corporate decision support received a daily extract file containing information on all patients currently

* The tool placement change occurred in 2010, but technical difficulties led to concern about using a 2010 comparison group for Study Period 2.

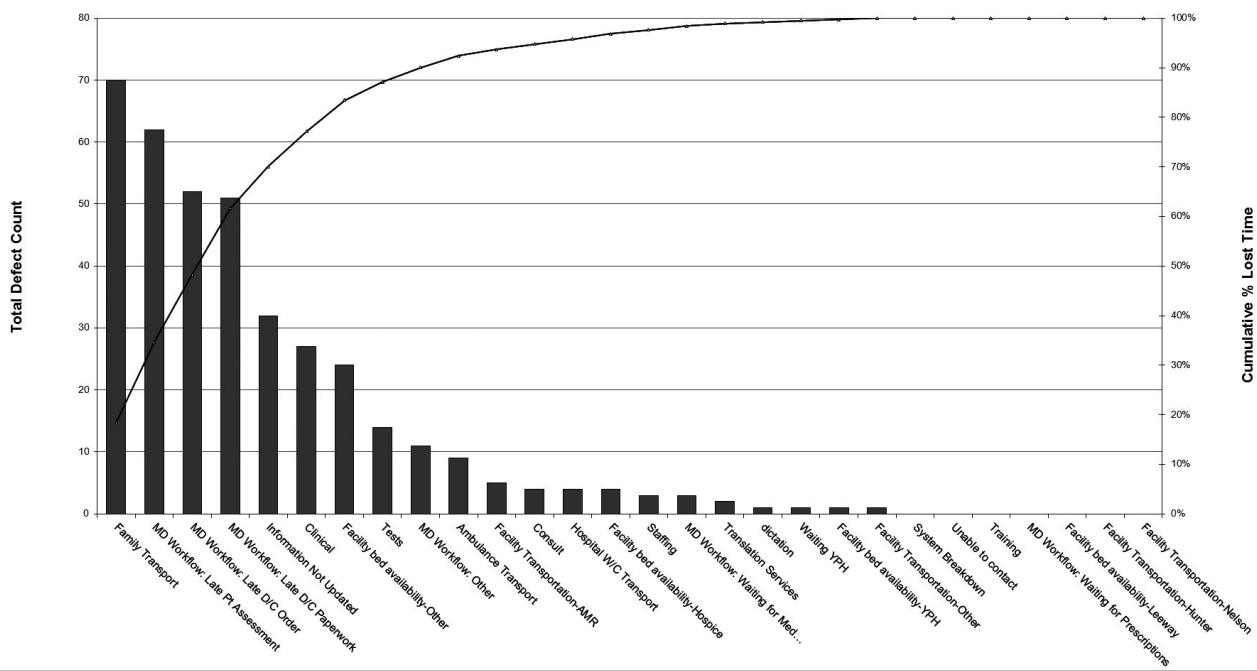

Figure 1. *This sample Pareto chart was used for the purposes of review and feedback of the Red/Yellow/Green (RYG) Discharge Tool and timeliness of 11 A.M. discharges. Reasons for discharge-ready patients (as identified by the previous day's RYG assignment) not leaving by 11 A.M. were reviewed on a unit-by-unit basis. D/C, discharge; AMR, American Medical Response (ambulance services); W/C, wheelchair; YPH, Yale Psychiatric Hospital.*

admitted to YNHH, including their RYG status. The data were imported into a database. To ensure data integrity and confirm that all inpatients were captured by the query, patient census data were reconciled with midnight hospital/unit census by YNHH's Admitting Department. The source of the RYG assignment came from either the daily progress note or sign-out document, whichever was last updated. Although practitioners were allowed to revise the RYG assignment through the day, only the latest status completed by midnight was recorded for each patient-day. We collected daily RYG assignments for every admitted patient during his or her hospitalization on medicine services during our two periods, with particular focus on the RYG status the day before discharge.

The study sample size was determined by the total number of admissions for the periods. Statistical analyses were run using the Pearson chi-square test, two-sample *t*-tests, the nonparametric Mann-Whitney U test, analysis of variance (ANOVA), and binary logistic regression. SPSS Statistics software Version 19.0.0 (IBM, Armonk, New York) was used in all analyses. Analyses comparing study periods and presence of an RYG assignment used the entire cohort with the aforementioned exclusions. Analyses regarding the specific color assignments and for the secondary outcome of prediction accuracy were done on the population with additional exclusion of those without an RYG status.

Our institution's Human Investigations Committee approved this EMR review study before the evaluation phase of this intervention. All data were gathered retrospectively.

Results

Study Population

During Study Period 1, 5,348 adult patients were discharged from the medicine unit services, while during the Second, there were 5,252 discharges. The number of patients excluded for a < 24-hour LOS was significantly higher in Study Period 1 (Table 1, page 247).

Patient characteristics, specifically, age, gender, and readmission rates, were similar between the two periods, although there was a significant increase in patients being discharged with home services by Study Period 2 ($p < .001$). There was also a significantly longer mean LOS in Study Period 2 ($p < .001$; Table 1).

Comparison between the group with RYG assignments and those without an assignment shows similar gender percentages and dispositions (Table 2, page 247). There was a higher percentage of excluded patients in the group without RYG assignments.

Table 1. Patient Population Characteristics, by Study Period

	Study Period 1 Oct–Dec 2009 (*N* = 5,348)	Study Period 2 Oct–Dec 2011 (*N* = 5,252)	*P* Value
Total number of discharged patients included in study	4,608	4,610	
Patient exclusions (*n*, % total population)			
• Length of stay < 1 day	677 (12.7)	568 (10.8)	< .003
• Left against medical advice or died during hospitalization	86 (1.6)	91 (1.7)	.617
Patient/visit characteristics (*N* = 9,218)			
Male (no., %)	2,261 (49.1)	2,305 (50.0)	.370
Age (years ± SD)	61.1 ± 18.6	61.0 ± 18.8	.733
Mean LOS (days)	5.34 ± 7.14	6.17 ± 8.82	< .001
LOS, truncated at 3SD			
• Mean (± SD)	4.61 ± 4.08	5.26 ± 4.82	< .001
• Median (IQR)	3.11 (3.73)	3.75 (4.13)	
• Range	1.00–25.22	1.00–30.67	
30-day hospital readmission rate (no., %)	1,004 (21.8)	943 (20.5)	.139
Disposition postdischarge (number, %)			
• Home	2,729 (59.2)	2,341 (50.8)	< .001
• Home with services or home hospice	890 (19.3)	1,210 (26.2)	< .001
• Facility (short-term/extended care)	989 (21.5)	1,059 (23.0)	.015
Service (number, %)			
• House staff teams	2,107 (45.7)	1,801 (39.1)	< .001
• Hospitalist teams	2,501 (54.3)	2,809 (60.9)	< .001

SD, standard deviation; LOS, length of stay; IQR, interquartile range.

Table 2. Intervention Versus Comparison Group Population Characteristics

	RYG Status Assigned (*N* = 8,400)	RYG Status Missing (*N* = 2,200)	*P* Value
Study period patients included in analysis (n, % total population)			
• First (Oct–Dec 2009)	3,499 (75.9)	1,109 (24.1)	< .001
• Second (Oct–Dec 2011)	4,184 (90.8)	426 (9.2)	< .001
Patient exclusions (*n*, % total population)			
• LOS < 1 day	614 (7.3)	631 (28.7)	< .001
• Left against medical advice or died during hospitalization	107 (1.3)	70 (3.2)	< .001
Patient/visit characteristics (*N* = 9,218)			
Male (no., %)	3,822 (49.7)	744 (48.5)	.361
Age (years ± SD)	61.3 ± 18.6	59.9 ± 18.8	.008
Mean LOS (days)	5.67 ± 8.03	6.22 ± 8.03	.013
LOS, truncated at 3SD			
• Mean (± SD)	4.88 ± 4.46	5.21 ± 4.59	.009
• Median (IQR)	3.39 (3.87)	3.80 (4.61)	
• Range	1.00–30.67	1.00–30.50	
30-day hospital readmission rate (no., %)	1,608 (21.0)	339 (22.1)	.318
Disposition postdischarge (no., %)			
• Home	4,216 (54.9)	854 (55.6)	.604
• Home with services or home hospice	1,763 (22.9)	337 (22.0)	.416
Facility (short-term/extended care)	1,704 (22.2)	344 (22.4)	.868
Service (no., %)			
• House staff teams	2,956 (38.5)	952 (62.0)	< .001
• Hospitalist teams	4,727 (61.5)	583 (38.0)	< .001

RYG, Red/Yellow/Green; LOS, length of stay; SD, standard deviation; IQR, interquartile range.

Aggregated 11 A.M. Discharge Rates for Medicine Service Units, October 2007–April 2012

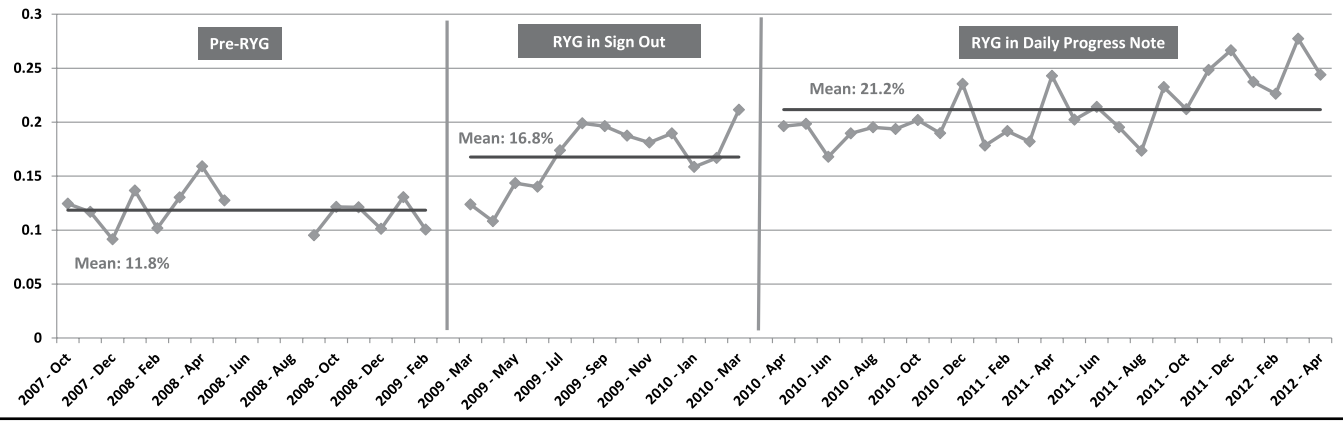

Figure 2. *The stepwise increase in 11 A.M. discharge rates for the medicine service units at Yale-New Haven Hospital is shown. The vertical dashed lines distinguish the periods of tool development (Pre-RYG [Red/Yellow/Green Discharge Tool]), tool implementation (RYG in sign-out), and tool placement change (RYG in daily progress note). By early 2012, the proportion of patients achieving 11 A.M. discharges reached 24.6%. Medicine data for June–August 2008 were unavailable.*

Primary Outcome: 11 A.M. Discharge Rate and Overall Discharge Timing

RYG Discharge Tool implementation, partnered with continued attention to process and outcomes, has led to more than 100% improvement in the percentage of pre-11 A.M. discharges on medicine services, increasing from 11.1% in the preintervention period (October–December 2007) to 18.3% by Study Period 1 and then to 24.0% in Study Period 2 ($p < .001$). Figure 2 (page 248) demonstrates the trend in percent discharge times during the pre-, peri-, and postintervention periods. The median discharge time also decreased by 48 minutes from the preintervention period in 2007 to Study Period 2 ($p < .001$; Figure 3, page 248.)

For both study periods, the presence of any RYG assignment was significantly associated with higher 11 A.M. discharge rates (19.3% versus 16.4%, $p = .006$) and earlier median discharge times (2:07 P.M. versus 2:40 P.M., $p < .001$) than for those without an RYG assignment. When disposition was controlled for, patients with an assignment, and particularly if "green," were still more likely to be discharged before 11 A.M. ($p = .007$ and $p < .001$, respectively). Of discharged patients in Study Period 1, those with a "green" designation were more likely to be discharged before 11 A.M. than those with "yellow" or "red" designations ($p < .001$). This also held true for Study Period 2 ($p < .001$), as shown in Figures 4a and 4b, page 249).

Patients with any RYG assignment discharged before 11 A.M. also had a significantly lower LOS than those without an assignment (4.31 ± 4.13 versus 5.02 ± 4.52 days, $p < .001$). Those RYG patients who were discharged before 11 A.M. had significantly lower readmission rates than those who left later in the day (16.2% versus 21.8%, $p < .001$). Overall lengths of stay and readmission rates for all discharged patients were also lower for those with a RYG assignment (see Table 2).

Secondary Outcomes: Utilization and Accuracy

Overall adherence with the RYG Discharge Tool was 75.9% (3,499 patients) in Study Period 1, with assignments as follows: "green," 43.5%; "yellow," 41.1%; and "red," 15.4%. In Study Period 2, after the change in tool placement, adherence significantly improved to 90.8% (4,184 patients; $p < .001$), with discharge assignments as follows: "green," 34.5%; "yellow," 47.5%; and "red," 18.0%. Hospitalist services used the tool more often than house staff services in Study Period 1 (86.8% versus 63.0%; $p < .001$), but this difference was not seen in Study Period 2 ($p = .498$), with both services using the tool more than 90% of the time. House staff services showed a 43.5% increase in tool use between the two periods.

Providers completed RYG assessments throughout the day in both periods. Between the two study periods, the number of patients receiving RYG assignments before 12 noon increased by 46.6%. In Study Period 1, 28.1% of patients on house staff services received assignments before noon, which increased to 34.8% of patients in Study Period 2 ($p < .001$). A similar increase occurred on the hospitalist service (11.5% to 20.5%, $p < .001$).

Practitioners predicted discharge correctly in 75.1% of patients designated as "green" in Study Period 1. However, accuracy decreased in Study Period 2, with only 59.1% of "green"

Median Discharge Times for Medicine Patients for Preintervention and Study Periods 1 and 2, October 2007–December 2011

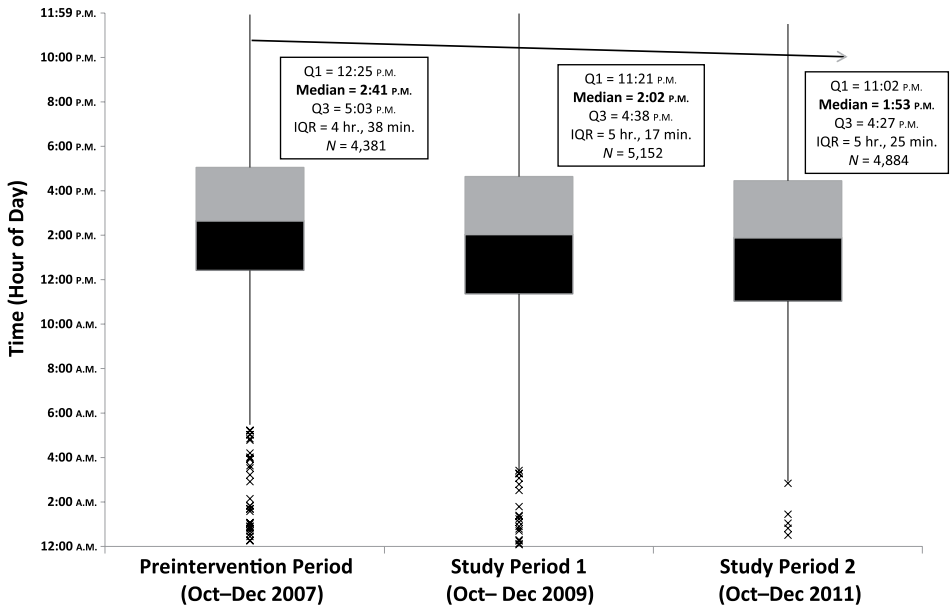

Figure 3. *The stepwise decrease in median discharge rates for the medicine unit services at Yale-New Haven Hospital is shown. The 2007 period reflects the preintervention time frame, while 2009 and 2011 represent the Study Periods 1 and 2, during which the Red/Yellow/Green Discharge Tool was in place. Q, quartile; IQR, interquartile range.*

Percentage of Discharged Patients Achieving 11 A.M. Discharge Times, Grouped by Red/Yellow/Green Designation

Figure 4a. Study Period 1 (2009)

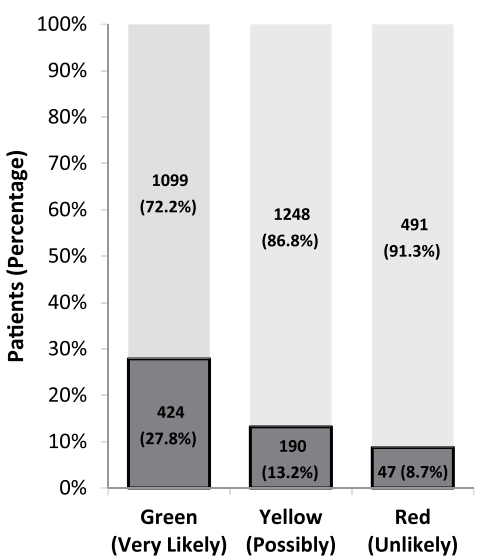

Figure 4b. Study Period 2 (2011)

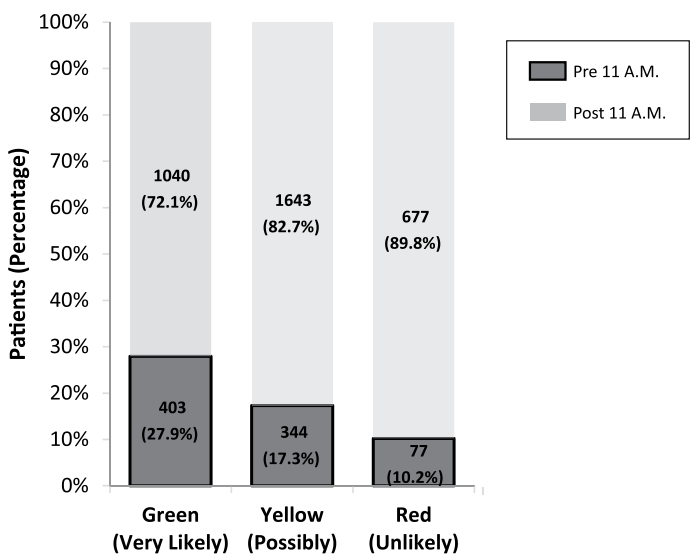

Figure 4. *These figures highlight the discharged patients who successfully achieved an 11 A.M. discharge time (solid color), grouped by their "red," "yellow," "green" designation made the day before discharge. Patients with "green" discharge assignments were more likely to be discharged by 11 A.M. than those with "yellow" or "red" assignments* ($p < .001$) *in both study periods. (Available in color in online article.)*

patients actually discharged the next day ($p < .001$). A similar decrease occurred among patients assigned as "yellow" (34.5% versus 29.2%, $p < .001$) (Figure 5, page 250). Only a small percentage of patients designated as "red" were actually discharged the next day in both periods (Study Period 1, 6.3%; Study Period 2, 5.1%).

The hospitalist service was significantly better at identifying "green" and "yellow" patients who successfully were discharged the next day than were house staff in both periods (Study Period 1, 50.7% versus 43.9%, p < .001; Study Period 2, 40.7% versus 34.8%, $p < .001$).

Discussion

Overall, the RYG Discharge Tool appeared to be both effective and straightforward to implement and use. As part of the Safe Patient Flow Initiative, the tool helped promote timely discharges.[35] There has been an overall stepwise increase in pre-11 A.M. discharges at YNHH. Those patients without an assignment in the intervention period still showed higher rates of 11 A.M. discharge than did the patients in the preintervention period, suggesting that a broader group of patients benefited from the institutionwide effort to promote earlier discharges. The patients with any RYG assignment, particularly those identified as "green" or "yellow," showed even higher rates of 11 A.M. discharge and earlier discharge times overall, indicating that the tool conferred additional benefit. Although accuracy decreased between the two periods, the "green" and "yellow "designations continued to trigger discharge steps, such as early morning huddles and initiation of time-consuming paperwork, which contributed to earlier discharges. This is evidenced by the increased 11 A.M. discharges by Study Period 2.

The overall mean LOS was significantly higher in Study Period 2, which may have reflected patient-level factors such as comorbidities and requirements of more home services (usage was significantly higher in Study Period 2). Provider- and hospital-related issues may also have contributed, including the practice of keeping patients longer as a means to avoid potential readmission and the increased assignment of more patients with expected short stays to an observation status (as evidenced by the significant decrease in patients with LOS < 24 hours by Study Period 2).[35] However, the presence of an RYG assignment was associated with an improvement in LOS, and patients who were discharged earlier did so without higher rates of readmission. These countermeasures suggest that practitioners were not holding patients longer to meet the 11 A.M. metric, nor were patients at risk for readmission by discharging them earlier in the day.

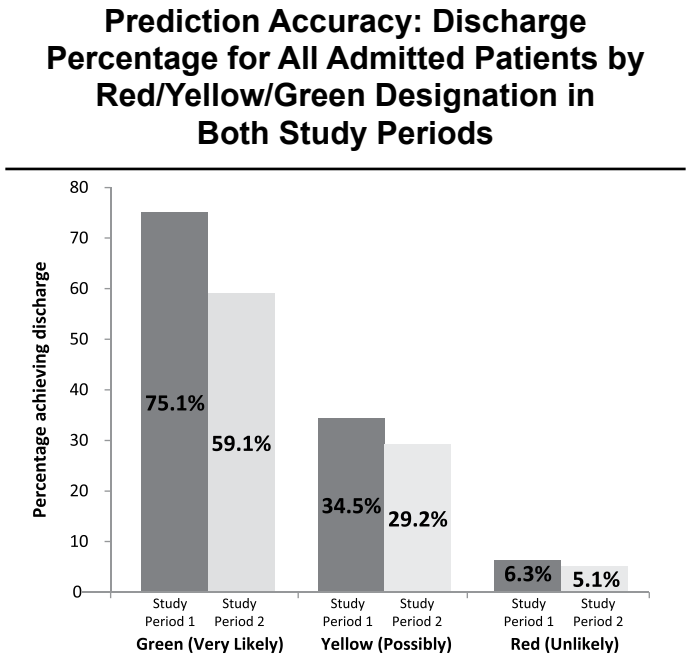

Figure 5. *The percentages of actual next-day discharge for patients who were predicted to be ready for discharge by red/yellow/green status according to the Red/Yellow/Green Discharge Tool are shown. Between the two study periods, the percentage of patients given "green" or "yellow" assignments who were successfully discharged significantly decreased (*p < .001*). (Available in color in online article.)*

Other studies have examined the discharge process and evaluated interventions to facilitate timely discharges.[36] Electronic-based communication about discharge has been described, such as the "Patient Tracker," a computer-based application that Maloney et al. used to standardize the discharge process.[22] Also, interventions similar to our use of the RYG Discharge Tool, which also deployed color alerts of red, yellow, and green, have been used to streamline treatment and discharge in hospitals.[37–40] Yet our study is the first to detail the development, process improvement, and evaluation of an easily implemented tool combining color alerts with an EMR to improve discharge planning and increase earlier discharges. Our efforts parallel other findings that accurate physician discharge predictions decrease LOS.[27]

Although we were unable to collect retrospective data about the process improvement steps, daily audits and weekly review of the variances were crucial for changing behavior. Staff became more engaged when they were given feedback about their performance and asked for their opinion about the process. Their input on tool adherence throughout the implementation period led to a change in tool placement and greater use.

Our evaluation of tool accuracy revealed that many "green"

and "yellow" patients did not successfully achieve discharge the next day, with a significant worsening in this proportion by the second study period. We discovered that inaccuracy of health care practitioners' discharge predictions affected nonpractitioner work flow. Practitioners more frequently designated patients as "yellow," an RYG category less associated with actual discharge, perhaps reflecting provider uncertainty. Interviews and focus groups with nursing revealed a perception that the RYG tool resulted in "wasted" work for these patients. This inaccuracy may be related to an increase in provider uncertainty associated with achieving discharge. Hospitalist and house staff services had significantly different prediction accuracy, suggesting that education and/or experience may contribute to practitioner choice of assignment. Predicting discharges could be addressed as a system-based practice competency, teaching characteristics of appropriate and timely patient discharges with integrated input from other disciplines. Further study will need to delineate aspects of the patient and process that can help predict early discharges.

Increasing RYG tool adherence between the two study periods was triggered, in part, by the process improvement step of changing the location of the forced prompt for RYG assignment. However, we believe that this contributed a large part to the tool's decrease in accuracy by Study Period 2. The latest update to RYG status occurred earlier in the day in that period, suggesting that patients may have been given "yellow" or "red" assignments at initiation of the daily progress note. Aspects of discharge planning completed later in the day may not have been incorporated into the discharge prediction. This is further evidenced by the decrease between study periods in the percentage of "green" patients successfully discharged the next day. Ideally, practitioners should complete discharge assignments with input from care coordination and nursing closer to the end of the work day.

Current efforts to address prediction accuracy and compliance include targeted discussion and education around the discharge process. Daily transitional care rounds that are attended by clinicians, nursing, care coordinators, and social workers have also been instituted, allowing for better communication of barriers to discharge. Next steps include testing changes around RYG work flow (for example, whether only "green" assignments should trigger discharge steps) as a means to increase discharge efficiency without decreasing the 11 A.M. discharge rate.

Limitations

As this was an observational study, we cannot make causal statements that practitioners' predictions directly contributed to patients' earlier discharge. We also did not have patient-level data on factors determining RYG status and their specific discharge planning. "Green" patients may have had clinical or social aspects that independently facilitated easier discharge. (That being said, these same "easy" patients most likely also existed prior to the implementation of the initiative, yet prior to 2008, few patients were able to get out by 11 A.M.)

We were also unable to evaluate the rate of adherence with the RYG tool's associated work flow, such as the nursing/care-coordination's discharge steps, but our study does demonstrate that those with "green" or "yellow" designations were discharged earlier than those with a "red" assignment. Leadership review of cases in which the discharge processes were not completed in a timely manner also contributed to improved discharge flow, though we are unable to quantify the impact of these process improvement steps. In addition, though we were able to estimate inefficiencies associated with "green" and "yellow" patients who did not achieve next-day discharge, we were not able to track the daily status of individual patients (for example, how many days patients stayed "green" or "yellow") to further quantify inefficiencies with the intervention.

Although we were able to compare utilization of the tool among study periods and between hospitalists and house staff, there was not a matched group of patients who did not use the RYG tool by which we could control for other confounders that could contribute to earlier discharge. The study periods may not reflect the overall discharge trends and tool utilization. However, our data suggest that the RYG tool remained effective between the two periods and continues to help improve timeliness of discharges.

Conclusions

Our study contributes to a growing literature on efficiency and communication as components of quality health care delivery. We showed that a simple electronic discharge prediction tool could help facilitate earlier discharges but that accuracy depends on experience and timing of completion. We believe that other institutions struggling to achieve early morning discharges may be able to learn from our communication process and the steps taken to develop and implement our intervention. This type of tool can be replicated in other hospitals' EMRs to help facilitate flow. Further research will need to evaluate how prediction accuracy can be improved. J

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Appendix 1. Automated Facility Board with Color-Coded Red/Yellow/Green (R/Y/G) Assignments

Figure 4. Percentage of Discharged Patients Achieving 11 A.M. Discharge Times, Grouped by Red/Yellow/Green Designation (color version)

Figure 5. Prediction Accuracy: Discharge Percentage for All Admitted Patients by Red/Yellow/Green Designation in Both Study Periods (color version)

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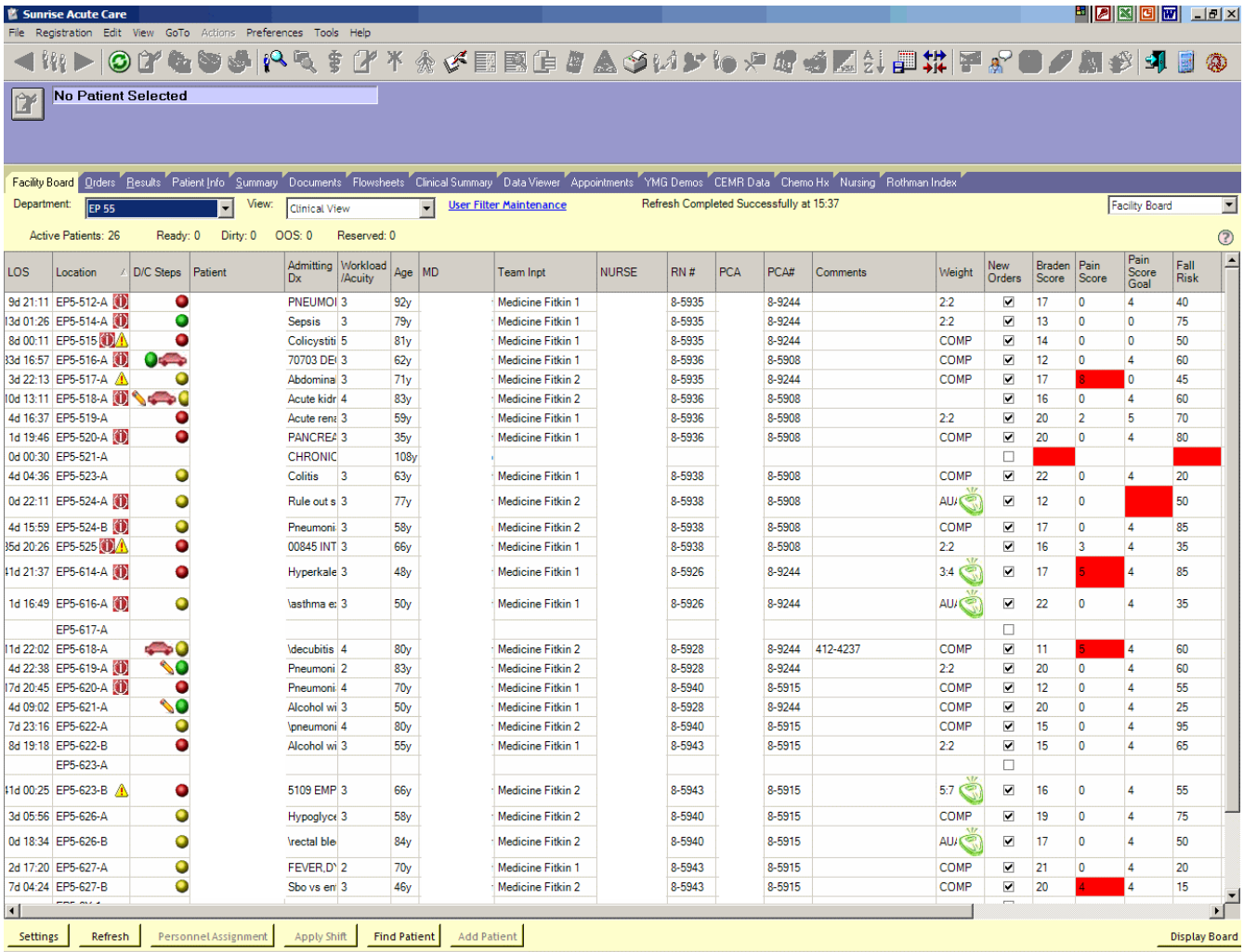
Appendix 1. Automated Facility Board with Color-Coded Red/Yellow/Green (R/Y/G) Assignments



This screenshot, from which patient-sensitive information has been removed, illustrates a sample medicine unit patient census, autopopulated with "red," "yellow," and "green" discharge assignments in the D/C (discharge) Steps column. This column also tracks the subsequent discharge steps that are triggered by the R/Y/G assignment, including discharge instructions and orders.

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Figure 4. Percentage of Discharged Patients Achieving 11 A.M. Discharge Times, Grouped by Red/Yellow/Green Designation

Figure 4a: Study Period 1 (2009)

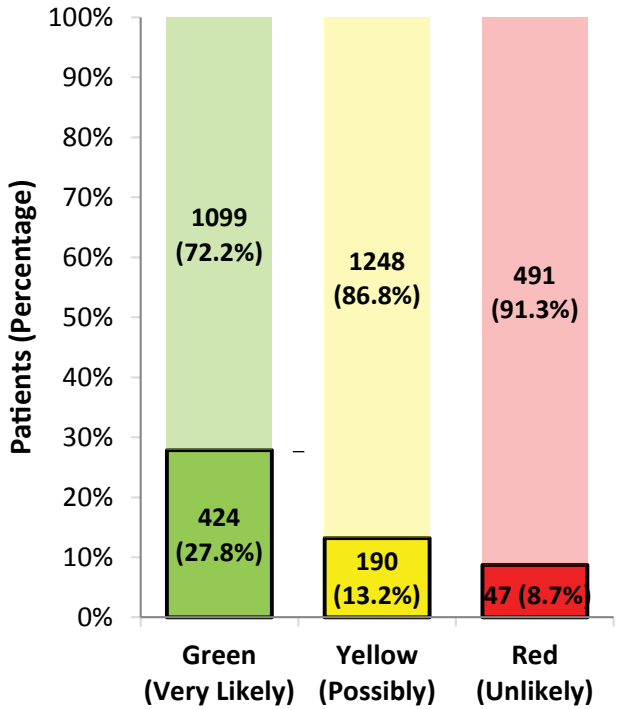
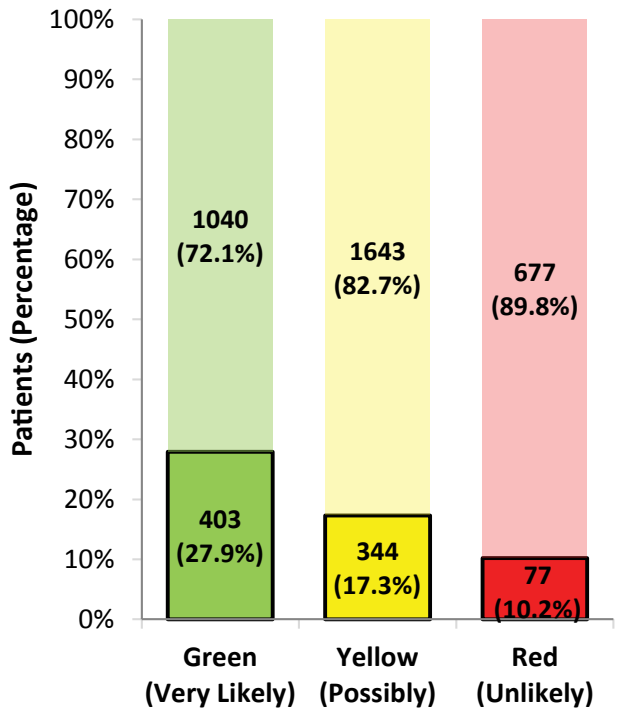


Figure 4b: Study Period 2 (2011)



These figures highlight the discharged patients who successfully achieved an 11 A.M. discharge time (solid color), grouped by their "red," "yellow," "green" designation made the day before discharge. Patients with "green" discharge assignments were more likely to be discharged by 11 A.M. than those with "yellow" or "red" assignments ($p < .001$) *in both study periods.*

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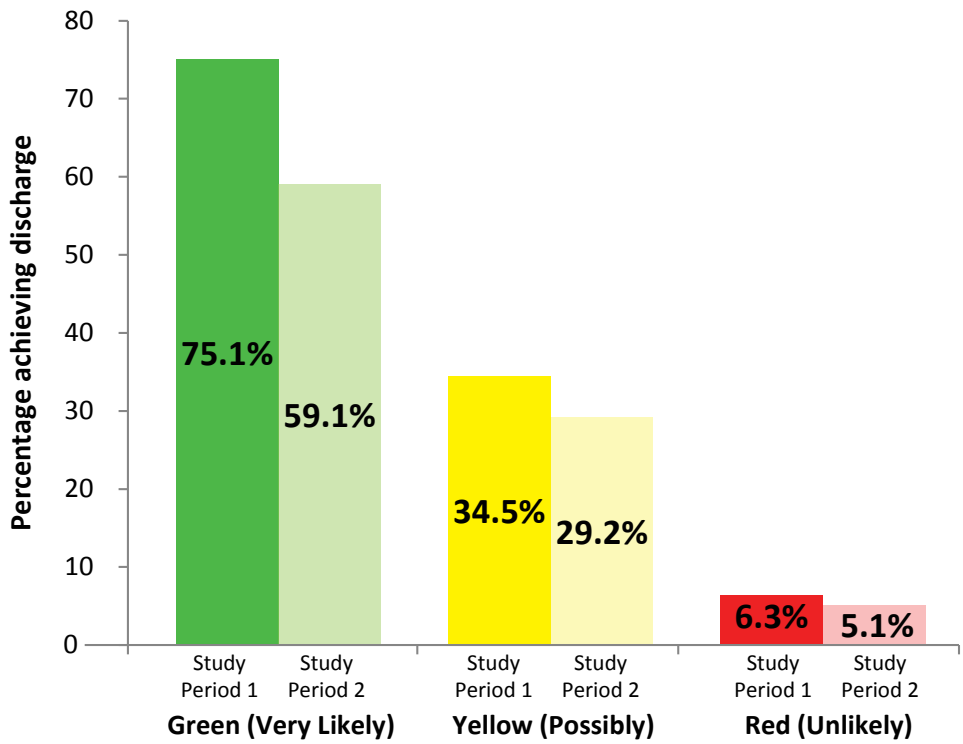
Figure 5. Prediction Accuracy: Discharge Percentage for All Admitted Patients by Red/Yellow/Green Designation in Both Study Periods



The percentage of actual next-day discharge for patients who were predicted to be ready for discharge by red/yellow/green status according to the Red/Yellow/Green Discharge Tool are shown. Between the two study periods, the percentage of patients given "green" or "yellow" assignments who were successfully discharged significantly decreased ($p < .001$).