Research article

Variation in diabetes care by age: opportunities for customization of care

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Abstract

Background: The quality of diabetes care provided to older adults has usually been judged to be poor, but few data provide direct comparison to other age groups. In this study, we hypothesized that adults age 65 and over receive lower quality diabetes care than adults age 45–64 years old.

Methods: We conducted a cohort study of members of a health plan cared for by multiple medical groups in Minnesota. Study subjects were a random sample of 1109 adults age 45 and over with an established diagnosis of diabetes using a diabetes identification method with estimated sensitivity 0.91 and positive predictive value 0.94. Survey data (response rate 86.2%) and administrative databases were used to assess diabetes severity, glycemic control, quality of life, microvascular and macrovascular risks and complications, preventive care, utilization, and perceptions of diabetes.

Results: Compared to those aged 45–64 years (N = 627), those 65 and older (N = 482) had better glycemic control, better health-related behaviors, and perceived less adverse impacts of diabetes on their quality of life despite longer duration of diabetes and a prevalence of cardiovascular disease twice that of younger patients. Older patients did not ascribe heart disease to their diabetes. Younger adults often had explanatory models of diabetes that interfere with effective and aggressive care, and accessed care less frequently. Overall, only 37% of patients were simultaneously up-to-date on eye exams, foot exams, and glycated hemoglobin (A1c) tests within one year.

Conclusion: These data demonstrate the need for further improvement in diabetes care for all patients, and suggest that customisation of care based on age and explanatory models of diabetes may be an improvement strategy that merits further evaluation.

Background

At present, about 4–5% of U.S. adults age 18 and over have diagnosed type 2 diabetes [1] In various populations, the median age of adults with diabetes typically ranges from 59 to 64 years [2] In the last decade, the over-all incidence of diabetes in America has risen due to increasing obesity, inactivity, and population aging – despite new diagnostic criteria for diabetes based on fasting glucose that may be less likely to classify elderly patients as having diabetes [3–6]

The care of older patients with diabetes presents special clinical challenges and opportunities [7] Clinicians may tailor diabetes care based on a patient's age, functional status, attitudes towards diabetes, or other factors [8,9] Some physicians may treat diabetes less aggressively in elderly patients [10,11] due to anticipated short life expectancy, fear of hypoglycemia, or other factors [12] However, there are many adverse short-term consequences of inadequately controlled diabetes, including excess hospitalizations, increased costs [13] and decreased quality of life [14–16] While the majority of previous studies suggest general under treatment of diabetes in the elderly, at least one prior report suggests this may not be the case [17]

We hypothesized that quality of diabetes care varies by age, and that older patients receive lower quality diabetes care than younger patients. To test this hypothesis, we analyzed care received by diabetes patients 65 years and over, and compared it to care received by those 45–64 years old, in the following clinical domains: (1) glycemic control, (2) cardiovascular risk factor profiles including cholesterol, hypertension, smoking cessation, physical activity, and aspirin use, (3) screening for microvascular complications, (4) general preventive care, and (5) patient education and utilization of care [5,18–20] In addition, we attempt to understand how patient assessments of the seriousness of diabetes may vary with age. We and others have previously hypothesized that patient views of the seriousness of diabetes may be a key factor in understanding variation in diabetes care [9,21]

Methods
This study was conducted at HealthPartners, a large mixed model managed care organization in the Twin Cities with about 650,000 members in owned clinics and contracted clinics. Adults age 19 years and older who were continuously enrolled in calendar year 1994 were defined as having diabetes if they had either (a) two or more clinic visits with a primary or secondary diagnosis of diabetes mellitus (defined as any ICD-9 250 code) during 1994, or (b) one or more filled prescriptions for a diabetes-specific drug including insulin, sulfonylureas, or biguanides in 1994. This strategy for identifying diabetes in this health plan has an estimated sensitivity of 0.91, specificity of 0.99, and positive predictive value of 0.94 as previously reported [22]

A random sample of 1828 health plan members with diabetes was drawn from all adults with diabetes attending either owned or contracted clinics. These members were surveyed in July 1995 by mail with telephone follow-up, with an 85.6% corrected response rate (N = 1565). After exclusions for age under 45 years and for incomplete data on all variables of interest, 1109 study subjects, including

610 in owned clinics and 499 in contracted clinics were included in the analysis and are the basis of this report. The 16-page, 61-item diabetes survey included questions from the Centers for Disease Control's (CDC) Behavioral Risk Factor Surveillance System (BRFSS) core items and diabetes module. Data collected included demographics, disease characteristics, comorbidity, duration of diabetes, diabetes treatment, preventive care, diabetes monitoring, self-care practices, and other topics.

Additional administrative data including number of primary care visits, visits with specialists, dilated retinal exams, and glycated hemoglobin (A1c) results from the 12 months prior to the survey were linked to survey responses before purging all personal identifiers. All A1c assays were performed at the same centralized, accredited clinical chemistry laboratory using a high pressure liquid chromatographic assay with a normal range of 4.5% to 6.1% and a coefficient of variation of 0.58% at a A1c level of 8.8% [23] Of 610 study subjects enrolled in owned clinics, 517 (84.8%) had at least one A1c test done in the 12-month period prior to the survey. However, comparable A1c data were not available for contracted clinics, which used various laboratories and laboratory reporting systems.

Intensity of diabetes care was measured across several clinical domains. Glycemic control was assessed using laboratory data to calculate A1c test rates and A1c values. Macrovascular risk factor control was measured by patient report of aspirin use, smoking status, physical activity, body mass index, and rates of patient-reported hypertension, lipid disorders, and heart disease. Screening for microvascular complications was measured by self-reported eye exam rates and foot exam rates. General preventive care was measured by self-report of preventive care exams, blood pressure checks, and immunization rates. Utilization of care was measured through survey questions and from administrative data.

Initial analysis of data used the Chi-square statistics or t-tests to evaluate the relationship between patient age group and measures of the relevant clinical domains. Multivariate modelling of the data was then done using logistic regression and least-squares linear models [24] to adjust for covariates including gender, race, years of education, duration of diabetes, and whether the patient attended an owned or contracted clinic. The main a priori hypothesis of difference in quality of diabetes care is based on measured differences in A1c values and is tested at a two-tailed alpha of 0.05 after multivariate adjustment for relevant patient characteristics. Secondary measures of quality of care were numerous, and an alpha of 0.01 is suggested to appropriately assess significance [25] Previous analysis of clustering of A1c values within clinics of

Table 1: Unadjusted demographic, social, and health characteristics of 1109 adults with diabetes. P-values address differences between age groups.

Variable	45–64 N = 627	65+ N = 482	*p*-value
Analysis Demographics (% Of respondents):			
Mean Age (years)	55	73.2	N/A*
Gender (% male)	53.6	49.0	0.126
Education (% >= high school)	67	47.1	<0.001
Race: White (%)	87.9	95	<0.001
Ethnicity: Latino (%)	1.5	1.8	0.72
Marital Status (% married)	77.5	66.8	<0.001
Employed for Wages (%)	63.5	5.2	<0.001
Clinic-type (% in Owned Clinics)	46.9	65.6	<0.001
Diabetes Demographics			
Mean Age at Diagnosis (Years)	45.7	61.5	<0.001
Mean Duration of Diabetes (Years)	9.3	11.7	<0.001
Age at Diagnosis < = 30 Years (%)	9.7	1.9	<0.001
Age at Diagnosis < = 30 Years and using Insulin (%)	8.9	0.6	<0.001
Diabetes Medications/Treatment			
Any Insulin Use (% Yes)	42.4	35.7	0.023
Insulin Use Only (%)	37.6	31.1	0.024
Any Oral Medications (%)	44.7	45.6	0.744
Oral Medications Only (%)	39.9	41.1	0.685

* Not Applicable

the medical group demonstrated that this was not a significant factor, [26,27] and therefore results from ordinary least squares and logistic models are presented.

Results

Table 1 shows characteristics of study subjects age 45 to 64 years compared to those age 65 or over. As expected, the distribution of gender, race, educational, marital status, and duration of diabetes varied with age. Therefore, when analyzing the effect of age on dependent variables, multivariate models were used to adjust for the effect of potentially confounding variables such as gender, educational level, owned versus contracted of clinic, and duration of diabetes. The 8.9% of those age 45 to 64 years who had diabetes diagnosis before at age 30 years and were on insulin treatment only had no significant differences.

Table 2 shows data on glycemic control by age group, after adjustment in multivariate models for gender, educational level, race, marital status, and duration of diabetes. There were 610 study subjects enrolled in health plan-owned clinics, and 517 of these had two or more A1c tests available for analysis. The proportion of patients with A1c tests did not differ significantly by age. Mean A1c was 8.4% in younger patients and 8.0% in older patients. The percent of patients with A1c > 10% was 16.5% in younger patients and 6.4% in older patients (p = 0.008). The percent of patients with A1c < 8% was 43.9% in younger patients, and 57.6% in older patients (p = 0.038). Thus,

after adjusting for potential confounders, older subjects with diabetes had significantly better glycemic control than younger adults with diabetes had.

Table 3 shows data on cardiovascular risk factors by age group. Older patients had nearly twice as much self-reported heart disease and significantly higher self-reported hypertension than younger patients. However, older patients did not generally attribute their cardiovascular comorbidities to having diabetes. After adjustment for gender, educational level, marital status, race, and duration of diabetes, older adults had significantly lower levels of obesity and overweight, more physical activity, less current and former smoking, and higher rates of aspirin use. As expected, older adults also reported higher rates of cardiovascular comorbidities, hypertension, and high cholesterol.

Table 4 shows use of preventive care services by age. The rate of dilated eye exams within one year was 58.9% in younger patients and 67.2% in older patients by self-report (p = 0.04), and was 56.4% in younger patients and 77.7% in older patients in health plan owned clinics based on a standard set of procedure codes for diabetes eye exams (p = 0.006) [28] Two or more physician foot exams were reported within one year by 60.5% of younger patients and 64.5% of older patients (p = 0.06). The mean number of foot exams within one year was 1.3 in younger

Table 2: Measures of glycemic control for study subjects with diabetes (N = 610) enrolled in clinics with automated laboratory data, by age group, after adjustment for gender, educational level, marital status, race, and duration of diabetes. All data in this table based on automated laboratory databases.

Variable	N	45–64 Years	65+ Years	*p*-value
Percent of subjects with at least one A1c test in the last year.	610	81.3	88.0	0.055
Percent of subjects with two or more A1c measures in the last year.	610	53.4	60.8	0.242
Average number of A1c tests in the last year in those with any A1c test.	517	2.1	2.3	0.112
Percent of subjects with A1c <8%	517	43.9	57.6	0.038
Percent of subjects with A1c ≥ 10%	517	16.3	6.5	0.008

Table 3: Cardiovascular comorbidity and risk measures of 1109 adults with diabetes, by age group, after adjustment for gender, educational level, marital status, race, and duration of diabetes.

Variable	45–64 Years N = 627	65+ Years N= 482	*p*-value
Mean Body Mass Index (kg/m2)	31.1	28.7	<0.001
Percent Overweight '98 (BMI >25)	85.2	74.5	<0.001
Percent Obese '98 (BMI >30)	53.1	32.8	<0.001
Percent Current Smoker	17.9	6.0	<0.001
Percent Ever Smoker	66.8	56.2	<0.001
Percent Taking Aspirin at least 3× per week	29.0	43.6	<0.001
Days in last week with physical activity for 30 minutes or more	4.6	5.1	0.002
Percent told by a health professional they had heart trouble	20.4	41.5	<0.001
Percent told by a health professional they had high blood pressure	52.6	64.5	0.002
Percent told by a health professional they had high cholesterol	42.7	37.3	0.08

patients and 1.8 in older patients (p < 0.001). Immunization rates were higher in older patients, but use of other preventive care and dental care were not significantly related to age.

The proportion of patients who believed their doctor was good at working with them to modify treatment plans was 84% and did not differ by age. Younger patients more often reported that their doctor asked them to take some responsibility for their diabetes treatment (59.4% vs. 44.1%). Younger and older patients had similar confidence in their ability to adjust medications (63%), and perform home glucose monitoring (82%).

Attitudes towards diabetes varied with age. Younger patients (8–16% on various questions) reported that diabetes made life more difficult, and reported feeling more unhappy and depressed and more diabetes-related dissatisfaction with their lives than older patients (6–11% on

various questions). Older patients reported diabetes interfered with travel and caused financial difficulties, while younger patients reported that diabetes interfered with the types and amounts of food they ate. Overall social support was greater (p < 0.001) for those 65 and over, while more younger adults (88.5%) than older adults (77.6%) had people depending on them (p = 0.001). Finally, self-reported health status was significantly better (p = 0.01) for those 45–64 years old than those 65 years and over.

Table 5 shows utilization of care data. Both younger and older patients self-reported a mean of 2.8 visits for diabetes care each year. However, physicians coded a diabetes diagnosis at 5.6 visits per year in younger patients and 6.7 visits per year in older patients. Diagnostic codes indicate that 83.3% of younger patients and 92.0% of older patients had two or more diabetes visits within one year. About 98% of all patients identified a regular clinic, and 88% identified a regular provider of diabetes care, with no

Table 4: Preventive care and other measures of 1109 adults with diabetes, by age group, after adjustment for gender, educational level, marital status, race, and duration of diabetes.

Variable	45–64 Years N = 627	65+ Years N = 482	*p*-value
Percent with self-report of good/very good/excellent general health	74.3	65.6	0.01
Percent with a visit for a routine check-up within one year	83.9	86.1	0.19
Percent with blood pressure taken by health professional within one year	95.2	94.2	0.85
Percent with cholesterol check within one year	78.2	73.2	0.15
Percent with dental check-up within one year	68.4	65.4	0.08
Percent with an influenza immunisation within 1 year	56.1	82	<0.001
Percent ever having a pneumonia immunisation	31.3	64.7	<0.001
Percent with a dilated eye exam within one year	59.2	67.0	0.04
Percent with one or more foot checks within one year	60.8	64.9	0.06
Percent with two or more foot checks within one year	35.1	44.0	0.006

differences by age. Outpatient primary care visits, outpatient specialty care visits, and number of hospitalisations were all significantly higher in older versus younger patients, after adjustment for gender, educational level, marital status, race, and duration of diabetes.

Discussion

Quality of diabetes care depends upon many factors, including characteristics of health insurance, medical groups, clinics, providers, and patients(10, 29, 30) In this report, we focus on an especially interesting piece of the puzzle – how diabetes care and outcomes relate to patient age and patient attitudes towards diabetes. Is such a narrow focus on patient-related factors justified? Previous studies and our data suggest that patient factors such as age and attitudes towards diabetes may contribute significantly to undesirable variation in diabetes care [26] If this is so, customization of diabetes care based on patient age, attitudes towards diabetes, comorbidity, risk of complications, or other factors may be an improvement strategy that can lead to better diabetes care and outcomes.

There were distinct differences in patterns of care and quality of care by age. Older patients had longer duration of diabetes, higher cardiovascular comorbidity, poorer perceived health status, and higher inpatient and outpatient utilization rates. Older patients also had better glycemic control even though they were less often treated with insulin, more often treated with no diabetes medications, and did less home glucose monitoring. These differences in health and in diabetes care by age across multiple clinical domains persisted after control in multivariate models for educational level, gender, functional health status, duration of diabetes, and type of diabetes treatment.

Thus, among older patients, the burden of diabetes appeared to be increasingly mediated through the cardiovascular complications of diabetes. Despite their longer duration of diabetes and much higher rates of cardiovascular disease, older patients had less negative views of diabetes and reported less adverse impact of diabetes on their lives than did younger patients. The data suggest that older patients do not attribute cardiovascular-comorbidities to their diabetes. Many diabetes patients, most especially older diabetes patients, appear to seriously underestimate the adverse effect diabetes may have on their health.

Although the overall level of diabetes care in this setting was better than reported in many other settings, [31–34] few patients received all recommended elements of care. For example, while eye exam rates were 66%, A1c test rates were over 85%, and foot exam rates were 62%, only 36% of all patients received all these elements of care within the past year. Older patients had higher prevalence of cardiovascular risk factors, but relatively better risk factor control, with lower rates of smoking, higher rates of aspirin use, lower rates of obesity, and more physical activity. Because this is a cross-sectional study, some of these age-related differences could be partially explained by selective mortality.

There is ample evidence that glycemic control could be further improved even in older patients [35,36] However, attention to reversible cardiovascular risks, including more use of aspirin, [30,37] better control of blood pressure [38–41] and better lipid control [42,43] may be the best strategy to improve care for patients who are already in reasonably good glycemic control [44,45] Improvement strategies deployed through primary care clinics may be effective, because older patients had frequent primary care visits. Successful strategies to improve chronic disease care in primary care practices using guidelines, registries, and more organized office care have been reported recently [46–53]

Table 5: Utilization of health care services in one year by 1109 adults with diabetes, by age group, after adjustment for gender, educational level, marital status race, and duration of diabetes.

Variable	45–64 Years N = 627	65+ Years N = 482	*p*-value
Mean number of mental health outpatient visits	0.3	0.2	0.06
Percent with one or more mental health outpatient visits	13.3	8.0	0.07
Mean number of primary care outpatient visits	9.3	14.8	<0.001
Mean number of specialty care outpatient visits	2.1	3.4	0.03
Percent with one or more specialty care outpatient visits	40.2	56.0	<0.001
Percent with one or more hospital admissions	11.2	22.6	<0.001

Relative to those age 65 years and over, those age 45 to 64 years did relatively poorly with their diabetes care. Younger patients had worse glycemic control, higher rates of obesity, smoked more, and were less physically active – factors associated with high costs [54] and high mortality [8,55–57] in diabetes patients. Intriguing clues in the data suggest that many patients in the 45–64 year group may be either too busy to take care of their diabetes, or have "explanatory models" of diabetes that may reduce their motivation to care for the disease. Previous qualitative and quantitative studies have linked specific explanatory models to poor diabetes care and outcomes, and those with shorter duration of diabetes may be in more "denial" than those with longer duration disease [21,58]

In a time when variation in care is often viewed negatively, the data reported here suggest the need to customize diabetes care to accommodate patient factors, such as age, comorbidity, functional health status, and attitudes towards diabetes [59–62] "Mass customization" theory provides insight on how to achieve better self-care behaviors and clinical outcomes [63–66] Such care models may be especially suitable in cost-conscious and data-rich practice settings, such as many health plans. There are several examples of successful innovation in diabetes care that provide templates for improvement [49,50,52,53] and it is interesting to note that practices that have successfully improved diabetes care have used many of the same basic strategies: leadership; resource allocation for improvement; clinical guidelines; patient activation; reorganized care teams; automated information systems to identify, monitor, and prioritize patients; visit planning, and active outreach [67,68]

There are several factors that constrain the interpretation of the data presented here. First, the accuracy of self-reported data must be considered. We have previously studied this issue in depth, and sought to use the type of measure (self-report or database derived) that is most accurate for a particular variable [28] Thus, comorbidities such as hypertension and dyslipidemia are based on self-report, while A1c values, diabetes diagnosis, and utilization of care are derived from automated databases. Second, the study was limited to insured patients at one urban managed care organization, and generalizability of results to other sites, or to populations with different demographic profiles, may not be justified. Third, in the population we studied 8.9% of younger subjects and 0.6% of older subjects had both (a) insulin treatment and (b) diagnosis of diabetes before age 30. We have included all adults with diabetes in the analysis because it is very difficult to accurately distinguish type 1 from type 2 diabetes in office practice [69]. Finally, investigation of age effects is a hazardous undertaking, especially in observational studies with short follow-up periods such as ours. Age confers increased mortality risks, and associated selection effects could affect the findings, especially with respect to prevalence rates of behavioral and biological risk factors such as smoking that are related to mortality risk.

Conclusions
We conclude that older patients achieve more recommended goals of diabetes care than younger adult patients. Despite high rates of heart disease, older patients fail to ascribe heart disease to their diabetes. Younger adults often have explanatory models of diabetes that interfere with effective and aggressive care, and appear to access care less frequently, despite having comprehensive pre-paid health insurance. These data demonstrate the need for further improvement in diabetes care for all patients, and suggest that customizing care to age and explanatory models of diabetes may be an improvement strategy that merits further evaluation.

Competing interests
None declared.

Authors' contributions
Patrick O'Connor contributed to the design of the study, data collection, writing and revising the manuscript. Jay Desai contributed to the design of the study, analysis of

data, writing and revising of manuscript. Leif Solberg contributed to design of study, writing, and revising of manuscript. William Rush contributed to design of study, collection of data, analysis of data, and interpretation of data. Donald Bishop contributed to design of study, interpretation of data, and writing the manuscript.

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