Effect of crew resource management on diabetes care and patient outcomes in an inner-city primary care clinic

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Background: Diabetes care in our inner-city primary care clinic was suboptimal, despite provider education and performance feedback targeting improved adherence to evidence-based clinical guidelines. A crew resource management (CRM) intervention (communication and teamwork, process and workflow organisation, and standardised information debriefings) was implemented to improve diabetes care and patient outcomes.

Objective: To assess the effect of the CRM intervention on adherence to evidence-based diabetes care standards, work processes, standardised clinical communication and patient outcomes.

Methods: Time-series analysis was used to assess the effect on the delivery of standard diabetes services and patient outcomes among medically indigent adults (n = 619).

Results: The CRM principles were translated into useful process redesign and standardised care approaches. Significant improvements in microalbumin testing and associated patient outcome measures were attributed to the intervention.

Conclusions: The CRM approach provided tools for management that, in the short term, enabled reorganisation and prevention of service omissions and, in the long term, can produce change in the organisational culture for continuous improvement.

Diabetes is a complex chronic metabolic disorder. It affects more than 21 million Americans and is a leading cause of new cases of blindness in adults, end-stage renal disease and non-traumatic lower extremity (toe(s), foot and lower leg) amputation in the US.^{1–3} Lifestyle modifications and standard treatments can prevent or postpone these disabling comorbidities,^{4–6} but diabetic care in the US is suboptimal.^{7–11} Failure to deliver recommended care is associated with poor outcomes among vulnerable populations such as medically indigent people.¹² Successful diabetes management requires teamwork and regular information exchange between patients and providers across multiple settings and disciplines, yet providers typically have few opportunities to develop or practise teaming or communication skills. Crew resource management (CRM), developed in aviation to improve communications and safety, may be a strategy for narrowing the gap between evidence-based care and current practice.^{13–15}

The CRM targets improved decision making within high-hazard, dynamic environments such as aviation and health-care.¹⁶ Training includes human factors and performance limitations, team leader and follower roles, situation awareness, crosschecking, effective communication, performance feedback, and developing an environment for reporting and correcting potential errors. Thus, CRM is a grouping of proactive risk management strategies aimed at identifying potential sources of error and initiation of corrective action to prevent unwanted outcomes.^{15–17}

Diabetes care in our inner-city primary care clinic remained suboptimal despite traditional improvement efforts (provider education, performance feedback and flow sheets). We hypothesised that implementation of CRM-based teamwork and decision-support tools (eg, redefining teamwork roles, task clarification and workflow reminder checklists) would measurably improve the process and delivery of standard diabetic services. This study aimed to assess the effect of the intervention on the (1) organisation of diabetes care processes, (2) adherence to standard diabetes care recommendations, and

(3) associated patient outcomes in a cohort of medically indigent, adult primary care patients.

SETTING AND SAMPLE

Located in an inner-city public housing development in Nashville, Tennessee, the Vine Hill Community Clinic (VHCC) is a primary care clinic managed by the Vanderbilt University School of Nursing, Advanced Practice Nurse (APN) faculty, Nashville, Tennessee, USA. VHCC has an average of 13 000 patient care visits annually; one in four visits is related to diabetes, and 40% of visits are unscheduled. A registry of all adult (≥ 18 years) patients, diagnosed with diabetes (International Classification of Diseases-9 Code 250), reporting for care at least once between 1 April 2004 and 31 May 2005, was used. The Vanderbilt University's institutional review board approved the study.

The intervention

The intervention included common CRM components—namely, task redistribution, standardised communication methods and decision-support tool (checklist) development. Training goals included standardisation of the diabetes care process and improved communication of diabetes-related patient information. APNs, support staff and administrators revised existing diabetes care protocols and processes using the American Diabetes Association clinical guidelines.¹⁸ Communication and team-building skills needed to support revisions were determined by VHCC personnel, the Medical Center's CRM programme and a CRM trainer from LifeWings Partners, LLC. All VHCC personnel were compensated for participation in 8 h of CRM training, tool development and

Abbreviations: APN, advanced practice nurse; CRM, crew resource management; LDL, low-density lipoprotein; LEAP, lower extremity amputation prevention; MiAL, microalbumin; VHCC, Vine Hill Community Clinic

process redesign on a non-clinic day, consisting of the following:

1. Emphasising teamwork and strategies for developing and maintaining an effective team.
2. Recognising and managing human factors linked to error (eg, fatigue, stress, multitasking).
3. Developing situation awareness (proactive threat recognition) and initiation of error mitigation strategies.
4. Developing improved interpersonal communication (eg, standardisation of observations, respect for team members, briefing, crosschecking, performance feedback).
5. Utilising conflict management strategies.

Participants developed a checklist with work steps for the new diabetes care process, structured and practised information briefings, and discussed team accountability and strategies for overcoming communication barriers. All participants agreed to complete the checklist and alert the team if a potential omission/error was noted. Clerical staff agreed to perform final crosschecks for checklist completion.

The new process and diabetes checklist were implemented on 18 November 2004. Each morning, all participants attended a structured briefing (≤ 10 min) led by the clinic director or manager. Briefing format included clinic/patient issues from the previous day, assignments and announcements, task clarification and input from team members. Any team member could initiate a mini-briefing if a potential error or omission was suspected throughout the clinic day.

DESIGN AND MEASURES

A quasi-experimental, interrupted time-series design was used. Demographic information was collected from medical records. Using 1805 clinic visits completed during the study period (160 pre-intervention clinic days and 122 post-intervention clinic days), diabetic services and associated patient outcomes were evaluated for adherence to the American Diabetes Association periodicity recommendations and treatment targets:

- Quarterly blood sugar (A1c $< 7.0\%$)
- Quarterly blood pressure (BP $< 130/80$ mm Hg)
- Annual low-density lipoprotein (LDL < 100 mg/dl)
- Annual urine microalbumin (MiAL < 30 mg/24 h)
- Annual lower extremity amputation prevention (LEAP) foot check (score = 0)

Patient service or outcome variables were assigned a value of 0 (not received or not at target) or 1 (received or at target). Qualitative data included observations of work flow, briefing structure and frequency, checklist completion, structured communication and shared responsibility/accountability.

DATA ANALYSIS

To address aim 1, preintervention and postintervention work flow, team behaviours, communication and use of the diabetes checklist were compared. To address aims 2 and 3, multiple analytical procedures were used to triangulate on the actual effect: preintervention and postintervention means were used to describe differences; individually paired preintervention and postintervention scores were compared using the McNemar test and repeated-measures analysis of variance; and weekly aggregate data were used in interrupted time-series analyses.

RESULTS

The registry comprised 619 patients with diabetes. Their mean (SD; range) age was 51.4 (12.6; 18–88) years. Females ($n = 379$) outnumbered males ($n = 240$). Race/ethnicity was

similar to that of the VHCC population: 42% White ($n = 260$), 39% Black ($n = 241$) and 19% ($n = 118$) other or unknown.

Aim 1: impact and practical usefulness of CRM on the diabetes care process

Table 1 summarises the key changes in the diabetes care process. The preintervention diabetes care process included a protocol without work steps or task assignments, and occasional unstructured briefings not attended by APNs, whereas after intervention, structured daily briefings were attended by all participants. Before the intervention, APNs initiated screens and examinations. After the intervention, support staff performed these functions and summarised clinical information using CRM communication and teamwork tools for the providers' review. The phrase "I am concerned that...." signified detection of a potential care omission.

Before the intervention, three APNs and two support staff left the clinic, compared with no APNs and only two support staff after the intervention. Visit time of patients with diabetes was estimated to decrease by 10 min per visit. Orientation of new employees to the diabetes care routine was reduced from several days with multiple ANPs 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 observer. The new process, decision support checklist and communication strategies were evaluated as highly useful by VHCC personnel ($n = 16$). They expressed appreciation for "knowing what is expected" of their performance, noting that their work was more organised and efficient.

Aims 2 and 3: preintervention and postintervention diabetic process measures and patient outcome measures

Table 2 shows that improvement was achieved for annual MiAL testing and LEAP testing, and for the all-services measure ($p < 0.01$) by t test, and for MiAL testing ($p < 0.001$, +7.40%) and A1c testing ($p = 0.029$, +3.80%) using time-series analysis. Similar comparisons suggested improvements for all the outcome measures, with the exception of A1c, with significant improvements in MiAL, LEAP and the all-outcomes measures

Table 1 Changes in diabetes care processes following implementation of crew resource management	
Pre-CRM	Post-CRM
Diabetes care protocol: No defined work steps No assigned responsibilities	Diabetes care checklist: Defined work steps Assigned tasks and responsibilities
No visible patient treatment targets Different APNs used different processes Competing tasks during APN visit	Visible patient treatment targets One standardised process
Omissions of care	Role redefinition Work redistribution Clear expectations Checklist
Fragmented care	Situational awareness Briefing to prepare the day's work Checklist Crosschecks
Missing or poor communication	Communication strategy: Checklist Daily briefing "I am concerned..."
Complexity of training	Transparent simple training Checklist with visible cues

APN, advanced practice nurse; CRM, crew resource management.

Table 2 Preintervention and postintervention diabetes process and patient outcome measures

Variable	Pre-CRM mean percentage	Post-CRM mean percentage	Post-pre per cent change	p Value	Interrupted time-series effect p value
Diabetes process measure					
A1c within 3 months	78.07	81.07	+3.06	0.1144	0.03796 (0.029)
BP within 3 months	97.35	97.87	+0.52	0.4799	0.00529 (0.4933)
LDL within 12 months	78.10	78.67	+0.57	0.7751	0.00051 (0.9819)
MiAL within 12 months	54.88	64.40	+9.52	<0.001	0.07403 (0.0002)
LEAP within 12 months	50.14	59.07	+8.93	<0.001	*
All services	71.70	76.21	+4.51	<0.001	*
Patient outcome measure					
A1c <7.0	31.94	28.67	-3.28	0.1367	-0.03811 (0.0110)
BP <130/80	39.94	42.27	+2.55	0.2773	0.01704 (0.4887)
LDL <100	33.74	35.73	+2.01	0.3815	0.00548 (0.7041)
MiAL <30 mg	37.63	42.67	+5.04	0.0312	0.03867 (0.0180)
LEAP score 0	49.67	55.07	+5.40	0.0237	*
All outcomes at or below target	38.54	40.88	+2.34	0.0460	0.024989 (0.0986)

A1c, blood sugar level; BP, blood pressure; CRM, crew resource management; LDL, low-density lipoprotein; LEAP, lower extremity amputation prevention; MiAL, microalbumin.

*A significant positive preintervention trend followed by a significant negative postintervention trend was found for these variables.

by t test ($p < 0.05$). Time-series analysis revealed a significant increase in MiAL levels that were at target ($p = 0.018$, +3.87%), and a significant decrease in A1c levels that were also at target ($p = 0.011$, -3.81%).

For the 277 individuals who had at least one preintervention visit and one postintervention visit, using their last preintervention and last postintervention visits, McNemar tests and repeated measures analysis of variances were computed. All service and outcome changes were in the positive direction, except for blood pressure. Positive changes for MiAL and LEAP testing and outcomes were statistically significant ($p < 0.01$; table 3).

Using the continuously scored all-services and all-outcomes measures (which could range from 0% to 100%), the improvement from 75.23% to 82.09% on services was significant ($F(1,276) = 31.40$, $p < 0.001$). The improvement from 42.96% to 45.34% on outcomes measures was marginally significant ($F(1,276) = 3.11$, $p = 0.079$).

DISCUSSION

CRM training and tools enabled personnel to reorganise their work processes, work as a team with new roles and responsibilities, coordinate and communicate their actions, and check for omissions using checklists to structure and drive clinical workflow. An intervention byproduct has been change in work culture, bringing order, organisation and strategy for organisational change. Clinically significant, sustained improvements in both service delivery and patient outcomes were observed, despite personnel turnover typically associated with deterioration in these measures.

Translation of scientific evidence into clinical diabetes care has historically been difficult, owing to diverse provider, system and patient characteristics.¹⁹⁻²¹ Additionally, few guidelines exist for direct implementation of the new recommendations, and, when improvements have occurred, they are difficult to sustain in the safety net and other service delivery environments due to staffing, resource and infrastructure constraints.¹⁹⁻²³ CRM offers a framework for structuring clinical work and communication around goal-centred decision making.^{15-17, 24} We translated CRM principles into standardised communication, workload redistribution and routine care delivery within the clinical safety net environment. In addition to our objective findings, decreased patient visit time and shortened orientation for new employees were welcome efficiencies in the under-resourced safety net 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 personnel turnover, and by positive feedback from personnel indicating that CRM-based processes and tools have instilled a sense of order absent in the preintervention milieu surrounding diabetic care.

Strengths of this study include availability of electronically stored data and the quasi-experimental, interrupted time-series design useful when randomisation is not possible.²⁵ Although before-and-after comparisons reflected significant improvements, the addition of time-series analysis revealed existing improvement trends that would have gone undetected with

Table 3 McNemar test for preintervention and postintervention process and patient outcome measures

Variable	No change below target (n)	No change at target (n)	Change: at target to below (n)	Change: below target to at target (n)	McNemar test (p value)
Diabetes process measure					
A1c within 3 months	19	188	28	42	0.0943
BP within 3 months	2	264	7	4	0.3657
LDL within 12 months	20	213	16	28	0.0704
MiAL within 12 months	51	149	18	59	<0.001
LEAP within 12 months	76	148	11	42	<0.001
Patient outcome measure					
A1c <7.0	157	53	40	53	0.1122
BP <130/80	106	62	56	53	0.7738
LDL <100	167	110	0	0	—
MiAL <30	113	95	23	46	0.0056
LEAP score 0	86	143	13	35	0.0015

A1c, blood sugar level; BP, blood pressure; LDL, low-density lipoprotein; LEAP, lower extremity amputation prevention; MiAL, microalbumin.

before-and-after comparisons alone. We acknowledge absence of a comparison group, as well as reliance on some patient-dependent factors (eg, fasting for LDL testing), as a limitation. We believe that a change in the way LEAP scores were documented accounted for the negative postintervention trend observed in LEAP testing, but this cannot be confirmed.

Traditional hierarchy challenges remain. Some APNs were reluctant to attend briefings, suggesting that their time should be used for charting or direct care. Efforts to include all team members in briefings were generally well received, yet some support staff remained hesitant to voice concerns to providers. Also, whereas recurrent training and reinforcement of proactive problem-solving strategies are crucial CRM components, employees hired since the intervention have not received CRM training, and no coaching or refresher mechanism exists. It is important for the leadership to sustain improvements and integrate CRM into an enduring culture through endorsement, role modelling and booster training.

Previous CRM studies have been criticised for lacking content standardisation and rigour required to establish links between CRM training and behavioural change and outcomes.²⁶ This study represents an empirical approach to exploring those linkages using behavioural observations augmented by measurement of established diabetes care processes and patient outcome indicators. Analysis of team-based primary care is in the early stages of development,²⁷ and future analyses will benefit from more structured and well-defined measures for CRM applications.^{17–26} Moreover, although our findings seem to be due to the combined effects of team training, task clarification, structured daily debriefing and work flow decision-support checklist tools, it is possible that certain CRM components are more critical than others. This potential should be explored in future studies.

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

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