USING CREW RESOURCE MANAGEMENT TO IMPROVE DIABETES CARE IN A PRIMARY CARE SETTING

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Diabetes is a complex chronic metabolic disorder and the leading cause of adult blindness, end stage kidney disease, and non-traumatic amputation in the U.S. The majority of diabetes care is delivered in the out-patient primary care setting and is sub-optimal. Primary care is systematically ill-equipped to manage chronic care needs, and the need for process re-design is urgent. Aviation-based Crew Resource Management (CRM) has been suggested as one approach with potential for improving patient care and safety in healthcare settings. We assessed the impact and usefulness of a CRM intervention on work organization, process re-design, and standardized clinical information exchange strategies in an inner-city safety net clinic. We used time series analysis to assess impact on the delivery of standard diabetes services and on associated patient outcomes among medically indigent adults (n=619) reporting for care at the clinic. CRM principles were translated into practically useful process re-design and standardized care approaches. Significant improvements in microalbumin testing and associated patient outcome measures were attributed to the CRM intervention. CRM provided tools for management that in the short- term enabled reorganization and prevention of service omissions and in the long-term can produce a change in the organizational culture for continuous improvement.

Diabetes is a complex chronic metabolic disorder and a growing public health burden (Englegau, Geiss, Saaddine, Boyle, Benjamin, & Gregg, 2004). Impacting more than 18 million Americans, diabetes is the intractable leading cause of new cases of adult blindness, end stage renal disease, and non-traumatic lower extremity amputation (CDC, 2005). While these disabling co-morbidities can be postponed or prevented with lifestyle modifications and standard, evidence-based medical care (Haffner, 1998; UKPDS 33 & 38, 1998), sub-optimal diabetic care in the U.S. is well documented (Bodenheimer, Wagner, & Grumbach, 2002; Kerr, McGlynn, Adams, Keesey, & Asch, 2004; McGlynn, Asch, Adams, Keesy, Hicks, DeCristofaro, 2003; Saaddine, Engelgau, Beckles, Gregg, Thompson, Narayan, 2002). Failure to deliver recommended care may lead to particularly harsh outcomes among vulnerable populations such as the medically indigent (Smedley, Stith, & Nelson, 2003) and has been classified as medical *error* by the Institute of Medicine (IOM, 2000).

Clinical management of diabetes requires regular information exchange between patients and a myriad of professionals and paraprofessionals across multiple settings and disciplines, a situation known to increase risk for "drops" in health care and industrial settings. Notwithstanding the importance of teamwork and communication to effective clinical management, providers responsible for the majority of diabetic care have had few opportunities to develop or practice critical teaming or communication skills (IOM; AHRQ, 2001), and the care delivery system has not evolved to support integration of emerging new technologies and therapies. These systematic shortcomings prompted a call for fundamental re-design of the primary care system as a remedy for closing the chasm between current practices and recommended care standards. Aviation-based team training, Crew Resource Management (CRM), has been cited by both the IOM (2001) and the Agency for Health Care Research and Quality (AHRQ, 2001) as a promising strategy for improving health care quality and patient outcomes.

Emerging from commercial aviation studies in which human error was determined to be a major contributor to adverse events, Helmreich (2000) describes CRM as an effective use of all available resources, including human resources, hardware, and information. CRM training targets key areas of team performance to improve decision making within high-hazard, dynamic environments like those of aviation and healthcare. These include human factors and performance limitations, team leader and follower roles, situation awareness, crosschecking, effective communication, performance feedback, and development of an environment that invites reporting and correcting potential error vs. an environment of blame. While there is no universally adopted CRM curriculum, it has evolved into a grouping of proactive risk management strategies aimed at identifying potential sources of error or sub-optimal outcomes and initiation of corrective action before harm or undesired outcomes can occur (AHRQ, Helmreich; Musson & Helmreich, 2004). This study

assessed the impact of CRM on the process and delivery of standardized diabetes services and patient outcomes in a cohort of medically indigent, adult patients. Chronic diabetes care comprises well defined periodic laboratory tests and examinations (process or service measures) with accompanying biologic markers (patient outcome measures) and is uniquely suited to elucidate CRM's impact on standardized care delivery services and patient outcomes. Aims of this study were to (1) assess the impact and practical usefulness of CRM on organization of diabetes care processes in a primary care clinic; (2) assess the impact of CRM on delivery of standard diabetic care services, and (3) assess the impact of CRM on diabetic patient outcomes.

Methods

Setting. Vine Hill Community Clinic (VHCC) is a nurse-managed primary care clinic located in an inner-city public housing development in Nashville, TN serving a population of 9,000 patients, 90% of whom are in Tennessee's Medicaid managed care program. Race/ethnicity is 45% White, 40% Black, and 15% other or unknown. VHCC averages 13,000 patient care visits annually, one in four visits is related to diabetes, and 40% of visits are un-scheduled.

Sample. A registry of all adult ($\geq$18 years) patients, diagnosed with type 2 diabetes (ICD-9 Code 250), reporting for care at least once between 4/1/04 and 5/31/05, was created via electronic query (n=619). Mean age of the sample was 50.6 years (SD=12.5; Range=18-88). Females (n=379) outnumbered males (n=240). Racial/ethnic makeup of the sample was similar to the VHCC population: 42% White (n=260), 39% Black (n=241), and 19% other or unknown.

CRM Intervention. The CRM intervention included training, task re-distribution and decision-support tool (checklist) development. The existing VHCC diabetes care protocol and process were assessed, and new ones were developed and mapped by VHCC providers, support staff, and administrators according to American Diabetes Association (ADA) guidelines. Team-building and communication skill sets needed to support implementation of the protocol were determined with input from VHCC staff, Vanderbilt University Medical Center's (VUMC) department of Clinical Improvement and CRM, and a trainer from Crew Training International (CTI). CTI customized and delivered the 8-hour CRM training which was attended by all VHCC personnel on a non-clinic day for which they were compensated. Guided by the *Model of Threat and Flightcrew Error Management* (Helmreich, Wilhelm, Klinect, and Merritt, 2001), training consisted of the following elements.

1. Emphasizing *teamwork* and strategies for developing and maintaining an effective team.
2. Recognizing and managing *human factors* linked to error (e.g., fatigue, stress, multitasking).
3. Developing *situation awareness* or proactive recognition of potential threats to successful adherence to diabetes care guidelines and initiation of error mitigation strategies.
4. *Interpersonal communication* strategies (e.g., standardization of observations, respect for team members, briefing, crosschecking, and performance feedback).
5. *Conflict management* strategies were discussed with clinic administration only.

During the training day, a checklist was developed to include new process work steps associated with routine diabetes management. Short briefings for exchange of critical information were structured and practiced by all participants. Team accountability for diabetes care and overcoming traditional hierarchical provider and support staff communication boundaries were discussed. Agreement was reached that every team member would be responsible for assuring checklist completion and for raising team awareness if a blank (potential omission or error) was noted. Further, clerical staff agreed to perform a final cross-check for checklist completion at the time the patient checked out and scheduled their next appointment.

The new process and the diabetes checklist were implemented on 11/18/04. A short, structured daily briefing was initiated to review clinic/patient issues and to encourage regular input from the team. Briefings were led by the clinical director or clinic manager and restricted to less than 10 minutes each morning. Attendance at the regular daily briefing was expected of every team member, and any team member could initiate a mini-briefing at any time a potential error or omission was suspected throughout the clinic day.

Measures and design. A quasi-experimental, interrupted time series design was used to assess impact of the CRM intervention. Demographic information, height and weight were collected for each patient. Using 1683 clinic visits completed by patients during the study period (160 pre-intervention clinic days between 4/1/04 and 11/17/04 and 122 post-intervention clinic days between 11/18/04 and 5/31/05), standard diabetic services available in electronic format and associated patient outcomes were evaluated for adherence to ADA periodicity

recommendations and compared to recommended treatment targets:

- Blood sugar every 3 months (A1c <7.0)
- Blood pressure every 3 months (BP<130/80)
- Low density Lipoprotein (LDL <100)
- Urine microalbumin annually (MiAL<30)
- Lower extremity amputation prevention (LEAP) foot check annually.

Each patient service or outcome variable was assigned a 0 (not received or not at target) or 1 (received or at target). The percent of individuals who received the service, or who were at target, was calculated for each day. Qualitative data were collected including observations of work flow, briefing structure and frequency, use and completion of the diabetes checklist, structured communication, shared responsibility/accountability. Staff turnover was reported by the clinic director.

Analysis. To address aim 1, pre- and post-intervention work flow, team behaviors, communication, and use of the diabetes checklist were compared. To address aims 2 and 3, descriptive statistics were produced for the quantitative measures both pre- and post-intervention, and interrupted time series analysis was used to assess the statistical significance of the intervention.

Results

Aim 1: impact and practical usefulness of CRM on organization of the diabetes care process. Key changes in the diabetes care process are displayed in Table 1. The pre-intervention process for diabetes care included a protocol without specific work steps or task assignments and occasional briefings that lacked structure and were not attended by the NPs. Using CRM communication and teamwork tools, providers and staff identified care components to be assumed by staff prior to patient entry into the exam room. Pre-intervention, the NPs attempted to locate patient information and initiated all screens and exams while also attending to the patient and other competing priorities. In contrast, the post-intervention process included support and clerical staff initiation of recommended screens and tests. They obtained results, and shared information with providers, other team members, and patients. Clinical information required to support decision-making was summarized in the checklist format for providers' review before seeing patients. Daily, structured briefings were attended by all staff and providers for critical information exchange, and a standardized communication strategy using checklist criteria as the reference occurred. Any team member detecting a potential care omission was responsible for alerting other team members using the agreed upon phrase "I am concerned that..."

Table 1. Changes in process following CRM implementation

Pre-CRM	Post-CRM
Diabetes care protocol: - No defined work steps - No assigned responsibilities - No visible patient treatment targets	Diabetes checklist: - Defined work steps - Assigned responsibilities - Visible patient treatment targets
Competing tasks during NP visit	- Role re-definition - Work re-distribution - Clear expectations
Omissions of care	- Checklist - Situational awareness
Fragmented care	- Briefing to prepare the day's work - Checklist - Cross-checks
Missing or poor communication	Communication strategy: - Checklist - Daily briefing - "I am concerned…"
Complexity of training	Transparent simple training Checklist with visible cues

Post-intervention staff/provider turnover declined. Pre-intervention, 3 NPs and 2 support staff left the clinic compared to a loss of no NPs and 2 support staff post-intervention. Additionally, the clinic director estimated the re-designed process decreased diabetic visit time by 10 minutes per visit. New employee orientation to the diabetes care routine was reduced from several days of observation and instruction to a simple demonstration and review with one staff member. This was observed directly, as a medical assistant trainee at the clinic for only one day completed the recommended diabetic screens and the checklist without assistance and explained process steps to the CTI observer. Finally, the new process, decision support checklist, and communication strategies were evaluated as highly useful by all VHCC personnel in post-intervention surveys. Anecdotally, they expressed appreciation for "knowing what is expected" of their performance in conjunction with patient outcome targets and stated their work was more organized and efficient. Post-intervention requests for new protocols and checklists for other high volume illnesses were common.

With the Threat and Flightcrew Error Management Model (2001) as a guide, we framed simple

comparisons and common language between key team tasks and work steps, dynamic decision making requirements, and structured communication elements for out-patient diabetes management. For example, just as equipment failure or weather delays can produce chaotic schedule changes in aviation, medical equipment failure or walk-in, unscheduled patients can upset clinic operations and thereby increase the risk for not delivering needed care. As these threats are expected, proactive actions can be planned to mitigate potential error in both aviation and clinical settings. Thus, a notable finding is that CRM principles can be adapted and useful to guide development of team training and process standardization in a primary care environment.

Aim 2: pre- and post-intervention diabetic services. Improvements in adherence to designated diabetes service guidelines were demonstrated with comparison of pre- and post-intervention aggregate means (Table 2). Notably, pre-intervention service means for the VHCC aggregate were well above those reported nationally. Patients in the post-intervention group were more likely than patients in the pre-intervention group to have received A1c, blood pressure, microalbumin, and LEAP services. The average percentage of patients receiving all services improved from 69.7% to 73.6% (Table 2). Only LDL testing did not improve. Time series analysis revealed a significant intervention effect (6.97%) for increases in microalbumin testing ($p < .01$) and a trend for LEAP ($p = .15$) exams and for all services ($p=.1$). Undetectable in before-and-after mean comparisons, an existing pre-intervention improvement trend emerged in several time series analyses, and significant intervention effects were not observed for the remaining service measures.

Aim 3: pre- and post-intervention patient outcomes. Patient outcomes showed improvement in the percentage of patients reaching treatment goals (Table 3). The percentage of patients meeting recommended targets for blood pressure, LDL, urine microalbumin level, amputation risk (LEAP), and body weight improved. Time series analysis for patient outcomes revealed a significant intervention effect for the percent of patients with lower levels of urine albumin (greater percent of patients <300mg) with an increase of 5.7% ($p < .01$). This effect also significantly impacted the composite of target outcomes with an increase of 3% ($p=.04$). Trends were noted for A1C, LEAP, and weight. Remaining patient outcome changes, though generally improved, were not significant statistically.

Table 2. Service measures: mean percent of pre- and post-intervention adherence to diabetes guidelines

Diabetic Service	Pre-CRM Mean Percent	Post-CRM Mean Percent	Post – Pre Percent Change
A1C within 3 months	77.37	81.04	+3.67*
BP within 3 months	97.48	97.67	+0.19
LDL within 12 months	78.52	78.08	-0.44
MiAL within 12 months	55.31	62.89	+7.58*
LEAP within 12 months	49.93	59.43	+9.50**
All services	69.7	73.6	+3.9

*t-test statistically significant $p < .05$ ** Trend $p < .15$

Table 3. Patient outcomes: mean percent pre- and post-intervention patients at treatment goal

Patient Outcome	Pre-CRM Mean Percent	Post-CRM Mean Percent	Post – Pre Percent Change
A1C <7.0%	30.72	28.17	-2.55
BP <130/80	38.81	41.77	+2.96
LDL <100	34.60	36.68	+2.08
MiAL <30mg	37.52	40.37	+2.85
MiAL <300mg	51.64	57.65	+6.01*
LEAP score 0	49.20	55.57	+6.37*
Weight <200 lbs	42.33	48.17	+5.84*

* t-test statistically significant $p < .05$

Discussion

We examined the impact of CRM on diabetes care processes and team behaviors as well as diabetic services and associated patient outcomes in a cohort of medically indigent adult patients. Several interesting findings emerged. First, CRM training and tools enabled the clinic staff to reorganize their work processes, work as a team with new roles and responsibilities, coordinate and communicate their actions, and check for omissions using checklists. A byproduct of implementing CRM has been change in work culture, bringing order and organization to a busy clinic, and strategy for organizational change. Second, clinically significant, consistent and sustained improvements in both service delivery and patient outcomes were observed over the course of the study despite NP/support staff turnover which is typically associated with deterioration in these measures. High rates of adherence to diabetes care guidelines were observed in the pre-intervention phase at VHCC compared to national rates. Although ceiling effects due to high baseline and complex, chronically ill patients make improvements more difficult to achieve in the short-term, we anticipate significant long-term effects with sustained intervention. For example, VHCC patients

frequently report for acute complaints in a non-fasting state, and tests requiring the patient to be fasting (e.g. LDL) are not indicated, as results would be unreliable. Also, with growing numbers of uninsured patients in Tennessee and across the U.S., more patients refuse testing based on their ability to pay. Long-term implementation will begin to overcome these barriers. A third finding of interest was the qualitative observation that the CRM training, the re-structured care process, and the diabetes checklist were described as highly useful by clinic personnel. Decreased patient visit time and shorter orientation for new employees are welcome efficiencies in the under-resourced safety net environment.

Translation of scientific evidence into clinical diabetes care, particularly for vulnerable populations, has historically been difficult to achieve due to diverse provider, system, and patient characteristics (Chin, 2004; Garfield, 2003; Murphy, Chapel, & Clark, 2004). Additionally, few guidelines exist to direct implementation of new recommendations, and when improvements have occurred, they cannot be sustained in the safety net and other service delivery environments due to staffing and other resource and infrastructure constraints (Chin, et al., 2004; Garfield, et al., 2003; Murphy, Chapel & Clark, 2004; O'Connor, et al., 2005; Schachter & Cohen 2005). Aviation-based team training offers a framework for structuring routine clinical work and improving communication to enhance decision making centered on a common goal (AHRQ, 2001; Helmreich; 2000; Musson & Helmreich; 2004; Helmreich, Wilhelm, Klinect, & Merritt, 2001). Just as recognition and proactive response to a flight safety threat leads to greater probability of a safer flight, similar actions in primary care can result in delivery of recommended services. We were able to translate principles of CRM into action plans for standardized communication, workload re-distribution, and routine care delivery within the safety net, primary care environment. These findings may be applicable to other safety net settings where competing priorities for scarce resources and high patient volume and staff turnover have hampered improvements. We were encouraged by consistent, sustained improvements in diabetes care despite high staff and provider turnover and by positive feedback from personnel indicating CRM-based process and information exchange capabilities have instilled a sense of order and organization absent in the pre-intervention milieu surrounding diabetic care.

Strengths of this study include availability of electronically stored data and the quasi-experimental, interrupted time series design useful when randomization is not possible (Speroff & OConnor, 2004). The most commonly used design for evaluation of clinical improvement programs is the before-and-after comparison. While this method initially reflected significant improvements in pre- and post-intervention rates of adherence to recommended clinical guidelines, addition of time series analysis revealed important existing improvement trends that would have gone undetected with before-and-after comparisons alone. We acknowledge absence of a comparison group as a study limitation as well as reliance on some patient-dependent factors (e.g., fasting for LDL testing).

Several challenges remain. Some NPs attended daily briefings reluctantly, suggesting their time could be better used for charting or direct care, and elements of the traditional hierarchy remain. While efforts to include all team members in briefings have been generally well received, some support staff admit lingering reluctance to relay concerns to providers. Additionally, an NP returning from extended leave plus the 5 new employees hired since the intervention have not received basic CRM training due to staffing levels and training availability, and there is currently no capacity for further CRM coaching or updates. It is important for leadership to sustain change through endorsement, role modeling, and booster training. Still another challenge exists with the introduction of a paper checklist within the paperless VHCC environment, because duplicate documentation is required, increasing the likelihood of information "drop" or failure to capture critical information in the chart. Embedding processes reduces work burden and assures continuous improvement; for example, electronic checklists serving as patient documentation will be viewed as an advantage to staff and providers. Finally, implementation and analysis of team-based primary care is in early stages of development (Roblin, Vogt, & Fireman, 2003), and future analyses of care team behaviors will undoubtedly be structured with more definitive measures for CRM applications (Musson & Helmreich, 2004).

In conclusion, key elements of CRM were translated into useful re-design, standardization of information exchange, and improved diabetes care processes. Significant improvements in microalbumin testing and associated patient outcomes were attributed to the CRM intervention. The approach was rated as satisfactory, practical and useful by clinic staff. These findings may have implications for organizing efficient care delivery in primary care and should be validated in larger, controlled studies.

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