Original Research

IMPROVING SAFE PATIENT THROUGHPUT IN A MULTIDISCIPLINARY ONCOLOGY CLINIC

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In this article...

An oncology clinic conducts research to uncover ways to reduce downstream clinic visits by identifying high-value tasks that must be completed.

MULTIDISCIPLINARY CLINICS (MDCS) HAVE become common models for cancer care delivery in the United States and abroad.[1-3] A MDC model increases the accuracy of initial staging[1, 4] and is even associated with improved survival for breast, ovarian and pancreatic cancers.[5-7]

MDCs involve multiple providers, including oncologic specialists, radiologists, and pathologists, social work, palliative medicine, cancer pain specialists and nutritionists.[8]

Indeed, a major organizing principle for MDCs is to provide a common forum for discussion of patient cases among many or all providers offering care, facilitating communication and coherence of a final treatment plan.[9] Patients with a new diagnosis are also offered a one-stop experience for initial clinical consultations, explaining (at least in part) the favorable patient satisfaction surveys for MDCs.[10]

Despite these advantages, providers have not been unanimous in implementing multidisciplinary cancer clinics. In part due to challenges coordinating larger team structures under an increased task burden, surveys have identified administrative barriers that impede workflow and render the established processes of traditional clinic settings inert.[11]

In addition, providers worry that the MDC model is less sustainable financially. Institutional resource requirements (salaried staff, clinic space, etc.) for MDCs are high, and providers worry that these fixed costs will be amortized over a comparatively lower throughput of patients in the MDC setting.[1]

Cancer centers have addressed these challenges by developing organizational guidelines and best practices for implementing multidisciplinary cancer care,[8] and one framework exists for approaching efficiency in the multidisciplinary cancer care setting.[12] However, evidence-based tools to predict and manage the substantial task burden of a large patient census in a multidisciplinary clinic are currently unavailable.

The Military Acuity Model (MAM) is an operations management methodology focused on the execution of high-value clinical tasks at the point of care.[13] The methodology is centered around three core principles.

1. The first is the concept of process mining, or retrospectively determining which tasks are most deterministic of health and efficiency outcomes.
2. The second is cognitive capacity modeling, which uses algorithms to determine the task "tipping point" of individual providers at the point of care (upon which the likelihood of task saturation, and as a result, task failure,

increases substantially). It determines a point of provider "cognitive overload" by correlating patient and provider-specific factors to historical task execution rates.

3. The third is process arbitrage, which uses data from the first two principles to reallocate tasks (either prospectively or in real-time) from providers who are at risk of cognitive overload to a dedicated team of support staff (quality teams, etc.)

Underlying all of these principles is a need for a culture change, focused on offloading tasks that can be safely reallocated from physicians and nurses ("bottleneck" resources) to other staff members. Finally, central to the execution of these methods is a performance improvement coordinator (PIC), who oversees the cognitive bandwidth of providers and reallocates tasks accordingly.

The MAM has improved task execution in the inpatient setting, reducing costly readmissions and improving CMS quality core measure compliance.[14] To our knowledge, there have been no attempts to model unique personnel or resource needs for cancer MDCs. To date, the MAM methodology has not been formally tested in the outpatient setting.

The use of MAM in the MDC setting could mitigate efficiency challenges by allowing institutions to focus on the most important clinic tasks to ensure high-quality care. Importantly, this effect could also liberate the valuable time of physicians and nurses, as lower-value tasks are triaged out of workflow.

The ultimate goal of the MAM is to be able to encounter more patients safely, precisely via this mechanism of identifying (and executing) high-value tasks. If physicians are not allotted enough time in clinic for data review and clinical decision-making, errors or missed tasks are more likely.

This can lead to further preventable clinical encounters downstream, simply to handle the consequences that ensued because of inappropriate task allocation at the outset. Because labor productivity in health care is among the lowest of all industries,[15] predicting the likelihood of task execution for each provider could improve clinical outcomes, clinic operations and financial sustainability. MAM functions by reallocating high-value, yet fungible tasks away from physicians and nurses to qualified support staff.

We implemented the Military Acuity Model methodology at our institution's pancreatic MDC. Using MAM, we reallocated high-value, yet fungible tasks prospectively via multiple strategies and tracked productivity, efficiency and quality metrics.

In doing so, we attempted to address three key questions:

1. Can MAM identify tasks that are deterministic for both clinical volume capacity (provider time) and relevant clinical outcomes?
2. Can the methodology increase patient volume (and thus efficiency) of clinic operations?
3. Can MAM also maintain or improve clinical quality metrics, yielding an increase in the potential "safe volume" of patients seen in the MDC?

METHODS — The first step in the implementation of MAM required process mining, or identifying tasks that, when not completed, lead to increased physician room time, ED visits and patient phone calls.

Task execution failure was defined as either:

- A missed task.
- Tasks that delayed the clinic schedule, increasing the amount of time required to evaluate a patient.

A total of 139 consecutive patients, seen before May 24, 2011, (date of MAM implementation) constituted the cohort used for process mining analytics. An original list of 25 daily clinic tasks was formulated by consensus among physicians, nurses and other staff as the most important clinical information required to determine the treatment course for pancreatic cancer.[16]

TABLE 1

HIGH-VALUE TASKS OF THE PANCREATIC MULTIDISCIPLINARY CLINIC

1	Determine patient's assumed disease stage prior to clinic.
2	Obtain or perform necessary imaging studies.
3	Determine which therapies, if any, the patient has received to date.
4	Assess patients' comorbidities and offer treatment options accordingly.
5	Assess patients' social risk factors and offer treatment options accordingly.
6	Assess patient's pain level and treat accordingly.

The information gained as a result of each task was obtained from electronic health records. All times that physicians spent in patient rooms were recorded by individual volunteers tasked with writing the entrance and exit times of staff (the difference of which equaled physician room time).

Care was taken to note the specific providers for whom time was recorded, and only data for one specific oncologist for each role (i.e., the same medical, surgical and radiation oncologist) were included in the analysis to control for provider-to-provider variation in times. When an event was missed by a recorder, that time data point was labeled as "missing" in the statistical analyses.

Linear discriminant analyses were used to identify the particular tasks most associated with extended clinic times, our operating definition of "cognitive overload," or the point at which providers were saturated with tasks.

The variables associated with these tasks were further evaluated in multivariate linear and generalized linear regression models with adjustment for potential confounders. For ordinal variables, chi-square tests were used to find associations in two-way contingence tables and a generalized estimating equation was used in multivariate logistic and Poisson regression analyses.

Significant individual factors and combinations of factors were tabulated for each type of staff, comparing mean times required for patients with specific predictor(s) and those without. Standard errors and p values were determined via a multivariate regression mode of all combinations of factors.

Similar regression methods were used to determine which characteristics were associated with downstream outcomes. The specific outcomes measured included the number of ED visits per patient (and number of patients with ED visits) with the same diagnosis code as the initial clinic visit, and the number of phone calls patients made to clinic (and number of patients requiring phone calls) after the initial clinic date (indicating unresolved patient concerns).

All information was collected for a 30-day period after clinic. This information was obtained via medical record review using electronic health records where each encounter was labeled by type, including ED visits and telephone encounters.

A final list of high-value tasks was selected from those tasks that were correlated with extended physician room time and the incidence of downstream encounters. The final task list represented tasks that, if missed, would be likely to cause issues with downstream clinical encounters.

Once the high-value tasks were identified, strategies were employed to reallocate those tasks from frontline providers (physicians and nurses) to support staff. Tasks were also reallocated as needed on clinic day itself. The strategies were implemented on patients seen after May 24, 2011, the date of MAM implementation.

Several endpoints were compared between the pre- and post-MAM implementation periods. All clinic days after May 24, 2011, were considered post MAM implementation, tracking endpoints through January 28, 2014.

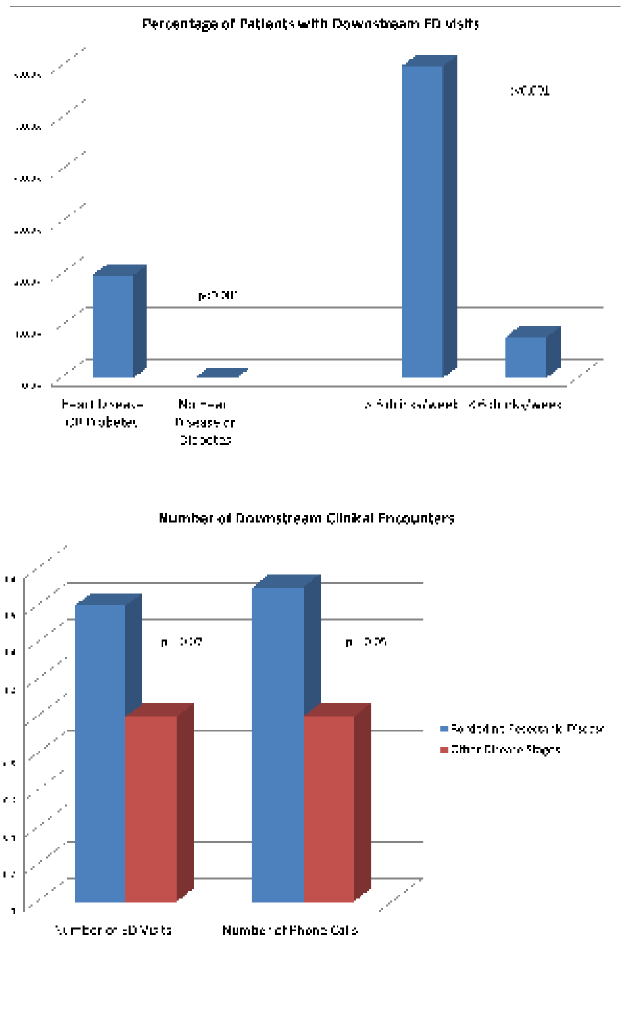
Daily clinic volume was compared between the pre- and post-implementation, using two-sided statistical T tests. Because of staff vacation time and other factors, MDC clinic days tended to be busier in the first half of the year (January – June) for all years.

Daily clinic volume for this period was also compared between the two groups. The percentage of total clinic days with a census of seven patients or greater, designated "busy clinic days," and days with a census of eight patients or greater, designated "very busy clinic days," were also compared between the two groups.

The same 30-day quality endpoints of ED visits and post-clinic phone calls for symptoms were used to identify high-value tasks to assess MAM in the post-implementation period.

FIGURE 1

Downstream ED Visits and Clinical Encounters



RESULTS — Clinical encounters for 139 consecutive patients were used to identify high-value clinic tasks. Via process mining, the list of tasks ranged from gathering key information about patients' history, obtaining or performing specific imaging studies, understanding patients' social environments and symptom assessment. (Table 1)

Baseline characteristics of the cohort used for process mining can be found in Table 2.

Several associations were discovered between specific tasks and physician room time, and can be found in Table 3. Assessing comorbidities and disease stage were the most shared task predictors for longer physician room times across all clinicians. Patients with resectable disease stage, in addition to ether cardiac disease or diabetes, required more time for the history and physical than those with none of these conditions (44.8 versus 20.8 minutes, $p < 0.01$).

Surgical oncologists spent significantly more time with patients with comorbidities than those without (20.1 versus 12.2 minutes, $p = 0.01$). Radiation oncologists also spent more

TABLE 2

BASELINE CHARACTERISTICS OF COHORT USED FOR PROCESS MINING

CHARACTERISTIC		PERCENTAGE OF TOTAL (N = 139)	CHARACTERISTIC		PERCENTAGE OF TOTAL (N = 139)
Disease Stage	Resectable	6.5%	Co-morbidities*	None	22.3%
	Borderline resectable	15.1%		Cardiac	49.6%
	Locally advanced	31.7%		Pulmonary	3.6%
	Metastatic	9.4%		Diabetes	35.3%
	Yet undetermined	37.3%		Other	35.3%
Number of Imaging Studies Before Clinic Day	0	6.5%	Habits	None	50.5%
	1	45.3%		Smoking	31.3%
	2	38.1%		Alcohol	4.3%
	3	4.2%		Illicits	1%
	4	2.9%		>1 Habit	12.9%
Previous Therapy*	None	50.4%	Pain score (0-10)	0	74.8%
	Surgery	23.7%		1-4	13.7%
	Chemotherapy	26.6%		5-8	10.1%
	Radiation therapy	7.2%		9-10	1.4%
	Chemoradiation therapy	9.4%			

* Note: Sum of percentages >100 due to patients with more than one characteristic in a single category.

time with patients with comorbidities versus those without (27.0 versus 20.0 minutes, $p<0.01$), as well as borderline resectable or yet-undetermined disease stage (25.5 versus 19.9 minutes, $p=0.03$).

Medical oncologists spent more time with patients with previous surgery (33.4 versus 19.8 minutes, $p=0.04$), and those with resected, metastatic, or yet-undetermined disease stage (28.1 versus 17.6 minutes, $p=0.02$).

Comorbidities and disease stage were also significant predictors of the need for downstream encounters, reflecting the substantial value of tasks involving gathering this information. (Figure 1).

The MAM method of process arbitrage was used to determine five interventions designed to improve task execution leading to clinical efficiency and better outcomes. Each of the interventions was aimed at enhancing task execution for at least one of the tasks determined to be high-value.

1. Existing staging information for each patient was collected prospectively (the week before clinic day) by the PIC or another support staff member. Patients were assigned to a particular oncologist as the "lead" physician for the clinic day based on staging and other relevant comorbidities.

   Specifically, patients with metastatic disease were primarily assigned to medical oncology, with radiation or surgery consulted for palliative reasons as needed; resectable patients were primarily assigned to the surgical oncologist, seeing radiation and medical oncology afterward; and unresectable/borderline resectable patients or technically resectable patients with prohibitive cardiovascular/endocrine comorbidities were sent primarily to the radiation oncologist.

   The lead physician would explain the entire trajectory of treatment for such patients, allowing for more brief, yet meaningful interactions with other oncologists. Ultimately, primary assessment of patients was reallocated

TABLE 3

TASKS ASSOCIATED WITH LONGER PHYSICIAN ROOM TIMES

TASKS	MEAN ROOM TIME FOR PATIENTS REQUIRING TASK (MINS)	MEAN ROOM TIME FOR PATIENTS NOT REQUIRING TASK (MINS)	DIFFERENCE (%)	P-VALUE (MULTIVARIATE)
HISTORY AND PHYSICAL TIME				
Assessing patients with resectable or resected disease stage	27.0	19.9	35.6%	0.05
Assessing patient with resectable or resected disease stage AND with cardiac or endocrine comorbidities	44.8	20.8	115.4%	<0.01
Assessing patients with previous chemotherapy, previous radiation therapy, or other previous single treatment	24.5	21.3	15.0%	0.03
SURGEON TIME				
Developing a treatment plan for patients with cardiac or endocrine comorbidities	20.1	12.2	64.8%	0.01
RADIATION ONCOLOGIST TIME				
Assessing borderline resectable or yet-undetermined disease stage	25.5	19.9	28.1%	0.03
Treatment plan for patients with cardiac or endocrine comorbidities	27.0	20.0	35.0%	<0.01
MEDICAL ONCOLOGIST TIME				
Treatment plan for patients with previous surgery	33.4	19.8	68.7%	0.04
Assessing resected, metastatic, or yet-undetermined disease stage	28.1	17.6	59.7%	0.02

to those oncologists who had a comparative advantage for a particular disease stage or comorbidity profile.

2. Prior imaging was acquired one week before clinic day. The need for more imaging was determined at that time, and authorization/acquisition of the study occurred at least one day before clinic to ensure availability of all required information on the day of clinic. If images could not be acquired for any reason, the patient would be rescheduled in order to avoid decisions based on incomplete information. Imaging approval and authorization were reallocated to a two-person support team.
3. If an emergency (e.g., pulmonary embolism) was evident on imaging performed one day prior, existing systems at our institution allowed for the ordering physician to be paged. The process for appropriate patient pass-off and admission was then handled by the PIC or another member of the support team. This bypassed the previous step required for the physician to send the patient to the ED, where redundant tests could have been performed and ultimate admission delayed. This also freed physicians' time to allow for more comprehensive evaluation of other patients in the clinic.
4. Pain assessment was conducted earlier in the clinic day by staff taking the basic history. The validated FACES scoring system was used and patients with a score of 6 or higher were added onto the queue of the dedicated pain specialist for the clinic (previously, referrals were made at the time oncologists were assessing patients, only if they were able to complete this task). Pain assessment was reallocated to a dedicated specialist prospectively.
5. A two-member support team remained on standby when physicians saw patients with multiple social risk factors (e.g., socioeconomic or insurance barriers, substance abuse issues, etc). If room time exceeded 30 minutes, the PIC would page the physician out of the room to probe for details. Social work and other referrals were then made as needed.

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A total of 207 clinic days and 838 patients were seen in the pre-implementation period. Total clinic days amounted to 106 in the post-implementation period, comprising 557 patients. The number of patients seen per day (daily clinic volume) increased from a mean 4.0 in the pre-implementation period to 5.2 (a 31.4 percent increase in volume, $p<0.001$) post-implementation.

"Busy season" (January – June) increased from a mean of 5.3 patients/day in 2012 to 10 by 2014 during the implementation phase, a 1.9-fold increase. The percentage of clinic days with a census of seven patients or more, or "busy clinic days," increased from 4 percent of total days to 14 percent in the post-implementation period, a 3.5-fold increase. Correspondingly, the percentage of clinic days with a census of eight patients or more increased from 0.5 percent to 6.7 percent of total days, or a 13-fold increase.

The average number of ED visits per patient in the pre-implementation period was 0.11 visits per patient and 0.09 in the post-implementation period. The percentage of patients requiring at least one post-clinic ED visit was 9.9 percent pre-implementation and 7.9 percent in the post-implementation period. The mean number of post-clinic phone calls per patient was 0.71 pre-implementation and 0.41 post-implementation ($p=0.098$). The percentage of patients requiring phone calls back to clinic with unresolved issues decreased from 34 percent to 22 percent ($p=0.049$).

DISCUSSION — To avoid compromising the quality of patient care in an increasingly resource-limited environment, the importance of organized and rational workflow is critical. For outpatient oncology clinics, this has become increasingly difficult in the setting of increased cancer incidence, prompting facilities to see high volumes of patients.

Furthermore, the field of oncology has seen a striking level of translational innovation — this is certainly beneficial to patients, but has also increased the volume of information that clinicians must process at the point of care.

Provider task load has increased correspondingly, elevating the risk of missed or incomplete tasks. This not only delays clinic operations, but also places patients at higher risk for misdiagnosis, redundant testing and other adverse outcomes.

To prevent this, cancer centers have met this challenge primarily by hiring more staff. However, because labor comprises a large percentage of ever-rising U.S. health expenditures, this is not a sustainable solution. Furthermore, multidisciplinary clinics, while clearly beneficial for patients, distribute even more tasks across fewer staff, amplifying challenges.

Our study investigated the application of an operations management methodology designed to increase successful task execution in the multidisciplinary setting. Although MAM has previously enhanced efficiency and improved quality in hospitals, ours is the first attempt to do so in an outpatient setting.

Overall, our results highlighted the importance of tasks that involve clinical information gathering, ensuring the availability of up-to-date imaging, prompt and comprehensive symptom assessment and the assessment of social risk factors that may impede care delivery.

Importantly, these tasks not only affected the clinic volume; failure to execute them was also associated with increases in downstream clinical encounters. To ameliorate this, we reallocated many high-value tasks away from the bottleneck resources in the clinic (i.e., the physicians and nurses) to support teams.

This was accomplished without increasing the number of employees; instead, existing personnel were redeployed in a targeted manner after identifying the tasks of highest value. As a result of this intervention, we saw significant increases in not only daily patient volumes, but also in the number of days when higher patient volumes could be seen. Most important, this was all accomplished while not only maintaining quality, but improving some quality metrics, indicating that these volume increases did not come at the expense of patient safety or outcomes.

Currently, several studies have demonstrated benefits of MDCs for patient outcomes and health care providers. One study demonstrated improved survival in patients with breast cancer evaluated at a breast multidisciplinary clinic[6] and another showed similar improvements in survival for patients with pancreatic cancer.[7]

Furthermore, MDCs enable providers to build clinical experiences[2] and foster closer working relationships with other specialties.[10] Given the significant clinical benefits of MDCs, the results of this study can augment this success by enhancing workflow, resource utilization and ultimately provider satisfaction. This further increases the likelihood of broader adoption of multidisciplinary clinic models.

There are some key limitations to our analysis. First, our methods did not track task completion discretely, but rather, looked to surrogates for timely task completion such as physician room time. However, our quality and efficiency outcomes did show that targeting these specific, high-value tasks led to improvements in those outcomes, highlighting the validity of this method.

1. Employment of advanced MAM tools in the future could allow for a more detailed analysis of task completion and faster, more facile task reallocation.
2. The intervention was not blinded to practitioners or patients; in fact, there was an explicit effort for every clinic participant to be aware of the intervention in order to achieve a culture focused on task triage and completion. However, rather than defining this as a "bias", culture change is viewed as a component of the MAM intervention. Furthermore, our favorable, objective results in reducing the number of downstream encounters speaks to the validity of the method beyond a simple mindset change.
3. MAM is most likely not completely explanatory for the increase in clinic volume achieved. However, the fact that clinic volume increases were observed without increasing staff, and while enhancing quality metrics, gives us confidence that the method worked as designed.
4. Our sample size for process mining to discover the

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importance of these specific tasks only amounted to 139 patients; studying larger samples of patients and providers retrospectively could have identified several more high-value tasks that were not discovered.

5. Finally, the multidisciplinary setting is unique in its substantial task burden over fewer staff; the ability for MAM to have such an effect on efficiency and quality requires further study in other outpatient settings for consideration of its broader application.

CONCLUSION — The Military Acuity Model increased productivity in a pancreatic multidisciplinary, all while maintaining a constant level of staff and resources (physician time). These benefits were seen while either decreasing or holding constant the number of downstream encounters after patients' initial visits to a pancreatic MDC, suggesting that MAM increased the maximum "safe capacity" of the clinic. MAM should be validated for comparable value enhancement in other clinic settings. ■

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