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Implementing and Evaluating a Discharge Before Noon Initiative in a Large Tertiary Care Urban Hospital

Khadeja Kausar, MHA; Edward Coffield, PhD; Regina Tarkovsky, MD; M. Alexander Alvarez, RN, BSN, MPA; Katherine A. Hochman, MD, MBA; Robert A. Press, MD, PhD

Background: Discharging clinically ready patients before noon on their discharge day may influence overall discharge process quality, emergency department (ED) boarding times, and length of stay (LOS). This study evaluated the effectiveness of a discharge before noon (DBN) initiative.

Methods: Many DBN components were refined or added during a pilot, including incorporating the DBN process into daily rounds, an electronic tracking system, and other elements for possible DBN patients such as a car service when appropriate and expedited lab results and physical therapy consults. DBN was evaluated through a retrospective pre-post study (12-month periods). Study patients were from Maimonides Medical Center's medicine units. Kaplan-Meier estimates and a log-rank test characterized and compared the discharge time probabilities in pre-DBN and post-DBN groups. Log-logistic accelerated failure time (AFT) analysis assessed the influence of DBN on discharge time. Secondary analyses examined the relationship between LOS and readmission within 30 days for any cause and DBN.

Results: The percentage of patients discharged before noon increased from 5.0% to 11.4% pre/post-DBN ($p < 0.001$). The AFT analysis estimated that post-DBN patients had discharge times 41.5% earlier ($p < 0.001$). DBN as an independent factor was not associated with LOS or subsequent readmissions within 30 days for any cause. Despite an increase in the percentage of patients admitted during the daytime (8:00 A.M. to 5:00 P.M.), the median ED boarding time increased by 41 minutes in post-DBN patients ($p < 0.001$).

Conclusion: The DBN initiative was associated with an increased percentage of patients discharged before noon. Further research is needed to identify strategies that reliably improve discharge timeliness while reducing ED boarding.

The "discharge before noon" (DBN) concept entails optimizing the hospital inpatient discharge process to promote safe and timely discharges. DBN programs have been implemented in hospitals to influence several goals, including improving the quality of the discharge process and overall throughput,[1,2] as well as reducing inpatient length of stay (LOS)[3] and factors related to the emergency department (ED) such as ED boarding times for admitted patients[4] and ED crowding.[5] Empirical evidence regarding the effectiveness of DBN is conflicting.[6–8] For instance, researchers found that DBN programs were associated with longer LOS,[9] had no influence on LOS,[10–12] or lowered LOS[13,14] / LOS indices.[15] Similarly, some studies illustrated that DBN programs were associated with reduced readmission rates[9,10] and ED boarding times,[16,17] while other authors found that DBN programs had no impact on emergency room boarding times[11] and readmission rates.[11,12]

Despite the indeterminant evidence regarding the effectiveness of DBN and similar programs, many hospital administrators[18] continue to implement versions of such programs as a possible way to address throughput.[1,2,19] Accordingly, a continued examination of DBN programs is required to clarify the effectiveness of such programs and provide stakeholders with information to use when evaluating whether they should pursue DBN–like programs within their organizations.

This study furthers the literature by evaluating a DBN program using an accelerated failure time (AFT) model to directly evaluate how discharge times changed pre- and postimplementation of a DBN program. This model includes controls for confounding factors, providing a more detailed review of how a DBN program may influence discharge times. Second, this study illustrates how a DBN program was formulated, implemented, and adjusted within Maimonides Medical Center (MMC), a 711-bed Level 1 trauma center and academic medical center in the New York City borough of Brooklyn. MMC is the largest hospital in Brooklyn and serves as the borough's tertiary care hub, with 1.1 million people residing in the hospital's core service area.

METHODS

DBN at MMC

Before the DBN initiative, among patients admitted to MMC's medicine service line units, less than 5% of patients

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who were determined to be clinically stable for discharge were actually discharged before noon. In addition, the mean LOS in the pre-DBN implementation was 6.77 days. MMC implemented the DBN initiative on the medicine service line units with the primary objective of increasing the number of patients who receive timely discharges that are safe, effective, and patient centered.[20] Development of the DBN program at MMC comprised three stages. The first stage consisted of establishing the DBN team and developing the initial DBN program based on established practices. In stage two, the initial DBN program was piloted under a rapid prototyping methodology that allowed the team to adjust the program as needed. The third stage consisted of implementing the DBN program, as revised from lessons learned in stage two, across an entire service line.

Stage One: Leadership and Initial DBN Program Development

MMC's DBN program was initiated and sponsored by the executive vice president of Medical Affairs. Among the multiple stakeholders involved in the program, project leadership included the director of Business Intelligence and Value Based Management, the director and associate director of the Division of Inpatient Medicine, the director of Advanced Practice Providers, the vice president of Case Management and Social Work, and the program director of the Residency Program. Daily operations of the program were led by the director of Business Intelligence and Value Based Management and a team that consisted of frontline staff with representation from nursing, advanced practice providers, hospitalists, and Medical Affairs administrative interns. The development phase started internally within the Medical Affairs group with preliminary data evaluation as well as interviews and focus group discussions with frontline staff from each clinical area of the medicine service line to establish baseline process and metrics. With this information, the next step was to convene stakeholders in a meeting led by the executive vice president of Medical Affairs and included the leadership previously mentioned as well as stakeholders from the medicine service line units.

After the initial meeting, the director of Business Intelligence and Value Based Management led the process of developing a prototype DBN program based on best practices in the field. This process consisted of a literature review, brainstorming, interviewing frontline staff, and discussion with the director of a Division of Hospital Medicine at another academic hospital who had successfully implemented and sustained high DBN percentages.[15] Select practices adapted from this process are listed in Table 1.[15] These practices and the overall prototype DBN program were reviewed and approved by program leadership. After this approval, frontline staff and program leadership selected one of the hospital's multiple medicine service line units as a pilot unit. The pilot was to be implemented and reviewed using rapid prototyping methodology (RPM). RPM allows rapid testing of a process prototype to gather real-time information from the frontline staff with a short turnaround time to adopt, evaluate, and make adjustments to the prototype DBN program during the pilot stage to align with MMC's objectives.

Stage Two: Pilot and DBN Program Refinement

Pilot. The four-month pilot was initiated in the selected medicine service line unit on November 1, 2021. The practices and elements initially included in the pilot DBN are listed in Table 1. The DBN process was integrated into daily rounds, which started with the identification of eligible patients for the DBN program based on the clinical team's determination of patients being medically ready for discharge. Clinical determination of discharge readiness is defined as when the following criteria are both met: (1) a patient's acute illness is resolved or improved enough that it no longer requires close inpatient monitoring, and (2) no further inpatient diagnostic or therapeutic interventions are planned.

During the morning interdisciplinary team (IDT) rounds the clinical team identified patients who potentially could be discharged before noon on the following day. After being identified for possible discharge on the following day during these rounds, patients entered the DBN program. The unit secretary documented patients identified for DBN in SharePoint, an electronic database. These patients were further confirmed as possible candidates to be discharged before noon on the following day during the afternoon huddle on the same day of their initial selection for DBN. The clinical team then made the final determination as to whether the patient identified to be discharged before noon was indeed medically ready for discharge on the morning of the patient's projected discharge. These identified patients were rounded on early on their days of projected discharge. If a discharge was confirmed, the case management team was notified by that clinical team that the patient could be discharged.

SharePoint, as previously mentioned, is an electronic system used to document patients identified for DBN. It is an intranet-based Web solution developed by the hospital's business intelligence and information technology teams as a temporary alternative until a DBN–focused discharge list was integrated into the hospital's electronic health record (EHR) system.[21–23] During the pilot, the SharePoint site served as the discharge list as well as an accountability tool (capturing reasons for delays and cancellations of a potential discharge). The DBN discharge tracking list in the SharePoint site included patient name, assigned location/unit, discharge status (pending, discharge canceled), and anticipated discharge date. In addition, the site featured dropdown options (yes, no, and blank) for house staff, nursing, and case management to document completion of various discharge-related tasks. The discharge list included dis-

Table 1. Select Practices Developed During the Development and Refinement Stage of Discharge Before Noon (DBN) Program

Initial DBN Program Development Stage Improvements	Source
1. Adaptation of a 4-question template to be followed during the interdisciplinary team rounds: (a) Why is the patient here? (b) Why is the patient still here? (c) What has to happen for the patient to leave the hospital? (d) When and where are they going to get discharged?	Interview hospital
2. Education of providers to (a) enter consults early in the admission and earlier in the day, and (b) review all orders for tests, identify those tests that can be performed as an outpatient, and schedule them accordingly.	Internal and brainstorming sessions
3. Creation of roles and responsibilities document for all care team members	Interview hospital and their published literature*
4. SharePoint site developed to document possible candidates to be discharge before noon on the following day.	Interview hospital, internal brainstorming sessions
5. Conduct multidisciplinary kickoff event. In this event, all team members, including the voluntary attendings, received an education on the DBN project and a clear description of roles and responsibilities.	Interview hospital and their published literature*
6. Posting signs in patient areas to remind patient and families that the discharge time is 11:00 A.M.	Internal and brainstorming sessions
7. Weekly scorecards of DBN by units	Internal sessions
8. Monthly celebration of units that met the goal of 20%	Interview hospital
DBN Program Refinement Stage Improvements	**Source**
1. Car service (Uber) for nonmedical transport patients	Feedback from case management to resolve transportation challenges
2. Prepackaged food	Feedback from hospitalists and nursing
3. Expedited physical therapy consults for patients identified as DBN	SharePoint-captured reasons for delay
4. Expedited lab results for patients identified as DBN	SharePoint-captured reasons for delay
5. Pharmacy residents joining daily rounds for medication reconciliation	Hospitalist suggestion at weekly meeting
6. Discharge tracking list in electronic health record	Interview hospital

* Wertheimer B, et al. Discharge before noon: an achievable hospital goal. J Hosp Med. 2014;9:210–214.

charge summary, medication reconciliation and tests pending the following day for house staff to complete, 24-hour discharge notice, transportation services arranged for case management to complete, and teaching provided and patient belongings returned for nursing to complete.

For the pilot, a place within the SharePoint site was also present for team members to enter any discharge delay(s)/cancellation(s) for patients identified as DBN as well as the reasons for the delay(s)/cancellation(s). The SharePoint site provided a centralized location for all team members to view, track, and make entries on the discharge lists of patients identified for the DBN program. Accordingly, hospital staff, nursing, and case management teams updated patient DBN information through SharePoint as they completed their discharge tasks. The SharePoint system then generated automated e-mails twice a day (12:00 P.M. and 4:00 P.M.) to maintain communication and collaboration between patients' care teams throughout the DBN planning process.

Project leadership during the pilot consisted of the DBN project team and frontline staff from all clinical areas of the pilot unit. Frontline staff consisted of the unit's hospitalist, residents, nurse, case manager, house staff (advanced practice providers and residents), and unit secretary from the pilot unit. In addition, the team included leadership from case management and physical therapy as well as medical chief residents, representing all house staff. The team members met weekly, while daily, nonclinical operations, were led by the director of Business Intelligence and Value Based Management. During the initial stages of the pilot, the director of Business Intelligence and Value Based Management was physically located in the pilot unit to provide continuous support for the program. In addition, Medical Affairs administrative interns assisted the unit team in answering questions, assisting with the new SharePoint site, and reporting any challenges they observed.

Following RPM practice, information from the DBN prototype (the pilot) and feedback from the customers (all clinicians) was collected through daily observations and weekly meetings. Feedback that was gained in multiple ways—observational information, data from the SharePoint site, and ideas generated from weekly meetings—was synthesized by team members for continuous process improvement. This process allowed MMC to capture the voice of stakeholders and helped to build their buy-in throughout the development and implementation of the DBN pilot. Clinical leadership also provided periodic DBN pilot debriefings in separate meetings of their respective groups (hospitalists, residents, advanced practice providers, and nursing and case management). Disseminating the pilot process and outcomes across the medicine service line units allowed opportunities to obtain communication and

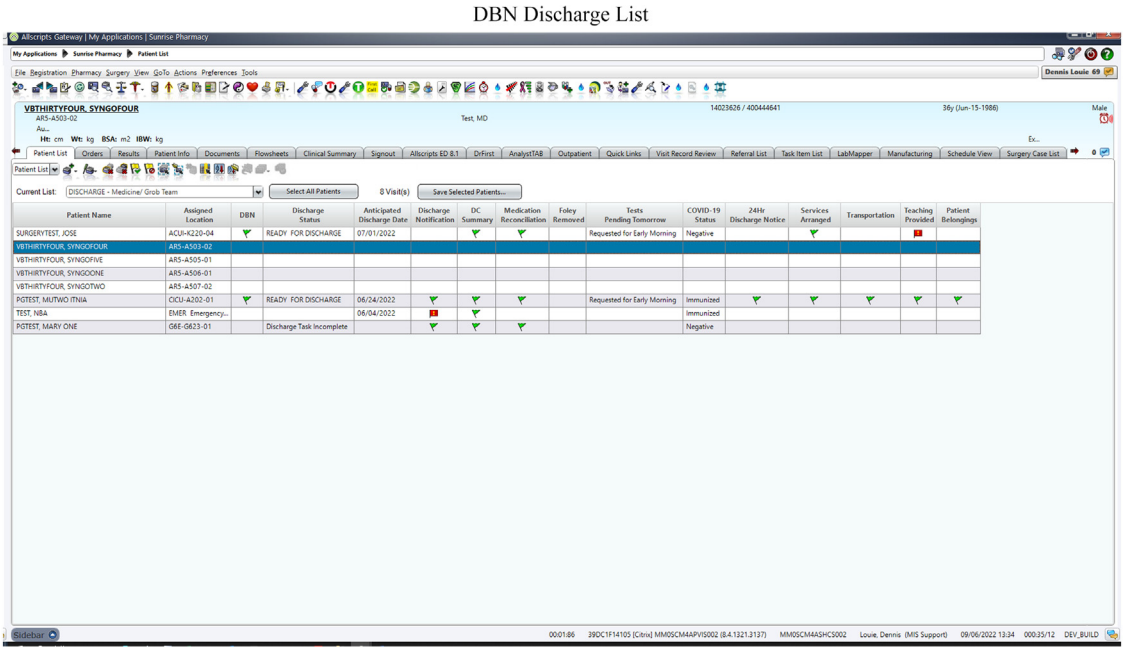


Figure 1: Shown here is a screenshot of the discharge tracking list in the electronic health record. DBN, discharge before noon.

feedback from all clinicians and increase project awareness, thereby creating a shared understanding of the project's goals.

DBN Program Refinement. The pilot unit achieved a DBN rate of 20% of all discharged patients. Within the first two weeks of the pilot, 24.1% of admitted patients were discharge before noon, while the average number of admitted patients discharge before noon over the entire pilot was 13.7% (November 1, 2021–February 28, 2022). The pilot provided objective data and valuable feedback from stakeholders that was used to refine the initiative. Areas of improvement were identified through SharePoint-based and other data, team meetings, and direct floor-based observations. Using this information, the team looked for patterns as well as the frequency with which challenges arose to determine when an adjustment or alteration in the DBN process was required.

Areas identified for process improvement consisted of transportation, food services, physical therapy, laboratory results, medication, and, refinements to the discharge list. Solutions to these challenges are illustrated in Table 1. As illustrated in the table, for the team to address a transportation challenge with the support of case management, patients who did not need medical transport were provided a car service (Uber, with support of case management). Second, to address patient wishes to wait for a meal, take-home-ready prepackaged food was provided for DBN patients. Third, case managers created a communication process with physical therapists to expedite in-house physical therapy evaluations that are essential for safe discharge planning. Fourth, to expedite final clearances that required external laboratory results, a process was created wherein external lab managers were notified by e-mail about DBN patients, with the expectation that results were then prioritized. Fifth, pharmacy residents joined daily rounds for medication reconciliation completion and prior authorization acquisition. This addition introduced an extra layer of safety in medication reconciliation. Finally, an EHR–based DBN discharge list was created. This list, illustrated in Figure 1, replicated the information captured in the SharePoint site and simplified the process of documenting the patients as DBN for the next day in the EHR directly. This EHR–based DBN discharge list consists of patients' current location and discharge status, anticipated discharge date, and all elements that affect discharge readiness.

Stage Three: Implementing DBN Throughout the Medicine Service Line Units

The revised DBN process, with the pilot-identified changes, is illustrated in Figure 2; Table 1 provides a list of key DBN program elements; and the discharge tracking list currently in the EHR is illustrated in Figure 1. This is the DBN model that was implemented across the medicine service line units on March 1, 2022. Implementing DBN across the medicine service line units began with a kickoff event for each unit where service line leadership discussed the importance of timely and safe discharges as well as results from the DBN pilot with all care providers. During these meetings, the DBN process was explained and program roles and responsibilities were defined. Although patients and families were not provided education specifically about this process

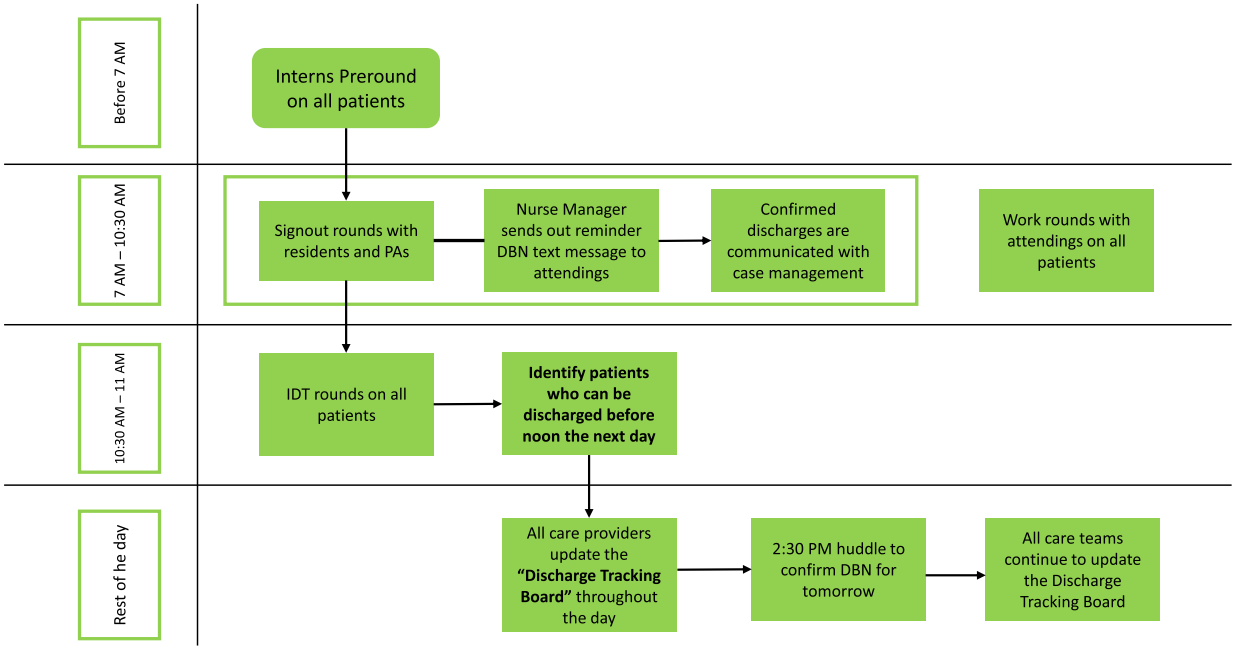


Figure 2: Shown here is the discharge before noon (DBN) initiative process model. PA, physician assistant; IDT, interdisciplinary team.

improvement project, signs were posted in patient rooms illustrating that the discharge time was set at 11:00 A.M.

The Medical Affairs administration team provided continuous support to the units during implementation and was physically present to assist with questions and document any challenges with the process. The director of Business Intelligence and Value Based Management from the Medical Affairs administration team continued to manage the daily operations of the DBN program. For residents rotating through the service line units, education was provided by the attendings responsible for the unit. These attendings, as well as nurse managers, medicine chief residents, case management, and leadership of advanced practice providers, participated in weekly meetings in which challenges to discharges and possible solutions were discussed. Representation from supporting disciplines (for example, radiology, laboratory services, podiatry, physical therapy) were invited as needed. The first DBN goal for each unit was to discharge at least 20% of all discharges for the day before noon. A recognition system, including pizza parties, was implemented to celebrate attaining this goal.

Data and Study Population

MMC's Institutional Review Board (IRB) deemed this study a Healthcare Operations Activity; thus, it was exempted from IRB approval. MMC patients included in this study were admitted to the medicine service line between November 1, 2020, and February 28, 2023. Patients under observation status were not included in the study. Patient discharge data allowed an exploration of the possible direct effects of the DBN program (for example, whether more medicine service line unit patients were discharged before noon, whether there was a change in the average time of discharge). Data from admitted patients allowed an evaluation of possible indirect effects of the DBN program, including changes in ED boarding times because of earlier availability of beds. The pre-DBN implementation group consisted of patients discharged from November 2020 through October 2021; the post-DBN implementation group consisted of patients discharged from March 2022 through February 2023. The gap between the two groups was the period in which the pilot DBN program was implemented. During the two years evaluated in this study, the percentage of COVID-19–positive cases fluctuated greatly in Kings County, New York. These fluctuations could influence the results of the study. Accordingly, as highlighted in the statistical analysis section, we included a study variable to control for COVID-19 at MMC.

Among the selected population, patients admitted to ventilator support and stroke units in the medicine service line units were excluded from the sample because of low discharge numbers on any given day. In addition, patients with a discharge status of expired were not included the sample.

Study Variables

Patients' clinical and demographic variables as well as their discharge units were abstracted from MMC's enterprise data warehouse ($n = 15{,}465$). The study's analytic sample was created to include patients who had complete variable data ($n = 14{,}993$). Time of discharge was placed in hour increments. For instance, patients discharged between 1:00 A.M. and 1:59 A.M. were considered discharged at 1:00 A.M.

Patients discharged from 12:01 A.M. to 11:59 A.M. were identified as being discharged before noon. For patients admitted through the ED, their ED boarding times as well as their arrival time at their medicine service line units were obtained from MMC's teletracking system. ED boarding time was defined as the time (minutes) from the ED clinicians' requests to transport patients to the time (minutes) that the patients arrived on the medicine service line unit. This metric was grouped by the hour.

Patients' clinical characteristics consisted of their discharge status (home, hospice, nursing home/skilled nursing facility/other discharge status), LOS, and subsequent readmissions within 30 days for any cause. The subsequent readmissions within 30 days variable accounts for whether a study patient has a subsequent readmission within 30 days of a prior admission within the evaluated periods. This variable is not fully accurate, as we only know about readmissions that occurred within MMC, preventing a full analysis with the subsequent readmissions within 30 days variable. This challenge, however, applies to both the pre- and post-DBN patient groups. Patients' demographic information included gender (female, male), age (years), religion (Catholic, Christian, Jewish, Muslim, none or unknown religion, and other religion), race (African American/ Black, Asian, white, and other or unknown race), ethnicity (Hispanic, Non-Hispanic, and unknown ethnicity), marital status (divorced, married, other marital status, separated, single, and widowed), and health insurance status (commercial, Medicaid, Medicare, and other insurance status).

The final study variable was introduced to control for the prevalence and incidence of COVID-19 within the community. COVID-19 prevalence and incidence in the community may have influenced the time at which patients were discharged from the hospital. For this measure, we selected the percentage of the hospital's beds that were occupied by patients with COVID-19. The use of a hospital-focused measure allows a more direct examination of how COVID-19 may have influenced hospital resources and therefore the time at which patients were discharged. The percentage of the hospital's beds with COVID-19 patients was identified through the information provided by the Centers for Disease Control and Prevention.[24] For some observations, the number of available beds was missing; for consistency, we assumed 711 beds across the time period evaluated in this study.

Statistical Analysis

A series of statistical analyses were completed for this study. An analytic sample consisting of patients discharged during the 12-month pre- and post-study periods with complete variable data was generated. Descriptive statistics for patients' clinical and demographic characteristics were computed for patients in the pre-DBN group and patients in the post-DBN group. Statistical comparisons were then conducted on these variables between the pre- and post-DBN groups using chi-square test and *t*-tests. The next two statistical analyses were structured from a time to event perspective (for example, did the time to discharge differ among pre- and post-DBN medical unit patients?). The first analysis in which time to discharge was the analytical framework consisted of estimating probabilities of discharge time, in hour segments, for the pre/post-DBN groups through the Kaplan-Meier method. Statistical differences between the pre/post-DBN Kaplan-Meier curves were estimated with a log-rank test.

The second analysis using time to discharge as the analytical framework consisted of a log-logistic accelerated failure time (AFT) analysis. The AFT was conducted to assess the impact of the DBN initiative on the time to discharge while controlling for patients' clinical and demographic factors, including LOS and subsequent readmissions within 30 days. These two variables are included in the AFT analysis, as each—like the DBN initiative—could influence when a patient is discharged. For instance, a longer LOS may provide more time for discharge planning and completing needed tests. Similarly, patients who were discharged from a prior hospitalization and readmitted for a subsequent hospitalization within 30 days may be more familiar with the discharge process, and the facility staff may be more familiar with the needs of these patients at discharge, thereby influencing the discharge process. The log-logistic parametric model was chosen among other models by selecting the model with the smallest Akaike information criterion. The Huber-White sandwich estimator, as implemented in statistical software package Stata,[25] was used to account for the lack of independence between the observations.

The Kaplan-Meier and AFT analyses provided insights into how the time to discharge changed from the pre-DBN period to the post-DBN period, which was the primary focus of this study. However, as a secondary level of analysis, we estimated regression models to evaluate whether the DBN program was associated with LOS and subsequent readmissions within 30 days. In these models, LOS is a dependent factor in one model, while subsequent readmissions within 30 days is a dependent factor in the second model. A binary variable indicating if the patient's admission was in the pre- or post-study period is included in each model to evaluate the association between the DBN initiative and the dependent variables.

The first secondary analysis was a negative binomial regression model (NBRM) in which LOS was the dependent variable. NBRM was selected due to the count-based nature of the LOS variable. The second analysis was a logistic regression in which subsequent readmissions within 30 days was the dependent, binary variable. The purpose of this regression was to estimate whether subsequent readmissions within 30 days were associated with the DBN program. In both regressions, the key independent variable was the binary variable denoting whether patients were included in the DBN program. Additional independent variables are

Table 2. Characteristics and Means Comparison of Pre-DBN and Post-DBN Groups ($n = 14,993$)*

	Pre-DBN Mean (SD) or % ($n = 7,512$)	Post-DBN Mean (SD) or % ($n = 7,481$)	p value†
DBN‡	5.0%	11.4%	0.000
Age in years	66.87 (18.59)	67.98 (18.23)	0.000
Female	49.0%	50.3%	0.136
Religion			
Catholic	24.8%	24.1%	0.310
Christian	14.5%	15.0%	0.350
Jewish	25.1%	23.1%	0.004
Muslim	6.4%	5.6%	0.053
None or unknown religion	22.7%	24.4%	0.013
Other religion	6.5%	7.7%	0.004
Race			
Asian	15.6%	16.6%	0.096
African American/Black	15.4%	17.8%	0.000
Other and unknown race	15.4%	14.7%	0.183
White	53.6%	50.9%	0.001
Ethnicity			
Hispanic	13.8%	12.9%	0.089
Non-Hispanic	80.1%	81.3%	0.057
Unknown ethnicity	6.1%	5.8%	0.465
Marital status			
Married	42.4%	41.3%	0.196
Divorced	5.4%	6.1%	0.059
Separated	1.3%	1.4%	0.422
Single	34.4%	34.9%	0.598
Widowed	15.4%	14.9%	0.435
Other marital status	1.2%	1.4%	0.234
Insurance			
Medicaid	29.6%	27.9%	0.019
Medicare	60.5%	63.5%	0.000
Commercial	9.5%	8.1%	0.003
Other insurance status	0.4%	0.5%	0.517
Discharge status			
Home	68.2%	64.2%	0.000
Hospice	1.7%	1.8%	0.637
Nursing home/Skilled	30.1%	34.0%	0.000
Nursing home/Skilled			
Nursing facility/Other discharge status			
Length of stay	6.77 (7.10)	7.00 (8.99)	0.077
30-day readmission	12.7%	14.3%	0.003
COVID-19 patient occupancy	8.9%	4.8%	0.000

* Analytic sample with complete variable data.
† χ^2-test and t-tests.
‡ Patients discharged from 12:01 A.M. to 12:00 P.M. were identified as being discharged before noon.
DBN, discharge before noon; SD, standard deviation.

the same as those in the AFT model and are listed in Table 2. Furthermore, the Huber-White sandwich estimator was applied in each model.

The final evaluation consisted of the ED boarding time analysis. For this analysis, the median ED boarding time (in minutes) of pre/post-DBN ED–admitted patients was computed and then compared with a Wilcoxon rank-sum (Mann-Whitney) test. For the second ED boarding time evaluation, mean and median arrival time from the ED to an inpatient bed among the pre/post-DBN time groups were computed and compared using the Kolmogorov-Smirnov test. The Huber-White sandwich estimator, as implemented in statistical software package Stata,[25] was used to account for the lack of independence between the observations. Stata 17 was the primary statistical software used to complete the analyses.[26]

RESULTS

Evaluation of DBN Program in Medicine Service Line Units

A total of 14,993 patients met the study's inclusion criteria; the pre-DBN group consisted of 7,512 patients (50.1%), while the post-DBN group consisted of 7,481 patients

Table 3. Percentage Increase in Discharge Before Noon (DBN)* and Decrease in Average Time to Discharge Across All Study Units

	Mean DBN (% [*n*])		Mean Time to Discharge (SD in Hours)		Median Time to Discharge (IQR in Hours)	
	Preintervention	Postintervention	Preintervention	Postintervention	Preintervention	Postintervention
Overall	5.0% (7,512)	11.4% (7,481)	5:31 P.M. (3.20)	4:35 P.M. (3.11)	6:00 P.M. (3)	5:00 P.M. (4)
Pilot Unit	6.8% (1,459)	17.6% (1,447)	5:19 P.M. (3.33)	4:15 P.M. (3.38)	6:00 P.M. (3)	5:00 P.M. (5)
Unit A	3.7% (684)	7.1% (789)	5:50 P.M. (3.19)	4:44 P.M. (2.97)	6:00 P.M. (4)	5:00 P.M. (4)
Unit B	4.7% (1,356)	10.8% (1,301	5:15 P.M. (3.07)	4:30 P.M. (3.02)	5:00 P.M. (3)	5:00 P.M. (4)
Unit C	5.7% (1,484)	12.8% (1,578)	5:17 P.M. (3.11)	4:28 P.M. (3.10)	5:00 P.M. (3)	5:00 P.M. (4)
Unit D	3.8% (1,521)	9.0% (1,320)	5:34 P.M. (2.96)	4:52 P.M. (2.93)	6:00 P.M. (4)	5:00 P.M. (4)
Unit E	4.5% (1,008)	7.7% (1,046)	6:14 P.M. (3.52)	4:53 P.M. (3.12)	7:00 P.M. (3)	5:00 P.M. (4)

* Patients discharged from 12:01 A.M. to 12:00 P.M. were identified as being discharged before noon.
SD, standard deviation; IQR, interquartile range.

(49.9%). The pre-and post-DBN groups' characteristics are illustrated in Table 2. The percentage of patients discharged before noon in the post-DBN group (11.4%) was significantly higher ($p < 0.001$) than the percentage in the pre-DBN group (5.0%). Although the percentage of patients discharged before noon in the postintervention period was below the goal of 20%, it represents a 128.8% increase in the number of patients discharged before noon. Moreover, the frequency of patients discharged before noon increased across all evaluated medical service line units between the pre- and post-DBN periods (Table 3).

Statistically significant differences were also found between the pre-and post-DBN patients on clinical and demographic characteristics. A few select differences were the average age (pre-DBN = 66.87 years, post-DBN = 67.98 years; $p < 0.001$), the percentage of patients identifying as white (pre-DBN = 53.6%, post-DBN = 50.9%; $p < 0.001$), the percentage of patients identifying as African American/Black (pre-DBN = 15.4%, post-DBN = 17.8%; $p < 0.001$), the percentage of patients with Medicaid insurance (pre-DBN = 29.6%, post-DBN = 27.9%; $p = 0.019$), and the percentage of patients with a subsequent readmission to MMC within 30 days of discharge from a prior hospitalization (pre-DBN = 12.7%, post-DBN = 14.3%; $p = 0.003$).

The Kaplan-Meier estimator was used to evaluate the unadjusted probability of patients being discharged at certain times (hours); estimated points were then illustrated through Kaplan-Meier curves. Results from this analysis are provided in Figure 3 and demonstrate how the post-DBN group showed a marked difference in being discharged earlier relative to the pre-DBN group. Indeed, the median time to discharge—the time when 50% of discharges for the day have occurred—was significantly earlier ($p < 0.001$) in the post-DBN group (4:00 P.M.) relative to the pre-DBN group (5:00 P.M.). These results are supported by the AFT regression analysis (Table 4), where the estimated discharge

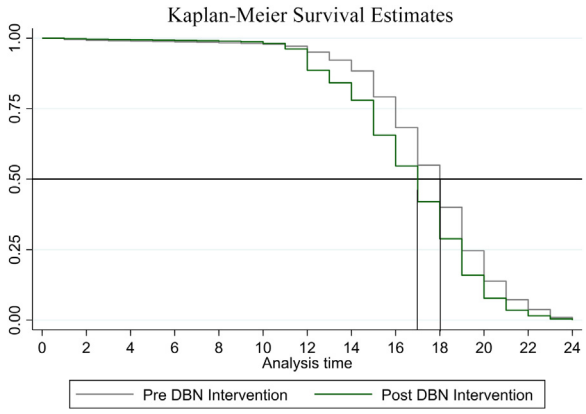


Figure 3: This graph shows Kaplan-Meier estimates of unadjusted probability of patients discharged at certain times (hours) pre- and post-DBN (discharge before noon) initiative.

time for post-DBN patients was 41.5% earlier (time ratio [TR] 0.58, $p < 0.001$) relative to the discharge time of pre-DBN patients after adjusting for patients' demographic and clinical factors. It was also estimated that the discharge time for patients being discharged to a skilled nursing facility/nursing home was 9.9% earlier relative to patients discharged to their home (TR 0.90, $p = 0.014$). For COVID-19, the discharge time was 1.5% later with each unit change in the percentage of the hospital's beds occupied by COVID-19–positive patients (TR 1.02, $p < 0.001$).

LOS and subsequent readmissions within 30 days were not associated with time to discharge in the AFT regression. To evaluate whether LOS and subsequent readmissions within 30 days were influenced by the DBN program, the secondary analyses were estimated. Results from these regressions are available from the authors. The DBN program was not associated with changes in LOS or changes in subsequent readmissions within 30 days. As noted in the Methods section, the subsequent readmissions within 30 days variable reflects only subsequent readmissions to

Table 4. Multivariate Accelerated Failure Time (AFT) Model ($n = 14,993$)

Variable	TR	TR (95% CL.L)	TR (95% Cl.U)	*p* value
Post DBN*	0.58	0.54	0.63	0.000
Age in years	1.01	1.00	1.01	0.000
Female	1.09	1.01	1.18	0.021
Religion (base group: Christian)				
Catholic	1.03	0.90	1.17	0.655
Jewish	1.06	0.92	1.22	0.426
Muslim	1.10	0.91	1.34	0.336
None or unknown religion	0.96	0.84	1.09	0.496
Other religion	1.02	0.86	1.22	0.819
Race (base group: Asian)				
African American/Black	1.13	0.98	1.31	0.092
White	0.97	0.85	1.10	0.617
Other and unknown race	0.93	0.79	1.08	0.340
Ethnicity (base group: Hispanic)				
Non-Hispanic	1.03	0.90	1.19	0.628
Unknown ethnicity	1.06	0.87	1.29	0.535
Marital Status (base group: Married)				
Divorced	1.09	0.92	1.29	0.329
Separated	0.95	0.71	1.28	0.754
Single	1.01	0.92	1.11	0.861
Widowed	0.91	0.80	1.03	0.125
Other Marital Status	1.23	0.85	1.79	0.270
Insurance (base group: Commercial)				
Medicaid	1.09	0.95	1.25	0.202
Medicare	1.12	0.96	1.29	0.138
Other insurance status	0.94	0.56	1.57	0.817
Discharge status (base group: Home)				
Hospice	0.86	0.65	1.13	0.265
Nursing home/Skilled	0.90	0.82	0.98	0.022
Nursing facility/Other discharge status				
Length of stay	1.00	1.00	1.01	0.567
30-day readmission	1.02	0.91	1.13	0.769
COVID-19 patient occupancy	1.02	1.01	1.02	0.001

* Patients discharged from 12:01 A.M. to 12:00 P.M. were identified as being discharged before noon.

TR, time ratio; CI.L, confidence interval, lower limit; CI.U, confidence interval, upper limit; DBN, discharge before noon.

MMC. Thus, the measure is not completely accurate. Although it is recommended that all discharges be included in a dataset where dependency issues may be prevalent (for example, patients with subsequent readmissions are in the dataset at least twice),[27] as a robustness check all three regression models (the AFT regression and the two secondary regressions) were estimated using only the first discharge per patient, excluding any subsequent readmissions among those patients with multiple 30-day all-cause readmissions. A binary indicator was included in these three robustness check models to indicate if a patient had one or more 30-day all-cause readmissions to MMC. Estimating these robustness check models, the AFT regression results for the time to discharge was very similar (TR 0.59, $p < 0.001$). This was true for all other variables of interest with the exception of gender, which was no longer significant. The LOS regression results as well as the results from the subsequent readmissions within 30 days regression were very similar to the results from the models that included all observations.

Evaluation of DBN Program in Medicine Service Line Units: Emergency Department

Among medical unit patients admitted through the ED (pre-DBN = 7,843; post-DBN = 7,860), the median ED boarding time was 41 minutes longer ($p < 0.001$) in the post-DBN group relative to the pre-DBN group. The mean arrival time from the ED to an inpatient bed increased from 1:39 P.M. in the pre-DBN group to 2:12 P.M. in the post-DBN group; the median arrival time remained the same for both periods at 5:00 P.M. However, the overall load of admissions shifted significantly ($p < 0.001$) in the pre and post groups, as illustrated in Figure 4. The overall daytime admission (8:00 A.M.–5:00 P.M.) shifted and increased by 7.7% ($p < 0.001$).

DISCUSSION

Based on best practices, MMC developed and implemented a prototype DBN program to further enhance safe and timely discharges. After testing and improving the prototype DBN program through a pilot, MMC implemented

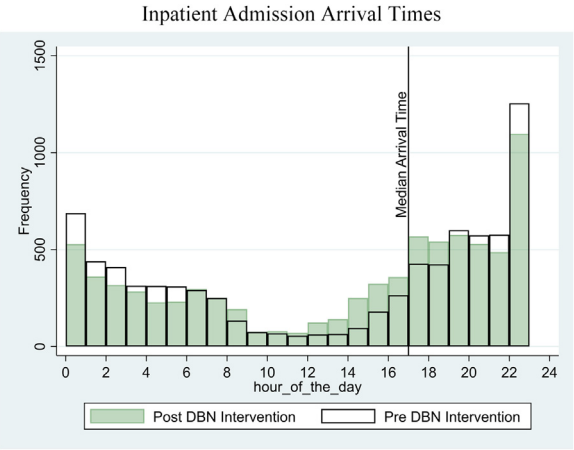


Figure 4: This graph shows inpatient admission arrival times from emergency department groups by hour of the day. DBN, discharge before noon.

the refined DBN program across all medicine service line units. During the period evaluated in this study, it was estimated that the DBN program increased the percentage of patients discharged before noon from 5.0% to 11.4% and reduced the median discharge time by one hour. These results are similar to those found in the literature.[15,16,28] In the ATF analysis, it was estimated that 41.5% ($p < 0.001$) of post-DBN patients had earlier discharge times; this was a significant relationship between time to discharge and the DBN initiative. Other independent variables of interest in the ATF models—patients' LOS and whether they had subsequent readmissions within 30 days for any cause—were not associated with time to discharge. In addition, the DBN program was not associated with changes in LOS and subsequent readmissions within 30 days, which is both similar[11,12] to and different[13] from other studies.

The positive DBN outcomes at MMC (for example, reduced median discharge time, increased percentage of patients discharged before noon) may have resulted from a series of factors. As illustrated, the DBN program was constructed from best practices, piloted, adjusted to address barriers, and then implemented with support from medical leadership. These factors may have fostered increased communication and collaboration between all team members, enabling success in increasing the number of patients who were discharged before noon. The open discussion in meetings regarding patients, the rapid implementation of solutions to barriers, and the EHR–based discharge list may also have contributed to increased communication and DBN program effectiveness.[22] This collaboration and communication was both internal and external, as MMC also adjusted communication processes with external laboratories. Although not evaluated in this study, the increase in communication and collaboration[29] may have resulted in increased clinician coordination,[30] an increase that may have reduced the time patients spend in the hospital for nonmedical reasons.[31,32]

It has been found that completing a safe, well-planned, and timely discharge may also influence outcomes such as 30-day readmission rates.[33] However, a significant relationship between DBN and readmission rates and/or LOS was not found in this study's secondary regression analyses. Although it may be that an association does not exist, factors that affect LOS and subsequent readmissions are complex, so further evaluation is needed to conclude the impact of DBN on these factors.[6,7] It is important to note that in the AFT analysis, we also found that time to discharge was not associated with LOS and subsequent readmissions within 30 days. Together, these results imply that the estimated improvements in time to discharge are not associated with adverse impacts on subsequent readmissions within 30 days. Gains from reducing the time of discharge, however, have not carried over to ED boarding time changes (for example, if a bed is open sooner, could admitted patients be moved to a room sooner?).

The percentage of ED–admitted patients to the medicine service line units from 8:00 A.M. to 5:00 P.M. increased from 15.9% pre-DBN to 23.6% post-DBN, indicating that more patients were moved to their admitted unit during the day. However, we also found that ED boarding times increased during the DBN program, a finding that does not align with the literature.[16,17] The DBN program at MMC, as examined in this study, was exclusive to medicine service line units. Capacity, staffing, and other challenges, such as acuity of patients in the ED, are factors that influence overall throughput and were external to the DBN initiative. Thus, to fully examine the increase in boarding times found here, further examination is needed to account for these factors.

The gains estimated in this study among medicine service line units' patients from the DBN program provide support for continuing the program and considering its expansion and/or additional collaborations across service lines (such as the ED). Additional evaluation may also illustrate further increases in DBN percentages as the program becomes more ingrained in the hospital, as well as changes in other areas not yet examined, such as patient experience (the DBN program may influence patient experience through a number of factors, such as facilitation of movement to their next level of care earlier). These and other changes (for example, providing nonmedical transport and food, pharmacists participating in IDT rounds) may influence patient care and experience and should also be evaluated, as should a continued review of how DBN may influence ED boarding times.

Limitations

Study limitations begin with the study being based on a multiple-unit service line within one facility. Whether similar outcomes would be found in different service lines

within the same hospital or in other hospitals is unknown. Second, although the results presented here are based on one year of data, it is not known yet whether the DBN program, as implemented through the multistakeholder approach, generated long-term change in the discharge process, thereby ensuring that similar results to those found here will also be found in the future. It is also noted that the findings from the AFT analysis illustrate a statistically significant association between time to discharge and the DBN program; this correlation does not imply causation. Another limitation is the very likely possibility of incomplete information regarding the subsequent readmissions within 30 days variable. We only know patients who were readmitted to MMC; patients admitted to other facilities are not included in this measure. Last, the study did not estimate the costs and benefits of the DBN program. This is an area that is ripe for future research to better evaluate DBN programs and their cost-effectiveness.

CONCLUSION

The DBN program at MMC resulted in estimated improvements in the percentage of patients discharged before noon in the medicine service line units. Creating a shared understanding, channels for feedback for continuous process improvement, education, and support for the clinical team are elements that likely help explain the program's estimated success in improving the percentage of patients discharged before noon. Additional evaluation is needed to study how the program's effectiveness changes in the longer term and the possible influence on other factors, such as ED boarding times and patient experience.

Conflicts of Interest. All authors report no conflicts of interest.

Khadeja Kausar, MHA, is Director, Business Intelligence and Value Based Management, Medical Affairs, Maimonides Medical Center, Brooklyn, New York. **Edward Coffield, PhD**, is Associate Professor, Department of Population Health, Hofstra University. **Regina Tarkovsky, MD**, is Director of Inpatient Throughput Management, Associate Director of the Division of Inpatient Medicine and Chair of Continuing Medical Education Committee, Maimonides Medical Center. **M. Alexander Alvarez, RN, BSN, MPA**, is Vice President, Case Management and Post Acute Transitions, Medical Affairs, Maimonides Medical Center. **Katherine A. Hochman, MD, MBA**, is Director, Division of Hospital Medicine, and Associate Professor, Department of Medicine, NYU Langone Health, New York City. **Robert A. Press, MD, PhD**, is Executive Vice President, Medical Affairs, Maimonides Medical Center. Please address correspondence to Khadeja Kausar, kkausar@maimonidesmed.org.

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