Internal Medicine Resident Adherence to Evidence-Based Practices in Management of Diabetes Mellitus

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ABSTRACT

OBJECTIVE: Diabetic preventative health maintenance involves (1) adherence to guidelines and (2) appropriate documentation. This study evaluates the frequency with which internal medicine (IM) residents met these two outcomes. We also evaluated if there were differences in outcomes between resident classes.

METHODS: In this retrospective analysis, 234 diabetic outpatient visits were analyzed. Guidelines were derived from the American Diabetes Association (ADA). The outcomes for each guideline were averaged and stratified by resident class. Averages within and between classes were compared using the student's paired t-test and one-way ANOVA respectively.

RESULTS: Classes were most adherent to A1c testing guidelines (PGY-1 96.1%, PGY-2 97.6%, and PGY-3 95.9%). PGY-1 and PGY-2 classes were least adherent to podiatry (27.5% and 17.6% respectively), whereas PGY-3 had equal least adherence rates to podiatry and lifestyle modification guidelines (36.7%). All classes had highest rates in documenting A1c findings (PGY-1 92.2%, PGY-2 97.6%, and PGY-3 85.7%) and lowest rates in documenting relevant podiatry information (PGY-1 5.9%, PGY-2 5.9%, and PGY-3 11.2%). Comparing sequential resident classes, there was a decline in lifestyle counselling and documentation from PGY-1 to PGY-2. From PGY-2 to PGY-3, there was improvement in adherence to statin, podiatry, microalbuminuria, and monofilament guidelines. There was also improvement in documenting statin and monofilament usage, however, A1c reporting declined.

CONCLUSION: The findings of the study suggest disproportionate levels of care in diabetes preventative management. Additionally, program directors should take caution in assuming linear improvement with sequential resident classes.

KEYWORDS: Internal Medicine Resident, Adherence, Diabetes Guidelines

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Introduction

Diabetes mellitus (DM) is a chronic multisystem disease characterized by altered glucose metabolism leading to hypoglycemia, hyperglycemia, and their short and long-term complications. Short-term complications include diabetic ketoacidosis (DKA), hyperosmolar hyperglycemic state (HHS), and hypoglycemic crisis. Long-term sequelae are classically divided into microvascular complications such as retinopathy, nephropathy, and neuropathy as well as macrovascular complications such as atherosclerosis.[1] Within the United States (US), DM is the seventh leading cause of death, and is the most common contributing factor to chronic kidney disease (CKD) and lower limb amputations[2].

From 1999 to 2010, there were noted improvements in glucose, blood pressure, and lipid control in US adults with diabetes[3]. These trends can be partly attributed to the development of efficacious anti-glycemic drugs as well as frequent revisions of evidence-based guidelines by the American Diabetes Association (ADA)[4,5]. A recently published retrospective study however has shown that since 2010, glycemic and blood pressure control have declined,[6] and there have been increased rates of hyperglycemic emergencies, such as amputations of the feet or legs[7]. It has been postulated that national declines may be due to shifts towards more conservative management[6], but there is a paucity of objective data that documents clinician practicing behaviour, such as how frequently they adhere to ADA guidelines. Another poorly studied aspect of care is the frequency with which preventative care findings are documented within the electronic health record (EHR). Documentation is crucial as it allows for anticipatory management at future visits, ensures that needed pharmacological interventions or testing for patients are not overdue, and disinhibits perpetuating behaviours of guideline non-adherence. Lastly to our knowledge, there are no studies that evaluate the practicing pattern of internal medicine (IM) residents in the outpatient setting, despite them being central to the medical staff.

The goals of this study therefore were to (1) determine how frequently residents adhere to ADA preventative guidelines and (2) how frequently they document their findings within the EHR. We hypothesized residents to have higher outcomes in A1c, since this parameter is emphasized in both inpatient and outpatient medicine. We predicted lowest outcomes to be in podiatry given the noted trends[7] as well as the fact that the parameter is primarily addressed in the outpatient setting; at present, IM education at academic centres is centered around an inpatient training model. As a secondary goal, we investigated if there were differences in performance between resident classes. We predicted significant improvement in outcome rates with each subsequent resident class as they obtained more clinical experience.

Material and Methods

Study Design

The study is a retrospective analysis that evaluated resident practicing and charting behaviors between April-May 2019. The time frame within Spring towards the end of the resident year, was purposeful to ensure that resident practicing behaviors would not be confounded by inexperience. The outcomes included: (1) adherence to ADA guidelines in the treatment of patients with both Type 1 (T1DM) and Type 2 (T2DM) diabetes and (2) appropriate documentation of preventative care findings in the EHR. The ADA guidelines were simplified into eight different parameters (Table 1). The EHR used was the Centricity™ Electronic Medical Record 9.12.

Population and Location

The study analyzed the charts of 234 visits of patients with known DM diagnoses, at an urban outpatient clinic affiliated with a large US teaching hospital. The clinic is designed to provide primary medical service and specialized services (ie, podiatric, dental, and ophthalmologic care) to uninsured and underinsured peoples. The no-show rate is about 25 to 30%, which takes into account first time visits and follow-up patients. Each patient visit is allotted 15 minutes. 232 visits involved patients with T2DM and 2 involved patients with T1DM. 225 visits were initial visits, and 9 visits were follow-ups, which we collected as separate encounters to evaluate primary outcomes. A first-year resident (PGY-1) was the primary caretaker for 51, a second-year resident (PGY-2) for 85, and a third-year resident (PGY-3) for 98 visits. Of note, no patient was actively pregnant within the two-month study period. Additionally, all resident classes have equal duty times (10 weeks) within the outpatient setting per the residency program's curriculum, with board review during their outpatient time tailored towards diabetes management.

Data Collection and Statistical Analysis

The frequency with which a resident met the two outcomes was recorded quantitatively as a percent average over the two-month span, with associated 95% confidence interval. These averages were stratified across resident year. Statistically significant differences between ADA parameters within resident groups were determined using the student's paired t-test. Primary

Table 1. Summary of focused ADA preventative parameters.

ADA PARAMETER	ADA RECOMMENDATION
Cholesterol	Moderate-intensity statin should be started on patients above 40, on patients younger than 40 with CVD, and can be considered in patients younger than 40 with no CVD present if LDL-c level is above 100 mg/dL or if risk factors are present[8].
Hemoglobin A1c	A1c should be checked twice per year for those with glycemic control, defined as < 7% (mmol/mol), or thrice per year for patients lacking control[9].
RAASi	RAASi should be prescribed to all patients with uncontrolled HTN (defined as > 140/90 mm Hg) or if microalbuminuria is present[10,11].
Podiatry	Patients with T1DM should receive annual foot exams 5 years after diagnosis. T2DM patients should receive annual exams. Exams should consist of vascular assessment, (ie, pulses with ABI if needed) starting at the time of diagnosis[12] as well as recommendation for therapeutic footwear.
Eyes	Patients with T1DM should receive comprehensive eye examinations by an eye specialist annually 5 years after diagnosis. T2DM patients should receive annual exams at the time of diagnosis[13–16].
Diet, Exercise, and Smoking	Lifestyle modification counseling should occur at each patient encounter. Diets should be rich in fruits and vegetables and low in saturated fat, red meats, and sodium. Patients should engage in 150 min or more of moderate exercise weekly[17,18]. Patients should be encouraged to refrain from smoking.
Microalbuminuria	Microalbuminuria should be assessed annually for T2DM and 5 years after diagnosis for T1DM,[19] showing a positive 24-hour urinary collection in 2 of 3 specimens over 3 to 6-month period.
Monofilament	Patients with T1DM should receive annual monofilament testing 5 years after diagnosis. T2DM patients should receive annual exams starting at the time of diagnosis[20]

Abbrevations: ADA, American Diabetes Association; CVD, Cardiovascular disease; LDL-c, Low-density lipoprotein cholesterol; RAASi, Renin-angiotensin-aldosterone system inhibitor; HTN, Hypertension; ABI, ankle-brachial index.

Table 2. Percentage of visits in which adherence to ADA parameter was met stratified by resident year.

	CHOLESTEROL	A1C	RAASi	PODIATRY	EYES	DIET/EXC	MICROALB	MONOFIL
PGY-1 p-value[a]	74.5 [62.1 to 86.9][b] 0.0019	96.1 [93.1 to 99.1] ---	92.2 [85.2 to 99.2] 0.405	27.5 [24.4 to 30.6] <0.0001	56.9 [43.2 to 70.6] <0.0001	52.9 [41.7 to 63.2] <0.0001	49.0 [35.2 to 62.8] <0.0001	55.0 [41.6 to 59.5] <0.0001
PGY-2 p-value	77.6 [68.9 to 86.3] <0.0001	97.6 [95.6 to 99.6] ---	85.9 [78.5 to 93.3] 0.005	17.6 [16.0 to 19.2] < 0.0001	48.2 [37.5 to 48.9] < 0.0001	30.6 [28.6 to 32.6] < 0.0001	55.3 [44.7 to 65.9] <0.0001	28.2 [27.6 to 28.8] < 0.0001
PGY-3 p-value	90.8 [85.1 to 96.5] 0.15	95.9 [89.2 to 98.6] ---	93.9 [94 to 99.8] 0.26	36.7 [32.8 to 40.6] < 0.0001	53.1 [43.2 to 54.1] < 0.0001	36.7 [34.6 to 38.8] < 0.0001	78.6 [70.5 to 88.7] < 0.0001	56.3 [53.9 to 58.8] < 0.0001

[a]p-values were compared to the A1c parameter within that resident class (ie, the p-value comparing A1c to RAASi adherence in the PGY-1 class was 0.405).
[b]Bracket ranges below the raw percentages represent 95% confidence intervals.
Abbreviations: ADA, American Diabetes Association; RAASi: Renin-angiotensin-aldosterone system inhibitor; Diet/Exc., Diet, exercise, and smoking counseling cessation; Microalb: microalbuminuria testing; Monofil, monofilament testing.

Table 3. Percentage of visits in which documentation of ADA parameter was met stratified by resident year.

	CHOLESTEROL	A1C	RAASI	PODIATRY	EYES	DIET/EXC	MICROALB	MONOFIL
PGY-1 p-value[a]	39.2 [26.1 to 42.3][b] <0.0001	92.2 [84.7 to 99.9] ---	47.1 [33.9 to 50.4] <0.0001	5.9 [1.7 to 10.1] <0.0001	21.6 [10.2 to 33.0] <0.0001	52.9 [41.7 to 54.1] <0.0001	17.6 [13.3 to 21.9] <0.0001	27.5 [26.3 to 28.7] <0.0001
PGY-2 p-value	42.4 [31.8 to 53.0] < 0.0001	97.6 [95.4 to 98.8] ---	70.6 [50.9 to 80.3] 0.002	5.9 [2.7- 9.1] < 0.0001	20.0 [12.4 to 28.6] < 0.0001	30.6 [28.6 to 32.6] < 0.0001	21.2 [15.6 to 26.8] < 0.0001	14.1 [13.4 to 14.8] < 0.0001
PGY-3 p-value	61.2 [50.5 to 71.7] < 0.0001	85.7 [78.7 to 92.7] ---	79.6 [71.0 to 86.6] 0.26	11.2 [9.0 to 13.4] < 0.0001	28.6 [19.6 to 37.6] < 0.0001	36.7 [36.7 to 38.8] < 0.0001	35.7 [32.5 to 40.0] < 0.0001	29.5 [28.6 to 30.4] < 0.0001

[a]p-values were compared to the A1c parameter within that resident class.
[b]Bracket ranges below the raw percentages represent 95% confidence intervals.
Abbreviations: ADA, American Diabetes Association; RAASi, Renin-angiotensin-aldosterone system inhibitor; Diet/Exc., Diet, exercise, and smoking counseling cessation; Microalb: microalbuminuria testing; Monofil, monofilament testing.

outcome performances between resident groups were calculated using one-way analyses of variance (ANOVA). Post-hoc Tukey HSD (ie, Honest Statistical Difference) was used to determine which groups within ANOVA had true differences for the parameter of interest. A p-value < 0.05 was used to determine statistically significant differences.

Results

Parameters with Highest and Lowest Adherence Rates to ADA Guidelines per Class

All classes were most adherent to the A1c testing guidelines (PGY-1 96.1%, PGY-2 97.6%, PGY-3 95.9%). The PGY-1 residents were equally as adherent to use of RAASi (92.2%; p = 0.405 when compared to A1c) and PGY-3 residents were also equally adherent to RAASi and statin usage, at rates of 93.9% and 90.8% (p = 0.26 and 0.15 respectively when compared to A1c). The parameter with least adherence differed slightly between the three classes: podiatry was the least adhered to parameter for PGY-1 (27.5%) and PGY-2 (17.6%), while podiatry and lifestyle modification were equally not adhered to in the PGY-3 class (36.7% with no statistical difference). Otherwise, A1c and podiatry guideline adherence statistically differed from every remaining parameter in all classes (p < 0.05; Table 2).

Parameters with Highest and Lowest Documentation Rates per Class

Highest and lowest documentation rates were consistent with guideline adherence findings. All classes had highest documented rates with A1c findings (PGY-1 92.2%, PGY-2 97.6%, PGY-3 85.7%) with additional statistically similar documentation of RAASi in the PGY-3 class (79.6%; p = 0.26 when compared to A1c documentation). Documenting relevant podiatry information was the lowest for all classes: PGY-1 and PGY-2 equally at 5.9% and for PGY-3 at 11.2%. As before, A1c and podiatry documentation rates were significantly different from every remaining parameter in all classes (p < 0.05; Table 3).

Changes in Primary Outcomes Rates Between Resident Classes

Primary outcome rates of diet, exercise, and smoking cessation counseling statistically declined from PGY-1 to PGY-2 (p =

Table 4. p-values when comparing ADA parameter adherence rates between resident classes.

PGY COMPARISON	CHOLESTEROL	A1C	RAASi	PODIATRY	EYES	DIET/EXC	MICROALB	MONOFIL
PGY-1 versus PGY-2	0.900	0.867	0.447	0.401	0.590	0.046	0.713	0.006
PGY-2 versus PGY-3	0.030	0.799	0.156	0.027	0.773	0.651	0.003	0.001

Abbreviations: ADA, American Diabetes Association; RAASi: Renin-angiotensin-aldosterone system inhibitor
Diet/Exc.: Diet, exercise, and smoking counseling cessation; Microalb, microalbuminuria testing; Monofil, monofilament testing.

Table 5. p-values when comparing documentation rates per parameter between resident classes.

PGY COMPARISON	CHOLESTEROL	A1C	RAASI	PODIATRY	EYES	DIET/EXC	MICROALB	MONOFIL
PGY-1 versus PGY-2	0.900	0.503	0.020	0.900	0.900	0.025	0.883	0.175
PGY-2 versus PGY-3	0.028	0.011	0.459	0.388	0.369	0.652	0.066	0.037

Abbreviations: ADA, American Diabetes Association; RAASi: Renin-angiotensin-aldosterone system inhibitor
Diet/Exc.: Diet, exercise, and smoking counseling cessation; Microalb, microalbuminuria testing; Monofil, monofilament testing.

0.046). There was additionally a decline in monofilament testing adherence ($p = 0.006$), however documentation of RAASi usage increased ($p = 0.02$). From PGY-2 to PGY-3, there was significant improvement in adherence to statin usage, podiatry care, microalbuminuria testing, and monofilament testing guidelines. There was also improvement with documenting statin and monofilament usage ($p < 0.05$), however, A1c reporting declined ($p = 0.011$; Tables 4 and 5).

Discussion

A1c Primary Outcomes

Within all three resident classes, the A1c guideline had the highest rates of ADA adherence and documentation, aligning with the primary hypothesis of the study. Explanations for these outcomes include the universally accepted, evidence-based utility of the A1c test in guiding therapy, which extends to both inpatient and outpatient medical practice, as well as the emphasis placed on this parameter as part of the overarching didactic educational curriculum.

When comparing A1c primary outcomes between resident classes, there were no differences in adhering to A1c testing frequency, but we attribute these findings to the fact that primary outcome rates for A1c are relatively near perfect scores. The statistically significant decline in documentation rates of A1c levels from PGY-2 to PGY-3 could very well be an outlier that normalizes if the study were more strongly powered to reduce the Type II error rate, such as being longitudinal rather than a two-month snapshot in time.

Podiatry Primary Outcomes

The lowest rates of both primary outcomes in all three resident classes were found in the podiatry parameter, which also aligned with the primary hypothesis. The lower statistics in podiatry adherence may be multifactorial. A simple explanation is a mere lack of resident education on recommended podiatry care guidelines. Another reason may be due to the false sense of security that may exist with reassuring lab results and physical exam findings, dissuading residents from referring patients to podiatrists, especially those that require a more comprehensive vascular assessment. Suboptimal documentation rates may be a result of residents underscoring the importance of noting relevant podiatric information within their progress notes or history and physicals (H&Ps). A systems-based explanation is that the Centricity EMR places specialist referral results in a different location than in the notes section in the chart. Thus, a resident may see the referral and believe that documentation is appropriate, and therefore not include it within their note. The implication is that pertinent podiatry information would not be included in official documentation, which may perpetuate future instances of resident non-adherence to recommended guidelines.

There were no statistically significant differences in podiatry documentation rates between any resident class, alluding to systemic issues that could potentially be affecting the documentation performance of every class. Such issues can include EHR systems-based issue as highlighted above, cultural issues by the residency program and leadership in undervaluing or overlooking podiatry documentation, or merely a failure for the resident to understand that podiatry documentation within the note is necessary even if a referral exists within an "Orders" or "Referrals" section of the EHR.

Primary Outcome Rates of non-A1c Parameters Within Resident Classes

Reasons that can globally explain the significant underperformance in non-A1c parameters include lack of resident education on the full complement of ADA guidelines, uneven allocation of importance to certain parameters by both residents and supervising attending physicians, resident inattentiveness, and staff shortages. In addition, the current resident educational

model accounts for more inpatient clinical time, which may explain lower primary outcome rates for parameters which are more commonly dealt with in the outpatient setting (ie, eye care referrals, microalbuminuria analysis, monofilament exam, lifestyle counseling). Lastly, unique to the setting of the study, the no-show rate is known to be poor. Thus, subsequent patient visits may focus more on emergent care as opposed to ADA preventative recommendations within the allotted appointment time.

Lower outcome rates of certain parameters may have more specific explanations, in addition to the global ones. For example, lower rates of adherence to the monofilament parameter can be explained by lack of confidence in appropriately performing the exam (ie, resident may be unsure of recommended plantar sites to use), but also by lack of readily available monofilaments; the limited time per patient visit may further limit the resident from actively obtaining the instrument. Lower eye referral rates may best be explained by discordance between a patient's subjective lack of visual disturbances and ADA guidelines, similar to podiatry.

Lifestyle modification counselling (ie, diet, exercise, and smoking cessation counseling) may have been fulfilled by the resident. However, if there was a failure to document that event within the note, it would have been registered as poor adherence, since charting review was the sole way to determine if adherence was met for this parameter.

Primary Outcome Trends of non-A1c Parameters Between Classes

The decline in adherence to lifestyle modification counseling and monofilament testing from PGY-1 to PGY-2 conflicts with the hypothesis that there would be improvement in sequential classes. There was however significant improvement in adherence to statin use, podiatry care, microalbuminuria, and monofilament testing guidelines from PGY-2 to PGY-3. These trends suggest that (1) trainees may benefit from continuous and early reinforcement of guidelines by program directors to accelerate and maintain resident growth, (2) more time may be needed throughout the residency training for there to be maturation in key foundations of diabetes preventative knowledge, or (3) there may have been intrinsic differences between residency groups that disallow appropriate comparisons. Expanding on the third point, comparing trends between sequential resident classes assumes that each resident class is equal and controlled for with confounding variables (ie, baseline intelligence, work ethic, research experience, diabetes knowledge). Therefore, any noted significant difference would then be attributed to experiential learning, rather than intrinsic differences between classes. Thus, it would be more appropriate to instead follow the same class longitudinally, rather than comparing different resident class performances. To this end, a safe suggestion would then be for program directors to take caution in assuming linear, predictable improvement (as it pertains to the outcomes of this paper) with sequential resident classes.

Limitations

Limitations include the smaller sample size as well as the two-month time frame with which the study was carried out, limiting the study's power. To this end, we feel this paper best be used as a snapshot in time rather than a longitudinal assessment. The paper also does not approximate resident care for T1DM patients given their low sample size. Another limitation is the single setting used in the study and the inherent nature of the outpatient site, where patients exhibit inconsistent follow-up. Lastly, this paper viewed ADA guidelines as the gold-standard. If residents were adherent to a different set of preventative guidelines, it would not have been accounted for in this study.

Conclusion

Considerations

The findings of this study suggest disproportionate levels of care in diabetes preventative management. Thus, we believe the value of this study is that it provides an excellent snapshot of areas in which IM residents may be able to improve on, pertaining to the primary outcomes of the paper. Highlighting these areas is crucial, as it provides useful information to program directors on where to intervene, which hopefully can improve the care of diabetic patients. The noted primary outcome declines, as well as lack of statistically significant outcome change in sequential resident years, should prompt program directors to take caution in assuming linear improvement via experiential training. As such, early educational interventions with continuous reinforcement of diabetes preventive guidelines as well as the importance of documentation should be considered.

Due to the standardization of medical curricula by the Liaison Committee on Medical Education (LCME) and the Commission on Osteopathic College Accreditation (COCA), in addition to standardization of study resources in preparation for the US Medical Licensing Exams (USMLEs), it is likely residents enter programs with similar foundations of medical knowledge. To this end, we believe that this data is generalizable and can be utilized by many residency programmes. Variables which may explain differing statistics if the study were reproduced include: regional variability between medical centers, preferences by program directors on emphasis of ADA criteria or other guideline criteria, the diversity of electronic health records (ie, some EHRs may be more user-friendly, making it easier to organize diabetes findings which may result in improved resident outcomes), and timing of research conducted (statistics may be more favorable if the study is reproduced during Spring as residents become more

experienced, such as in this paper). It is also important to consider that the primary outcomes may be overestimated for certain ADA guidelines. For example, if a resident was unsure of microalbuminuria guidelines, but the patient had received a test within the year that was successfully found within the EHR, the resident was still deemed as adherent, despite the knowledge deficit.

Future Directions

Two key overarching explanations for the outcomes of this paper include lack of resident education on ADA guidelines and time constraints within the outpatient clinic environment, both of which prevent accurate information conveyance to patients. Numerous studies have already elucidated the benefits on patient outcomes when clinicians are provided with intensive diabetes educational training[17,18]. One future direction therefore is to attempt to minimize time constraints and provide quick reminders of the preventative services. A creative solution that has not yet been offered in the literature, is the reorganization of ADA guidelines into a friendly-user mnemonic, that can then be implemented within the EHR as a software or "dot-phrase." One such mnemonic is the phrase "CARPEDM," a play-on of the Latin aphorism "*Carpe diem*" which succinctly summarizes key diabetes parameters as emphasized by the ADA (Cholesterol, A1c, RAASi, Podiatry, Eyes, Diet, Monofilament & Microalbuminuria). The implication of this is that the clinician can promptly type in the phrase during the office-visit, which would pull all pertinent diabetes preventative information for that patient into the note. This implementation could save time (ie, reducing the time the provider must search through the EHR) as well as provide an easy and effective approach to abide by guidelines in an organized, standardized, and concise manner. Future studies will hopefully elucidate if the primary outcomes of this paper would change after the implementation of this mnemonic and if the mnemonic positively affects primary endpoints within the diabetic sequelae, with programs that declined use of the mnemonic as controls. Despite high-quality evidence showing improved clinical outcomes for patients who receive various preventive and therapeutic interventions, it has been shown that many patients with diabetes do not receive them[20]. The gap between ideal and actual care is not surprising in view of the complex nature of diabetes management. The implementation of the "CARPEDM" mnemonic within the EHR can hopefully reduce this gap.

Authors contributions

Conception and design (CM, DC, PJ, PP)

Drafting of the article (CM, DC, PJ, PP)

Critical revision of the article for important intellectual content (CM, DC, PJ, PP)

Final approval of the article (CM, DC, PJ, PP)

Ethical Approval

Not applicable, because this article does not contain any studies with human or animal subjects.

Informed Consent

Not applicable, because this article does not contain any studies with human or animal subjects.

Trial Registration

Not applicable, because this article does not contain any clinical trials.

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