ORIGINAL ARTICLE

Effects of Physician Specialty on Use of Antidiabetes Drugs, Process and Outcomes of Diabetes Care in a Medical Center

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Background/Purpose: Physician characteristics might determine the quality of diabetes care. This study evaluated the effects of physician specialty on the use of antidiabetes drugs, process and outcomes of diabetes care.
Methods: In 2002, 12,023 diabetes patients visited outpatient clinics more than four times at National Taiwan University Hospital. One-tenth of the patients were randomly sampled out. A retrospective chart review was conducted for those who were regularly cared for by endocrinologists (EN), other specialists in internal medicine (IM) and family medicine (FM) physicians. The use of antidiabetes drugs was assessed. Effects of physician specialty on the process or outcome indicators were analyzed by logistic or linear regression, accordingly.
Results: A total of 875 diabetes patients (477 men, 398 women) with a mean age of 62.3 ± 12.7 years were recruited. EN patients had the highest rate of being prescribed insulin, metformin or nonsulfonylurea insulin secretagogues, and the lowest rate of being given sulfonylureas. EN patients showed a significantly better adherence to glucose checkup, glycosylated hemoglobin A_{1C} measures and urinalysis than IM patients. EN patients also showed better adherence to glucose checkup and urinalysis than FM patients. EN patients had the lowest mean fasting plasma glucose (FPG) and lowest mean postprandial plasma glucose (PPG). The difference in PPG between EN and IM patients and the difference in FPG between EN and FM patients were persistently significant following adjustment by patient and physician characteristics.
Conclusion: The use of antidiabetes drugs differed among patients cared for by EN, internists or generalists. Physician specialty had significant effects on the process and outcomes of diabetes care. [*J Formos Med Assoc* 2006;105(10):821–831]

Key Words: diabetes care, medications, physician specialty, process and outcomes

In 2003, expenditure on diabetes, the fourth leading cause of death in Taiwan, consumed more than US$320 million.[1] Improvement in the quality of diabetes care is critical, both for the sake of patients and to lower healthcare costs. However, previous studies have suggested poor adherence to practice standards, unsatisfactory glycemic control and a high prevalence of diabetic complications in Taiwan.[2–4]

Nonadherence and poor glycemic control could be related to patient-, provider- or healthcare system-based issues.[5] Different service provisions by generalists and specialists could result in variations in the quality of diabetes care. Several studies have shown better processes of care, superior glycemic control, and better cost-effectiveness or fewer complications in diabetes care provided by diabetes specialists.[5–15] However, other studies

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reported no meaningful differences in outcomes of diabetes care provided by different physician specialists.[12,16,17]

Comparisons of the quality of diabetes care provided by different specialty groups could have been influenced by patient characteristics, physician factors, organizational variations or insurance-program differences. Unlike most other countries, the National Health Insurance (NHI) program enrolls 96% of people and contracts 93.8% of the medical institutions in Taiwan.[18] This unique comprehensive nationwide medical insurance program minimizes barriers to medical care. With accreditation as one of the leading centers for clinical service, teaching and research, the quality of diabetes care at National Taiwan University Hospital (NTUH) is expected to be of a high standard in Taiwan.[19] Since neither the NHI nor the NTUH sets regulations for diabetes care referral, patients can freely access physicians of different specialties according to their own preference. At NTUH, the majority of diabetes patients are under the care of endocrinologists (EN), other specialists in internal medicine (internists, IM) or family medicine physicians (generalists, FM). Whether or not physician specialty has an influence on the quality of diabetes care in such a medical center is an interesting topic. To our knowledge, no previous report has discussed the use of antidiabetes drugs in patients cared for by physicians of different specialties. This retrospective study was conducted to evaluate the influence of physician specialty on the use of antidiabetes medications. With consideration of patient case-mix and physician characteristics, this study also evaluated the quality of diabetes care, both in terms of process and outcomes, provided by different physician specialists.

Methods

Study design and population

This retrospective medical chart review study was approved by the NTUH Research Ethics Committee. In 2002, 12,023 diabetes patients who had visited outpatient clinics (OPD) at NTUH more than four times were identified. One-tenth of the patients were randomly sampled out. The hospital computer database was reviewed. To minimize possible confounding, we excluded patients with type 1 diabetes, patients without antidiabetes drugs and those who had been admitted to the emergency room or hospital within the study year. A total of 875 patients who received antidiabetes medications regularly at the clinics of EN, internists or generalists were enrolled. No patients in the sample received antidiabetes medications from clinics of other physician specialties at NTUH. Demographic and clinical data including sex, age, duration of diabetes, annual counts of OPD visits, medications and comorbidities or complications of the recruited patients were abstracted by chart review. Antidiabetes drugs were categorized into six classes: insulin, sulfonylureas (glibenclamide, gliclazide, glipizide, glimepiride, gliquidone), biguanides (metfomin), α-glucosidase inhibitors (acarbose), thiazolidinediones (rosiglitazone, pioglitazone) and nonsulfonylurea insulin secretagogues (repaglinide, nateglinide). The maximal class-number of medications concurrently used in each patient was calculated. Documented comorbidities or complications were recorded under the categories of cerebral vascular disease, heart disease, hypertension, hyperlipidemia, renal disease and other systemic diseases (lung and liver diseases, malignancy, endocrinopathy, gastrointestinal problems, hematology disease), neuropathy, retinopathy and peripheral arterial disease (including diabetic foot disease). The total number of comorbidities and complications for each patient was calculated. The physician responsible for individual patients' every visit was identified. Most of the recruited patients were under the care of one particular physician. If a patient had visited more than two physicians within a year, the physician most frequently visited was recorded as the major care physician for that patient. The relevant characteristics of the major care physician for the individual patient were identified.

Evaluation of the process and outcomes of diabetes care

According to the diabetes care practice guidelines set up by the Department of Health, Executive Yuan[20] and the quality-based payment program implemented by the Bureau of National Health Insurance (NHIB),[21] tests of plasma glucose, glycosylated hemoglobin A_{1C} (HbA_{1C}), urinalysis and/or urine microalbumin, renal function test (RFT, serum creatinine), liver function test (LFT, serum alanine aminotransferase [ALT]), and plasma lipid profile should be done at least once annually. None of the studied patients was enrolled into the NHI quality-based payment program. Previous literature did not include adherence to LFT as an indicator.[5–17] We had demonstrated a high prevalence of abnormal liver function in diabetes patients and suggested adding LFT to the practice guidelines for safety medication considerations.[2] LFT is now recommended as one necessary diabetes care measure in the NHI quality-based payment program.[21] We therefore included adherence to LFT as one indicator in our analysis. In this study, the process indicators were evaluated by counting the annual frequency of those diabetic care measures. Glucose measurement included either fasting plasma glucose (FPG) or postprandial plasma glucose (PPG). Self-monitored blood glucose was not included in this study. The lipid profile included total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C). Urinalysis included urine routine and urine microalbumin. When more than one laboratory examination under the same category was performed during one OPD visit, the frequency of the examination in that category was counted only once. Adherence to the measures was considered to be positive when the examination was performed at least once within the year. The adherence to fundus examination or electrocardiogram was not assessed in this study.

The outcome indicators included systolic blood pressure (SBP), diastolic blood pressure (DBP) and blood levels of HbA_{1C}, FPG, PPG, TC, TG, HDL-C and LDL-C. Blood pressure (BP) checkup did not include home monitoring. Serum FPG or PPG level was measured using the TBA-120FR analyzer (Toshiba Corp., Tokyo, Japan) with the HK-G6PD (hexokinase and glucose-6-phosphate dehydrogenase) method. HbA_{1C} was measured using the Primus CLC 385 (Primus Corp., Kansas City, MO, USA) with the high performance liquid chromatography method. Serum creatinine, serum ALT, TC, TG, HDL-C and LDL-C were measured using the TBA-200 autoanalyzer (Toshiba Corp.) with Jaffe's method, JSCC transferable method, enzymatic method, enzymatic-colorimetric method, direct and direct methods, respectively. Those intermediate outcomes were analyzed using the latest data in that year. Percentages of patients with their BP, glycemic or lipid control achieving recommendations[22] were also included as outcome indicators.

Statistical analysis

Excel 7.0 for Windows and SAS 10.0 (SAS Institute Inc., Cary, NC, USA) for Windows were used for data management and statistical analysis. Continuous variables are presented as mean ± standard deviation. The significance of the difference for process or outcome indicators between different physician specialties was calculated by the χ^2 test for categorical variables and analysis of variance for continuous numerical variables. Process indicators of the IM and FM groups were further compared to the EN group by logistic regression analysis. The adherence to diabetes care measures was a dependent variable (1: examination was performed at least once in the year; 0: otherwise). Physician characteristics and/or patient case-mix were independent variables. The odds ratios (OR) and the 95% confidence intervals (CI) were calculated. Outcome indicators were compared between groups by linear regression. The standardized coefficients and 95% CI of the coefficients were calculated. The statistical significance of logistic or linear regression was evaluated in three different models. In model 1, regression analysis was adjusted for case-mix factors (sex, age, duration of diabetes, annual count of visits, insulin therapy and number of comorbidities/complications).

Table 1. Patient characteristics by physician specialty*

	EN patients (n=385)	IM patients (n=320)	FM patients (n=170)	$p^{\dagger}$			
				EN *vs.* IM	IM *vs.* FM	EN *vs.* FM	Overall
Male gender (%)	57.1	54.4	48.8	0.461	0.242	0.069	0.193
Age (yr)	60.0 ± 13.6	65.1 ± 11.4	62.1 ± 11.7	<0.001	0.006	0.084	<0.001
DM duration (yr)	10.3 ± 6.7	9.8 ± 6.6	8.8 ± 6.1	0.583	0.230	0.091	0.233
Annual visit counts	9.9 ± 4.4	9.1 ± 4.2	9.4 ± 3.4	0.016	0.502	0.160	0.039
Com-No	1.3 ± 1.3	2.1 ± 1.3	1.8 ± 1.3	<0.001	0.003	<0.001	<0.001
Patient number (% of patients in each group) with comorbidities/complications							
CVD	23 (6.0)	42 (13.1)	12 (7.1)	0.001	0.412	0.628	0.003
Heart disease	46 (12.0)	108 (33.8)	31 (18.2)	<0.001	<0.001	0.048	<0.001
Hypertension	168 (43.6)	238 (73.8)	110 (64.7)	<0.001	0.036	<0.001	<0.001
Hyperlipidemia	85 (22.1)	97 (30.3)	47 (27.7)	0.013	0.538	0.156	0.004
Renal disease	29 (7.5)	23 (7.2)	20 (11.8)	0.862	0.088	0.105	0.172
Neuropathy	27 (7.0)	29 (9.1)	27 (15.9)	0.316	0.024	0.001	0.004
Retinopathy	35 (9.1)	15 (4.7)	14 (8.2)	0.023	0.113	0.743	0.072
PAD	10 (2.6)	10 (3.1)	3 (1.8)	0.674	0.373	0.550	0.669
Other systemic diseases	83 (21.6)	100 (31.3)	30 (17.7)	0.004	0.001	0.292	<0.001

**Numerical variables are expressed as mean ± standard deviation; †calculated by χ^2 test for categorical variables and by ANOVA for numerical variables. EN = endocrinologist; IM = internal medicine; FM = family medicine; DM = diabetes mellitus; Com-No = numbers of comorbidities/complications; CVD = cerebral vascular disease; PAD = peripheral arterial disease.*

In model 2, regression analysis was adjusted for the major care physician's sex and age. Both case-mix and physician characteristics were considered in model 3. A p value of less than 0.05 was considered statistically significant.

Results

A total of 875 patients (477 men, 398 women) with a mean age of 62.3 ± 12.7 years (range, 19–100 years) were enrolled in this study. The mean duration of diabetes mellitus was 9.8 ± 6.6 years. The mean frequency of OPD visits during the year was 9.5 ± 4.2. The numbers of patients who were regularly treated by EN, IM and FM were 385, 320 and 170, respectively. Gender distribution and diabetes duration were not significantly different among EN, IM and FM groups. Patients in the EN group were younger. They had fewer comorbidities/complications, but more OPD visits than patients in the other two groups (Table 1). The mean serum creatinine levels for patients of EN, IM and FM were 1.1 ± 1.0 mg/dL (n=170), 1.1 ± 1.0 mg/dL (n=182) and 0.9 ± 0.3 mg/dL (n=117), respectively. The mean serum ALT levels for patients of EN, IM and FM were 31.5 ± 35.3 U/L (n=155), 38.4 ± 35.3 U/L (n=147) and 32.5 ± 27.2 U/L (n=100), respectively. Mean serum creatinine and ALT levels were not statistically different among the different patient groups.

There were 13 EN, 39 internists and 18 generalists enrolled in this study. The mean age of the major care physicians was 48.0 ± 8.1, 46.1 ± 7.7 and 42.0 ± 6.4 years for EN, IM and FM groups, respectively. The percentage of males in EN, IM and FM physicians was 97.5%, 96.9% and 82.3%, respectively.

About 29% of the patients were treated with a single oral hypoglycemic agent (OHA), 59.5% were treated with more than two classes of OHAs, 5.4% were treated with insulin alone and 6.1% were treated with a combination of OHA and insulin. For all patients, the maximum class-number of drugs had significant correlations with the levels of FPG, PPG and HbA_{1C} (r=0.202, 0.166, 0.213,

Table 2. Antidiabetes drugs by physician specialty

	EN patients ($n=385$)	IM patients ($n=320$)	FM patients ($n=170$)	p*			
				EN *vs.* IM	IM *vs.* FM	EN *vs.* FM	Overall
Patient number (% of patients in each group) with drugs							
Sulfonylureas	228 (59.2)	265 (82.8)	140 (82.4)	<0.001	0.898	<0.001	<0.001
Non-SU secretagogues	40 (10.4)	6 (1.9)	5 (2.9)	<0.001	0.448	0.003	<0.001
Metformin	271 (70.4)	194 (60.6)	114 (67.1)	0.006	0.161	0.433	0.023
Thiazolidinediones	70 (18.2)	61 (19.1)	25 (14.7)	0.765	0.228	0.316	0.473
Acarbose	44 (11.4)	24 (7.5)	23 (13.5)	0.079	0.031	0.484	0.077
Insulin	78 (20.3)	14 (4.4)	8 (4.7)	<0.001	0.866	<0.001	<0.001
Class-numbers of drugs	1.9 ± 0.8	1.8 ± 0.7	1.9 ± 0.8	0.034	0.245	0.575	0.106
Patient number (% of patients in each group) with different medication patterns							
OHA, one class	95 (24.7)	107 (33.4)	52 (30.6)				
OHA, ≥ 2 classes	212 (55.1)	199 (62.2)	110 (64.7)	<0.001	0.749	<0.001	<0.001
Insulin only	36 (9.4)	8 (2.5)	3 (1.8)				
OHA and insulin	42 (10.9)	6 (1.9)	5 (2.9)				

**Calculated by χ^2 test for categorical variables and by ANOVA for numerical variables. EN = endocrinologist; IM = internal medicine; FM = family medicine; Non-SU = nonsulfonylurea; OHA = oral hypoglycemic agent.*
Note: Sulfonylureas included glibenclamide, gliclazide, glipizide, glimepiride, gliquidone. Non-SU insulin secretagogues included repaglinide and nateglinide. Thiazolidinediones included pioglitazone and rosiglitazone.

respectively, all $p < 0.001$). The correlations remained significant no matter whether it was the EN, IM or FM group. The mean class-numbers of antidiabetes drugs did not differ among the different patient groups. However, EN patients had the highest rate of being prescribed insulin, metformin, nonsulfonylurea insulin secretagogues and the lowest rate of being given sulfonylureas (Table 2).

The adherence rates to annual measures for all the patients were as follows: glucose checkup 89.7%, HbA_{1C} measurement 82.5%, urinalysis 48%, RFT 53.6%, lipid profile 69% and LFT 45.9%. The EN group had the highest adherence to glucose checkup, HbA_{1C} measure and urinalysis, while patients in the FM group had the highest adherence to annual RFT, lipid profile and LFT (Table 3). The significance of the differences for the adherence between IM and EN groups and between FM and EN groups varied in different models of logistic regressions (Table 4). However, the differences in adherence to glucose, HbA_{1C} tests and urinalysis between the IM and EN groups remained statistically significant regardless of adjustment for case-mix, physician characteristics or both. The EN group also had persistently significantly higher adherence to glucose checkup and urinalysis than the FM group (Table 4).

Among those who had examinations within the study year, the EN group had the highest frequencies of glucose checkup, HbA_{1C} testing and urinalysis (Table 3). In the evaluation of the correlation between the process and the intermediate outcomes of diabetes care, we found that frequencies of glucose or HbA_{1C} testing had no correlation with FPG or HbA_{1C} levels, but more frequent glucose testing correlated with lower PPG levels ($r = -0.16$, $p < 0.001$).

Not all patients had body weight, body height or BP recorded in their medical charts. Body mass index (BMI) and BP measurement in the study year were available in 68.6% and 77.7%, 62.2% and 84.8%, and 76.5% and 90.8% of the EN, IM and FM patients, respectively. The mean levels of intermediate outcomes for all the patients with available data were as follows: BMI 25.3 ± 3.6 kg/m^2, SBP 134.8 ± 16.3 mmHg, DBP 78.2 ± 9.5 mmHg, HbA_{1C} 7.3 ± 1.5%, FPG 8.47 ± 3.08 mmol/L, PPG

Table 3. Patient numbers (%) having exams during the year and annual counts of exams (among those who had received annual exam) in different patient groups

	EN patients ($n=385$)	IM patients ($n=320$)	FM patients ($n=170$)	p*			
				EN *vs*. IM	IM *vs*. FM	EN *vs*. FM	Overall
Patient number (% of patients in each group) having exams during the year							
Glucose checkup	370 (96.1)	263 (82.2)	152 (89.4)	<0.001	0.035	0.002	<0.001
HbA_{1C} measure	357 (92.7)	224 (70.0)	141 (82.9)	<0.001	0.002	<0.001	<0.001
Urinalysis	254 (66.0)	98 (30.6)	68 (40.0)	<0.001	0.037	<0.001	<0.001
RFT	170 (44.2)	182 (56.9)	117 (68.8)	<0.001	0.010	<0.001	<0.001
Lipid profile	261 (67.8)	210 (65.6)	133 (78.2)	0.543	0.004	0.013	0.013
LFT	155 (40.3)	147 (45.9)	100 (58.8)	0.129	0.007	<0.001	<0.001
Mean annual count of examinations (patient number of those who had received annual examination)†							
Glucose checkup	5.4 ± 2.7 (370)	3.3 ± 2.2 (263)	2.9 ± 1.7 (152)	<0.001	0.044	<0.001	<0.001
HbA_{1C} measure	3.9 ± 2.1 (357)	2.4 ± 1.4 (224)	2.3 ± 1.1 (141)	<0.001	0.588	<0.001	<0.001
Urinalysis	3.9 ± 2.7 (254)	2.2 ± 2.2 (98)	1.5 ± 0.8 (68)	<0.001	0.006	<0.001	<0.001
RFT	1.5 ± 1.2 (170)	1.8 ± 1.6 (182)	1.4 ± 0.6 (117)	0.071	0.005	0.205	0.012
Lipid profile	2.2 ± 1.8 (261)	2.2 ± 1.3 (210)	2.0 ± 1.0 (133)	0.661	0.104	0.089	0.194
LFT	2.1 ± 1.8 (155)	2.2 ± 1.6 (147)	1.7 ± 1.0 (100)	0.803	0.008	0.028	0.038

**Calculated by χ^2 test for categorical variables and by ANOVA for numerical variables; †numerical variables are expressed as mean ± standard deviation. EN = endocrinologist; IM = internal medicine; FM = family medicine; RFT = renal function test; LFT = liver function test.*

Table 4. Adjusted odds ratio (95% confidence interval) for performing diabetes care measures in patients cared for by internists or generalists compared to patients cared for by endocrinologists

	Model 1*		Model 2†		Model 3‡	
	IM *vs*. EN	FM *vs*. EN	IM *vs*. EN	FM *vs*. EN	IM *vs*. EN	FM *vs*. EN
Glucose checkup	0.13§	0.22§	0.23‖	0.31¶	0.25¶	0.18¶
	(0.04–0.41)	(0.06–0.78)	(0.12–0.44)	(0.13–0.73)	(0.06–0.94)	(0.04–0.83)
HbA_{1C} testing	0.19‖	0.58	0.21‖	0.40¶	0.23§	0.39
	(0.09–0.40)	(0.23–1.48)	(0.12–0.36)	(0.19–0.85)	(0.08–0.64)	(0.10–1.45)
Urinalysis	0.31‖	0.48¶	0.20‖	0.34‖	0.32‖	0.36¶
	(0.18–0.53)	(0.27–0.87)	(0.14–0.29)	(0.21–0.58)	(0.16–0.63)	(0.15–0.84)
RFT	1.66	3.09‖	1.53¶	1.79¶	1.54	2.08
	(0.99–2.80)	(1.68–5.70)	(1.07–2.20)	(1.08–2.99)	(0.80–2.97)	(0.89–4.90)
Lipid profile	0.82	1.25	0.84	1.29	0.89	1.14
	(0.46–1.44)	(0.65–2.41)	(0.58–1.22)	(0.74–2.25)	(0.44–1.81)	(0.46–2.84)
LFT	1.6	2.30§	1.19	1.29	1.28	1.7
	(0.96–2.69)	(1.28–4.11)	(0.83–1.71)	(0.78–2.13)	(0.66–2.48)	(0.74–3.93)

**Model 1: adjusted for patient case-mix; †Model 2: adjusted for physician characteristics; ‡Model 3: adjusted for patient case-mix and physician characteristics; §$p<0.005$; ‖$p<0.001$; ¶$p<0.05$. Odds ratios and statistical significance were calculated by logistic regression. IM = internal medicine; EN = endocrinologist; FM = family medicine.*

Note: Adherence to exams is dependent variable (1 = with annual exam; 0 = otherwise). Patient and physician characteristics are independent variables.

12.04 ± 4.56 mmol/L, TC 5.25 ± 1.14 mmol/L, TG 2.05 ± 2.44 mmol/L, HDL-C 1.22 ± 0.30 mmol/L and LDL-C 2.92 ± 0.79 mmol/L. The percentage of patients with BP < 130/80 mmHg was 19.6%, having HbA_{1C} level < 7.0% was 49.3%, and with serum LDL-C level < 2.6 mmol/L was 33.5%. Patients cared for by EN had the lowest levels of FPG and PPG, and patients cared for by generalists

Table 5. Intermediate outcomes by physician specialty

	EN patients ($n=385$)	IM patients ($n=320$)	FM patients ($n=170$)	p*			
				EN *vs.* IM	IM *vs.* FM	EN *vs.* FM	Overall
Intermediate outcomes† (patient number with data available)							
SBP (mmHg)	133.7 ± 16.4 (293)	137.2 ± 16.1 (259)	132.9 ± 16.2 (154)	0.013	0.009	0.601	0.011
DBP (mmHg)	77.6 ± 9.7 (293)	78.8 ± 9.3 (259)	78.6 ± 9.6 (154)	0.136	0.810	0.309	0.296
HbA_{1C} (%)	7.3 ± 1.5 (357)	7.3 ± 1.5 (224)	7.5 ± 1.6 (141)	0.694	0.221	0.310	0.445
FPG (mmol/L)	8.22 ± 2.73 (370)	8.57 ± 3.43 (260)	8.92 ± 3.20 (152)	0.147	0.309	0.011	0.048
PPG (mmol/L)	11.00 ± 4.26 (223)	12.91 ± 4.71 (198)	12.58 ± 4.50 (109)	<0.001	0.547	0.002	<0.001
TG (mmol/L)	2.04 ± 3.13 (253)	2.06 ± 1.65 (208)	2.06 ± 1.98 (132)	0.952	0.995	0.958	0.997
TC (mmol/L)	5.24 ± 1.18 (259)	5.19 ± 1.06 (209)	5.37 ± 1.19 (133)	0.691	0.164	0.304	0.385
HDL-C (mmol/L)	1.26 ± 0.30 (83)	1.19 ± 0.31 (127)	1.22 ± 0.28 (65)	0.098	0.502	0.399	0.239
LDL-C (mmol/L)	2.94 ± 0.72 (77)	2.88 ± 0.79 (123)	3.13 ± 1.22 (12)	0.592	0.323	0.445	0.552
Patient number (% of patients with data available in each group) with optimal control							
BP <130/80 mmHg	63 (21.5)	40 (15.4)	35 (22.7)	0.068	0.063	0.766	0.107
HbA_{1C} <7.0%	181 (50.7)	108 (48.2)	67 (47.5)	0.560	0.897	0.522	0.754
FPG 5.0–7.2 mmol/L	120 (32.4)	82 (31.5)	40 (26.3)	0.813	0.263	0.169	0.377
PPG <10.0 mmol/L	106 (47.5)	56 (28.3)	34 (31.2)	<0.001	0.592	0.005	<0.001
TG <1.7 mmol/L	146 (57.7)	111 (53.4)	71 (53.8)	0.350	0.939	0.462	0.597
HDL-C >1.1 mmol/L	56 (67.5)	70 (55.1)	43 (66.2)	0.074	0.141	0.866	0.134
LDL-C <2.6 mmol/L	26 (33.8)	40 (32.5)	5 (41.7)	0.855	0.521	0.593	0.813

**Calculated by χ^2 test for categorical variables and by ANOVA for numerical variables; †numerical variables are expressed as mean ± standard deviation. EN = endocrinologist; IM = internal medicine; FM = family medicine; SBP = systolic blood pressure; DBP = diastolic blood pressure; HbA_{1C} = glycosylated hemoglobin A_{1C}; FPG = fasting plasma glucose; PPG = postprandial plasma glucose; TG = triglyceride; TC = total cholesterol; HDL-C = high-density lipoprotein cholesterol; LDL-C = low-density lipoprotein cholesterol; BP = blood pressure.*

had the lowest mean SBP (Table 5). Following adjustment for case-mix and physician characteristics, the difference in SBP between groups became statistically nonsignificant. In linear regression analysis, EN patients had persistently significantly better FPG control when compared to FM patients regardless of adjustments for patient case-mix, physician characteristics or both. EN patients also had significantly better PPG control when compared to IM patients. The differences in serum HDL-C and LDL-C levels between the EN and FM groups were originally nonsignificant, but the differences became statistically significant in linear regression analysis with full model adjustment (Table 6).

Discussion

Suboptimal accountability for diabetes care in Taiwan was first reported from a regional teaching hospital in 1996.[2] In that study, adherence rates to HbA_{1C} measure and urinalysis at diabetes patients' first visits were reported to be 40.9% and 57.5%, respectively.[2] About 9.9% and 18.6% of the diabetes patients never received any HbA_{1C} test or urinalysis during a follow-up period of 3 years.[2] Using year 2001 NHI Taipei Branch claims data, the annual adherence rates to glucose checkup, HbA_{1C} measure, urinalysis, RFT, lipid profile and LFT were reported to be 76.3%, 42.7%, 40.2%, 59.7%, 59.2% and 53.2%, respectively.[4] In October 2001, in a bid to improve the quality of diabetes care, the NHIB implemented the quality-based payment program for diabetes care. We did not evaluate the influence of that program because none of the studied patients were recruited into that program. The adherence rates to most of the diabetes care measures at NTUH were higher than those previously reported.[2,4,23] The mean HbA_{1C} and FPG levels in this study were also lower than those of 25 diabetes centers

Table 6. Standardized coefficients (95% confidence interval) of intermediate outcomes in patients cared for by internists or generalists compared to patients cared for by endocrinologists

	Model 1*		Model 2†		Model 3‡	
	IM *vs.* EN	FM *vs.* EN	IM *vs.* EN	FM *vs.* EN	IM *vs.* EN	FM *vs.* EN
SBP (mmHg)	0.01	–0.01	0.13§	–0.02	–0.03	–0.03
	(–3.72–4.29)	(–4.70–4.08)	(0.10–6.98)	(–5.47–3.50)	(–6.16–4.19)	(–7.56–4.88)
DBP (mmHg)	0.06	0.09	0.11§	0.08	0.05	0.1
	(–1.38–3.50)	(–0.66–4.69)	(0.04–4.04)	(–0.50–4.49)	(–2.01–3.93)	(–1.24–5.89)
HbA_{1C} (%)	0.11	0.08	–0.03	–0.01	0.13	0.06
	(–0.07–0.75)	(–0.15–0.70)	(–0.38–0.22)	(–0.43–0.37)	(–0.09–0.94)	(–0.40–0.84)
FPG (mmol/L)	0.13§	0.15§	0.06	0.10§	0.12	0.18§
	(0.05–1.62)	(0.19–1.89)	(–0.19–0.99)	(0.05–1.68)	(–0.28–1.79)	(0.20–2.79)
PPG (mmol/L)	0.24‖	0.21§	0.22¶	0.09	0.23§	0.08
	(0.80–3.65)	(0.59–3.64)	(0.16–3.20)	(–0.34–2.56)	(0.37–3.93)	(–1.23–3.10)
TG (mmol/L)	–0.03	0.12	–0.01	–0.03	–0.04	0.09
	(–0.59–0.40)	(–0.07–0.99)	(–0.002–0.49)	(–0.03–0.46)	(–0.61–0.42)	(–0.32–0.92)
TC (mmol/L)	0.01	0.10	–0.01	0.08	–0.01	0.15
	(–0.29–0.32)	(–0.09–0.57)	(–0.28–0.24)	(–0.09–0.57)	(–0.41–0.36)	(–0.06–0.88)
HDL-C (mmol/L)	–0.02	–0.06	–0.10	0.02	0.09	0.26§
	(–0.13–0.11)	(–0.17–0.10)	(–0.17–0.04)	(–0.12–0.15)	(–0.10–0.21)	(0.01–0.37)
LDL-C (mmol/L)	0.15	0.15	–0.01	0.17	0.09	0.45¶
	(–0.12–0.58)	(–0.20–1.10)	(–0.33–0.29)	(–0.03–1.44)	(–0.31–0.63)	(0.97–3.41)

**Model 1: adjusted for patient case-mix; †Model 2: adjusted for physician characteristics; ‡Model 3: adjusted for patient case-mix and physician characteristics; §$p<0.05$; ‖$p<0.005$; ¶$p<0.001$. IM = internal medicine; EN = endocrinologist; FM = family medicine; SBP = systolic blood pressure; DBP = diastolic blood pressure; HbA_{1C} = glycosylated hemoglobin A_{1C}; FPG = fasting plasma glucose; PPG = postprandial plasma glucose; TG = triglyceride; TC = total cholesterol; HDL-C = high-density lipoprotein cholesterol; LDL-C = low-density lipoprotein cholesterol.*
Note: Standardized coefficients and statistical significance were calculated by linear regression.

in Taiwan.[3] However, a failure to meet the recommended standards, such as low adherence to urinalysis or missing records for body weight or BP measures, was still noted. Our findings suggest that there is a need to improve the quality of diabetes care.

At NTUH, diabetes patients have free access to physicians for their diabetes care. Patients of internists usually have diseases other than diabetes. For convenience, most patients with other systemic diseases preferred to be cared for by internists for their major diseases and to get their antidiabetes drugs from the internists at the same time. Patients cared for by generalists usually had more, but relatively mild, diseases. The "cluster" effect of patients with specific characteristics to remain with physicians having specific characteristics has been discussed before.[17] In our series, EN patients were younger and had lower numbers of comorbidities/complications. This observation suggests that younger diabetes patients prefer to be cared for by EN. Trying to enroll patients with the same disease severity, we excluded patients who had visited emergency services or who had been admitted to hospital. The sex ratios, mean duration of diabetes, serum creatinine and ALT levels were not different among groups. To minimize possible bias originating from the heterogeneity of the patient population, we further adjusted patient characteristics in our analysis.

In reviewing antidiabetes prescription patterns, the tendency away from monotherapy with insulins or sulfonylureas and toward combination therapies has been reported in the US and in Stockholm.[24,25] The use of OHAs other than sulfonylureas has increased rapidly.[24–26] It was reported that improvement in metabolic and

cardiovascular outcomes of diabetes care was not correlated with the simultaneously changed prescription pattern.[25] By linking pharmacy and laboratory data, Wetzler and Snyder[27] reported few changes in therapy despite the large percentage of patients with suboptimal control. To our knowledge, the effect of physician specialty on prescription pattern has never been discussed. In our series, the mean maximum class-numbers of antidiabetes drugs did not differ among EN, IM or FM patients. The maximum class-numbers of drugs were significantly correlated with the levels of FPG, PPG and HbA_{1C}, regardless of patient group. These findings might reflect the common response of adding more drugs to overcome poor glycemic control. EN prescribed insulin, metformin and nonsulfonylurea insulin secretagogues more frequently than internists and generalists. Since the mean serum creatinine and ALT did not differ among groups, we would like to infer, but conservatively, that physicians of different specialties might have different preferences in prescribing antidiabetes drugs. The true effects of physician specialty on the targets of glycemic control and on suboptimal glycemic control should be further explored in future prospective studies.

Compatible with previous reports, our data clearly showed that patients of EN had better adherence to diabetes care measures than patients of internists or generalists. It has been said that specialists may order excessive tests and provide a higher cost style of care than generalists.[6,11] The mean annual frequencies of diabetes care measures for the EN patients were still not as recommended. Our data showed better, but not overutilized, process of diabetes care provided by EN.

Zgibor et al[13] reported a lower HbA_{1C} in patients with type 1 diabetes cared for by specialists. In our series, EN patients had the lowest mean FPG and PPG, and highest percentage of patients with PPG < 10 mmol/L. The difference in FPG levels between EN and FM groups and the difference in PPG levels between EN and IM groups remained statistically significant even after full model adjustment. The EN group had the highest percentage of patients, though not statistically significant, with HbA_{1C} level < 7.0%. The adherence to HbA_{1C} measure was lower, especially in the IM groups, than the adherence to glucose checkup. The statistical significance of the difference in glycemic control indicators among EN, IM and FM patients might, thus, be biased by incomplete data in some patients. Moreover, internists or generalists who continued to monitor HbA_{1C} might be more familiar with the diabetes care practice guidelines than those who did not. The difference in HbA_{1C} among EN, IM and FM groups might, therefore, be less significant than the difference in glucose levels among groups. Although not statistically significant in all indicators of glycemic control, patients of EN did have a tendency to achieve superior glycemic control than patients of other specialists.

A previous study reported a potential bidirectional relationship between glycemic control and adherence at adolescence.[28] Our analysis showed no correlations between frequencies of glucose and HbA_{1C} testing with FPG and HbA_{1C} levels. However, more frequent glucose measures correlated with lowering PPG levels. Increasing frequencies of testing might indicate the act to a poor control, but not necessarily be linked to changing therapy or improving outcome.[27] The true effects of the intensive monitoring might not be shown clearly in this retrospective study. The discrepancy in the correlations between FPG, PPG and HbA_{1C} with the frequencies of glucose and HbA_{1C} testing deserves further investigation in a future prospective study.

It was reported that general practitioners who are female or have ≤10 years of work experience have better recordings of BP.[12] Generalists, who were female and younger, showed better performance than EN with regard to BP and body weight recording in this study. Pellegrini et al[29] reported a higher risk for poor BP control by male physicians and a lower risk for poor BP control by EN. Other studies did not demonstrate the effects of physician specialties on BP control.[12,16,17] In our series, the FM group had the lowest SBP. However, the differences in BP control became insignificant after adjustment for case-mix and

physician characteristics. This result suggests that there are no meaningful differences in BP control for diabetes patients under the care of physicians of different specialties.

Berardis et al[10] reported better TC levels in patients cared for in diabetes OPD clinics. In our series, the differences in HDL-C and LDL-C between the EN and FM groups were originally nonsignificant, but the differences became statistically significant after full model adjustment. Since patient numbers with HDL-C and LDL-C available were small, we would like to be more cautious in making conclusions from these findings.

Our study showed a significant effect of physician specialty on the process and the intermediate glycemic outcomes of diabetes care. However, this conclusion has several limitations. First, outcome data were not available for patients who did not receive examinations in the year. The analysis is thus limited by incomplete data in some patients. Second, not all indicators of glycemic control showed similar statistically significant results. Third, initial glycemic and BP levels were not extracted from medical records in this retrospective study. We therefore cannot estimate the real improvement in glycemic and BP control contributed by different physician specialties. Fourth, we did not assess and adjust for physician attitudes and beliefs. It has been reported that the personal attitudes and beliefs of the individual physician, rather than physician specialty or setting of care, influence metabolic control.[30] Fifth, we did not evaluate the influence of patients' socioeconomic status. Studies have reported that patients of lower socioeconomic standing are less likely to receive specialist care.[5] Lower socioeconomic status is also an important risk factor for nonutilization of preventive services.[5,13,31] Sixth, the adjustment with numbers of comorbidities/complications might not be enough to reflect the variation and complexity of patients' disease entities.

In conclusion, our analysis showed different use of antidiabetes drugs among patients cared for by EN, internists and generalists. Our findings highlight the effects of physician specialty on the process and outcomes of diabetes care. We suggest consistent education and further enhancement for improving the quality of diabetes care in Taiwan.

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