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Achievement of Processes of Care for Patients with Type 2 Diabetes in General Medical Clinics and Specialist Diabetes Clinics in Thailand

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Abstract

Background: The process of care used for type 2 diabetes are common clinical performance indicators, but comparing achievement of process of care between clinic types at different hospital types has received little attention. This study compares process of diabetes care between specialist diabetes clinics (SDCs) and general medical clinics (GMCs), and how this disparity may vary across hospital types (regional, provincial, community) in Thailand.

Methods: We conducted a cross-sectional study based on medical records of type 2 diabetes patients (n=26,860) collected from 595 hospitals (26 regional, 70 provincial, 499 provincial) between April 1 to June 30, 2012 across all provinces in Thailand. Generalized linear mixed models were used to investigate the association between clinic type and processes of care. Processes of care outcomes included the "FACE of diabetes" where F is foot examination, A is HbA1c examination, C is low density lipoprotein cholesterol (LDL-C) examination, and E is eye examination. Aggregate measure including All FACE (yes/no), whether all four clinical examinations were achieved, and Any FACE (yes/no), whether any were achieved, were also examined.

Results: SDCs were often better at large hospitals, and only for LDL-C exam were SDCs not superior in this setting. For regional hospitals, SDCs exhibited higher achievement of All FACE (OR regional=1.68, 95%CI: 1.26-2.24). For provincial hospitals, SDCs were associated with higher odds of achieving All FACE and Any FACE (OR=2.14, 95%CI: 1.50-3.06; OR=1.76, 95%CI: 1.05-2.97, respectively). For community hospitals, no difference in achievement of All FACE and Any FACE could be demonstrated between clinics types.

Conclusions: SDCs perform better in process of care (singular or aggregated) than GMCs at regional and provincial hospitals, for all process of care indicators, and were never inferior. However, smaller community hospital-GMCs perform care no worse than their SDCs counterparts.

Keywords: Type 2 diabetes; FACE of diabetes; General medical clinics; Specialist diabetes clinics

Introduction

The number of people around the world suffering from diabetes mellitus is steadily increasing [1]. Overall, 7.5% of Thai adults age 20 years and older, an estimated 3.2 million people, have diabetes, of whom one-third remain undiagnosed [2]. Failure to diagnose, assess and control patients with diabetes effectively is also likely to lead to increased risk of chronic diabetic complications such as amputation, retinopathy, neuropathy, cardiovascular disease, and ultimately, mortality [3,4].

The Thai government has launched "The Healthy Lifestyle Strategy 2011-2020 Plan" to attempt to reduce the number of people developing avoidable diabetic complications, or at the very least, delay the onset of such complications [5].

Among the strategies outlined in this plan is the routine screening for diabetes complications in high risk population using examinations of glycated hemoglobin levels, cholesterol and conducting regular eye and foot examinations. It is accepted that through regular checking, substantial reductions in the morbidity and mortality associated with type 2 diabetes could be achieved [6-9].

Several studies conducted in a Thai context indicate that greater than 50 percent of patients with diabetes do not receive the basic checks (called processes of diabetes care) [10,11]. A previous study showed that general medical clinics attendance is associated with better clinical outcome [12].

Otherwise, whether specialist clinic or general medical clinic perform better for process of care, both in terms of individual measures, or overall performance (aggregate measures) remains largely unexplored for level of hospital (regional, provincial, or community). The aim of this study was to compare the process of diabetes care of specialist diabetes clinics, and general medical clinics for different hospital level (regional, provincial, and community).

Research Design and Methods

Data source

Data for this study were obtained from on ongoing project called "An assessment on quality of care among patients diagnosed with type 2 diabetes and hypertension visiting hospitals of Ministry of Public Health and Bangkok Metropolitan Administration in Thailand, 2011-2012" (www.damus.org.th), a project funded by the National Health Security Office (NHSO), Thailand. Clinical information were extracted from the medical records by participating hospital staff and clinical research associates and then transcribed to CRFs.

Ethical approval was obtained from the Ethics Committee of Khon Kaen University, Thailand. Written informed consent was obtained from all patients with type 2 diabetes prior to the research being undertaken.

Study design

This study was cross-sectional and employed a proportional to size stratified cluster sampling approach to collect patients from 26 regional, 70 provincial, and 499 community hospitals. Overall, 26,860 participants previously diagnosed with type 2 diabetes (T2DM) registered at outpatient department attending either specialist diabetes clinics (SDCs) or general medical clinics (GMCs) were collected from all 77 provinces under the Ministry of Public Health and Bangkok Metropolitan Administration Hospitals in Thailand. Patients with T2DM were eligible for inclusion if they were aged 35 and older, and had a diagnoses of T2DM for at least 12 months.

Those participating in experimental research for the study period were excluded. Data were collected retrospectively by reviewing medical records for patients attending clinics from April 1 to June 30, 2012.

Measurement of the processes of care

The processes of care outcomes considered in this study will be referred to here as the "FACE of diabetes" where F is foot examination, A is glycated hemoglobin (HbA1c) examination, C is low density lipoprotein cholesterol (LDL-C) examination, and E is eye examination.

These four outcomes were considered in binary form (yes/no) based on guidelines provided by International Diabetes Federation Global Guideline for type 2 diabetes and the American Diabetes Association's Standards of Medical Care in Diabetes-2014 for satisfactory processes of care examinations.

Foot examination at least once every 12 months (yes/no), HbA1c examination at least twice every 12 months (yes/no), LDL-C examination at least once every 12 months (yes/no), and eye examination at least once every 12 months (yes/no) [13,14]. Additionally, the achievements of any and all process of care examinations (aggregate measures) were considered.

Any FACE (yes/no) represents a measure that identifies patients achieving any of the clinical examinations, regardless of which of these examinations the patients achieved. All FACE (yes/no) represents a measure noting whether all four of the clinical examinations were achieved.

Study effect and other risk factors

The effect of interest in this study was clinic types attended (specialized diabetes clinic-SDC, or general medical clinic-GMC). Other covariates included as potential predictors and/or confounders in this study include: age, duration of diabetes (both measured continuously), sex, religion (Buddism or Muslism), medical coverage (universal coverage, civil security medical benefit (CSBM), social security scheme, and other), BMI class, hypertension, and hospital type (community, provincial, and regional).

Statistical analysis

Patient characteristics were represented by frequencies and percentages for categorical variables, and means and standard deviations for continuous variables. The data used in the present study are multilevel with some covariates measured at the patient and others at the hospital level.

To account for the multi-level structure of the data, we employed a mixed effect modeling, an approach that can also be used to account for any hospital clustering effect. Six process of care outcomes were binary and were analyzed using a generalized linear mixed model (GLMM) with a login link (binary logistic mixed effect regression).

Both crude (bivariate analysis) and adjusted associations were generated and the purposeful selection of covariates (PSC) [15] approach was employed to build the multivariable models with all covariates, except clinic type (the study effects), included (or excluded) in the model based on the PSC algorithm.

Clinic type (SDC or GMC) was the study effect and consequently was forced into all models. We chose the PSC approach because it allows for the identification, and subsequent statistical control, of confounders.

To probe significant interactions between clinic type and hospital level (community, provincial, regional), we performed a subsequent subgroup analysis. All statistical analyses were conducted using R version 3.0.3 [16]. We performed GLMMs using the R library lme4 version 1.0.5 [17].

Results

During the period of study, a sample of 26,860 patients with type 2 diabetes mellitus (T2DM) were collected, of whom 6,675 (24.8%) attended general medical clinics (GMCs) and 20,185 (75.2%) attended specialized diabetes clinics (SDCs).

Patients with T2DM attending SDCs tended to have a higher other insurance category (out of pocket), (n=5,046, 25.2%) compared to those attending the GMCs (n=887, 13.5%), and attendees of SDCs showed a lower prevalence of hypertension (n=13,250, 65.6%) than attendees of GMCs (n=4,957, 74.3%) (Table 1).

	SDCs N=20,185†	GMCs N=6675†
Sex n (%)		

Female	14,285 (70.8)	4554 (68.3)
Age in years		
<40	642 (3.2)	207 (3.1)
40-59	9454 (46.8)	2895 (43.4)
60-80	9553 (47.3)	3343 (50.1)
>80	534 (2.7)	229 (3.4)
Mean (SD)	59.6 (10.7)	60.4 (10.9)
Median (min:max)	59 (20:98)	60 (20:96)
Religion n (%)		
Buddhism	17,734 (96.1)	5729 (97.3)
Muslim	723 (3.9)	161 (2.7)
Scheme n (%)		
Universal coverage	11,416 (57)	3935 (59.9)
Gov't insurance	3045 (15.2)	1370 (20.8)
Social Security Scheme	522 (2.6)	383 (5.8)
Other	5046 (25.2)	887 (13.5)
BMI (kg/m2) n (%)		
<18.50	712 (3.7)	167 (2.9)
18.5-22.9	5116 (26.4)	1326 (23.3)
23.0-24.9	3980 (20.6)	1156 (20.3)
25.0-29.9	7059 (36.5)	2101 (36.9)
≥30.0	2488 (12.9)	938 (16.5)
Duration in years		
<5	5262 (26.1)	1918 (28.7)
5-10	8940 (44.3)	2863 (42.9)
>10	5983 (29.6)	1894 (28.4)
Mean (SD)	7.64 (4.6)	7.24 (4.6)
Median (min:max)	7 (1:6)	6 (1:5)
Hypertension	13,250 (65.6)	4957 (74.3)

BMI: body mass index; GMCs: General medical clinics; SDCs: Specialist diabetes clinics; CSMB: Civil servant medical benefit.

†Values used as denominator of prevalence calculations. For variables where patient information is missing, the denominator is adjusted accordingly.

Table 1: Patients characteristic in general medical clinics and specialist diabetes clinics.

Achievement of the individual process of care examinations outcome ranged from the 50.2% (eye exam) to 83.9% (LDL-C exam) and the achievement of HbA1c examination, LDL-C examination, eye examination, and foot examination appeared to be higher in SDCs than GMCs (Table 2).

Processes of Care	GMCs			SDCs			Total		
	N†	(%)	95%CI	N†	(%)	95%CI	N†	(%)	95%CI
HbA1C exam	4908	(73.5)	72.4-74.6	15,061	(74.6)	74.0-75.2	19,969	(74.3)	73.8-74.9

LDL-C exam	5283	(79.2)	78.2-80.1	17,248	(85.5)	84.9-85.9	22,531	(83.9)	83.4-84.3
Eye exam	2821	(43.1)	41.9-44.3	10,494	(52.5)	51.8-53.2	13,315	(50.2)	49.6-50.8
Foot exam	3076	(46.9)	45.8-48.2	13,655	(68.3)	67.7-68.9	16,731	(63.1)	62.5-63.6
All FACE	1245	(19.0)	18.1-19.9	6437	(32.2)	31.6-32.9	7682	(28.9)	28.4-29.5
Any FACE	6254	(93.7)	93.1-94.3	19,453	(96.4)	96.1-96.6	25,707	(95.7)	95.5-95.9

CI: confident interval; HbA1c: glycated hemoglobin; BP: blood pressure; LDL-C: low-density lipoprotein cholesterol; FACE (Foot, HbA1c, LDL-C, Eye), GMCs: General Medical Clinics; SDCs: Specialist diabetes clinics.

†Percentages are based on available case analysis. Where a patient had a missing value they were excluded from both the numerator and the denominator of the prevalence calculation.

Table 2: Comparison of number and percentage of achievement of FACE of diabetes in SDCs and GMCs.

Results of the bivariate and multivariate binary logistic mixed effect regression models are given in Tables 3 and 4, respectively. A comparison of the crude and adjusted associations (Tables 3 and 4) suggests that adjusting for case-mix had little impact on the efficacy of the type of clinic attended.

Perusal of the patient level effects for the multilevel model (Table 4) suggests that effect of particular patient characteristics were similar in terms of both direction and magnitude across many of the process of care examination outcomes.

For example, female were more likely to achieve eye examination, foot examination, and All FACE examination (OR eye=1.20, 95%CI: 1.12-1.29; OR foot=1.12, 95%CI: 1.04-1.21; OR All FACE=1.11, 95%CI: 1.03-1.21).

Every 5 years increase in diabetes duration is associated with an increase in the odds and rate of achieving the All FACE, eye exam, and foot exam. Hypertensive patients were more likely to achieve LDL-C examination (OR=1.17, 95%Cl: 1.05-1.32) and higher BMI was associated with higher achievement of eye examination and All FACE examination.

	n	HbA1c exam OR (95%CI)	n	LDL-C exam OR (95%CI)	n	Eye exam OR (95%CI)	n	Foot exam OR (95%CI)	n	Any FACE exam OR (95%CI)	n	All FACE exam OR (95%CI)
Specialist Clinics	26,860	1.96 (1.64-2.34)	26,860	1.26 (1.05-1.51)	26,529	1.87 (1.62-2.17)	26,536	3.37 (2.85-3.97)	26,859	1.70 (1.26-2.30)	26,529	2.73 (2.29-3.26)
Female	26,856	1.01 (0.94-1.09)	26,856	0.98 (0.90-1.07)	26,525	1.24 (1.16-1.32)	26,532	1.14 (1.06-1.22)	26,855	1.07 (0.91-1.25)	26,525	1.13 (1.05-1.21)
Age [10 years]	26,857	0.99 (0.96-1.03)	26,857	0.96 (0.93-0.99)	26,526	0.98 (0.95-1.00)	26,533	0.99 (0.96-1.02)	26,856	0.96 (0.90-1.03)	26,526	0.99 (0.96-1.02)
Buddhism	24,347	1.01 (0.78-1.31)	24,347	0.96 (0.72-1.28)	24,037	1.07 (0.86-1.31)	24,044	0.97 (0.75-1.24)	24,346	0.97 (0.49-1.95)	24,037	0.99 (0.79-1.24)
Duration [5 years]	25,639	1.05 (1.01-1.10)	25,639	0.98 (0.93-1.02)	25,606	1.11 (1.07-1.15)	25,612	1.13 (1.09-1.17)	25,638	1.03 (0.95-1.13)	25,606	1.08 (1.04-1.12)
hypertension	26,860	1.02 (0.94-1.11)	26,860	1.15 (1.05-1.27)	26,529	1.08 (1.01-1.15)	26,536	0.99 (0.92-1.07)	26,859	1.05 (0.88-1.23)	26,529	1.08 (0.99-1.17)
Scheme	26,604	χ2=231.8, df=3, p<0.001	26,604	χ2=204.8, df=3, p<0.001	26,276	χ2=304.1, df=3, p<0.001	25,164	χ2=4214, df=3, p<0.001	26,603	χ2=78.5, df=3, P<0.001	26,276	χ2=222.6, df=3, P<0.001
Civil Servant		1.14 (1.02-1.26)		1.13 (1.00-1.27)		0.88 (0.81-0.96)		0.74 (0.67-0.81)		1.07 (0.86-1.33)		0.83 (0.76-0.92)
Social security		1.11 (0.90-1.36)		0.98 (0.78-1.23)		0.98 (0.83-1.15)		0.66 (0.55-0.79)		0.69 (0.46-1.02)		0.81 (0.67-0.99)
Other [out of pocket]		1.05 (0.95-1.15)		1.00 (0.89-1.12)		1.11 (1.03-1.20)		1.00 (0.91-1.10)		1.16 (0.95-1.42)		1.02 (0.93-1.12)
BMI [kg/m2]	25,043	χ2=1822, df=4, p<0.001	25,043	χ2=1,080, df=4, p<0.001	24,750	χ2=2031, df=4, p<0.001	24,757	χ2=5784, df=4, p<0.001	25,042	χ2=878, df=2, P<0.001	24,750	χ2=1320, df=4, P<0.001

18.5-22.9		1.01 (0.82-1.23)		1.03 (0.81-1.30)		1.22 (1.05-1.40)		1.12 (0.92-1.35)		1.11 (0.73-1.70)		1.20 (0.99-1.46)
23.0-24.9		1.18 (0.96-1.45)		1.19 (0.93-1.51)		1.15 (0.97-1.33)		1.14 (0.94-1.38)		1.22 (0.79-1.88)		1.24 (1.02-1.52)
25.0-29.9		1.11 (0.90-1.35)		1.12 (0.89-1.42)		1.19 (1.02-1.36)		1.08 (0.90-1.31)		1.12 (0.74-1.70)		1.21 (1.00-1.47)
≥30.0		1.16 (0.94-1.45)		1.27 (0.99-1.63)		1.23 (1.04-1.41)		1.19 (0.97-1.45)		1.28 (0.81-2.00)		1.36 (1.10-1.67)
Hospital type	25,470	χ2=1297, df=2, p<0.001	25,470	χ2=1265, df=2, p<0.001	25,157	χ2=1573, df=2, p<0.001	25,164	χ2=4991, df=2, p<0.001	25,469	χ2=556.3, df=2, P<0.001	25,157	χ2=1050, df=2, P<0.001
Provincial hospital		0.38 (-0.62-1.38)		0.54 (0.22-1.32)		0.84 (0.33-2.16)		1.10 (0.38-3.20)		0.58 (0.17-2.03)		0.43 (0.16-1.18)
Community hospital		0.21 (-0.65-1.09)		0.83 (0.38-1.80)		0.57 (0.25-1.29)		2.17 (0.86-5.50)		0.75 (0.25-2.25)		0.36 (0.15-0.85)

*General medical clinics are as reference category n: number; OR: odd ratio; CI: confident interval; HbA1c: glycated hemoglobin; LDL-C: low-density lipoprotein cholesterol; FACE: (Foot, HbA1c, LDL-C; Eye); GMCs: General Medical Clinics; SDCs: Specialist diabetes clinics; CSMB: Civil servant medical benefit; BMI: body mass index

Table 3: Bivariate Mixed effect logistic regression for FACE of diabetes.

	HbA1c exam (n=23,692) OR (95%CI)	**LDL-C exam (n=20,626) OR (95%CI)**	**Eye exam (n=22,663) OR (95%CI)**	**Foot exam (n=22,669) OR (95%CI)**	**All FACE exam (n=20,600) OR (95%CI)**	**Any FACE exam (n=20,777) OR (95%CI)**
Specialist Clinics	3.60 (2.23-5.80)	0.97 (0.63-1.51)	1.14 (0.88-1.48)	1.87 (1.40-2.51)	1.89 (1.42-2.53)	3.24 (0.87-12.02)
Female	-	-	1.20 (1.12-1.29)	1.12 (1.04-1.21)	1.11 (1.03-1.21)	-
Age [10 years]	-	0.96 (0.91-1.02)	-	-	-	-
Buddhism	-	1.08 (0.77-1.52)	-	-	1.15 (0.90-1.48)	0.74 (0.30-1.85)
Duration [5 years]	-	0.98 (0.93-1.04)	1.09 (1.05-1.13)	1.10 (1.05-1.14)	1.06 (1.02-1.11)	1.06 (0.95-1.17)
hypertension	-	1.17 (1.05-1.32)	-		0.68 (0.33-1.02)	-
Scheme	χ2=142.2, df=3, p<0.001	χ2=91.6, df=3, p<0.001	χ2=201.3, df=3, p<0.001	χ2=199.1, df=3, p<0.001	χ2=131.5, df=3, p<0.001	-
Civil servant	1.1 1 (0.99-1.25)	1.11 (0.96-1.28)	0.85 (0.78-0.94)	0.76 (0.69-0.84)	0.86 (0.77-0.95)	-
Social security	1.01 (0.80-1.28)	0.77 (0.58-1.04)	0.88 (0.73-1.07)	0.81 (0.66-1.01)	0.78 (0.61-0.98)	-
Other [out-of-pocket]	1.07 (0.97-1.18)	1.03 (0.89-1.18)	1.11 (1.01-1.21)	1.04 (0.94-1.15)	1.09 (0.99-1.21)	-
BMI [kg/m2]	χ2=1544, df=4, p<0.001	χ2=1081, df=4, p<0.001	χ2=1649.9, df=4, p<0.001	χ2=1537.8, df=4, p<0.001	χ2=981.9, df=4, p<0.001	χ2=627.9, df=4, P<0.001
18.5-22.9	0.97 (0.79-1.20)	1.01 (0.77-1.31)	1.26 (1.04-1.51)	1.15 (0.95-1.40)	1.20 (0.97-1.48)	1.02 (0.64-1.64)
23.0-24.9	1.12 (0.91-1.39)	1.16 (0.89-1.52)	1.26 (1.05-1.52)	1.22 (1.00-1.49)	1.27 (1.02-1.58)	1.20 (0.74-1.95)
25.0-29.9	1.08 (0.88-1.32)	1.09 (0.84-1.41)	1.26 (1.05-1.51)	1.12 (0.92-1.36)	1.23 (1.00-1.52)	1.04 (0.65-1.66)
≥30.0	1.10 (0.88-1.38)	1.22 (0.91-1.62)	1.35 (1.11-1.64)	1.27 (1.03-1.57)	1.45 (1.16-1.81)	1.18 (0.71-1.97)
Hospital type	χ2=1056, df=2, p<0.001	χ2=824.1, df=2, p<0.001	χ2=1225, df=2, p<0.001	χ2=833.4, df=2, p<0.001	χ2=855.9, df=2, p<0.001	χ2=369.5, df=2, p<0.001
Provincial	0.36 (0.12-1.03)	0.52 (0.20-1.37)	0.50 (0.19-1.32)	0.40 (0.13-1.21)	0.15 (0.05-0.43)	0.56 (0.14-2.34)
Community	0.34 (0.13-0.87)	0.57 (0.24-1.37)	0.25 (0.11-0.60)	1.24 (0.47-3.32)	0.20 (0.08-0.50)	0.70 (0.19-2.64)

Hospital*Clinics	χ2=23.4, df=2, p<0.001	χ2=2.02, df=2, p=0.36	χ2=16.2, df=2, p<0.001	χ2=20.5, df=2, p<0.001	χ2=15.3, df=2, p<0.001	χ2=1.59, df=2, p=0.45
SDCs: Provincial	0.59 (0.34-1.03)	1.00 (0.56-1.76)	1.83 (1.23-2.73)	2.72 (1.73-4.27)	2.83 (1.66-4.81)	0.48 (0.12-1.94)
SDCs: Community	0.26 (0.15-0.47)	1.38 (0.79-2.43)	2.20 (1.45-3.33)	1.19 (0.76-1.87)	1.28 (0.78-2.11)	0.40 (0.10-1.3)

*General medical clinics are as reference category

OR: odd ratio; CI: confident interval; HbA1c: glycated hemoglobin; LDL-C: low-density lipoprotein cholesterol; FACE: (Foot, HbA1c, LDL-C, Eye); GMCs: General medical clinics; SDCs: Specialist diabetes clinic; CSMB: Civil servant medical benefit; BMI: body mass index

Table 4: Multivariate multilevel logistic regression for FACE of diabetes.

When patients from the different level (community, provincial and regional) were pooled, the achievement of the LDL-C examination, eye examination, Any FACE examination did not substantially differ between SDCs and GMCs.

However, achievement of the HbA1c examination, foot examination, and All FACE examination were substantially higher in SDCs (OR HbA1c=3.60, 95%CI: 2.23-5.80; OR foot=1.87, 95%CI: 1.40-2.51; OR All FACE=1.89, 95%CI: 1.42-2.53, respectively).

The multi-level analysis revealed evidence (Table 4) that hospital type represented a significant effect modifier of clinic type for HbA1c examination, eye examination, foot examination, and All FACE examination (HbA1c exam: 2=23.4, df=2, p<0.001; eye exam: χ2=16.2, df=2, p<0.001; foot exam: χ2=20.5, df=2, p<0.001; All FACE: χ2=15.3, df=2, p<0.001).

The nature of these effect modifications is presented in the sub-group analysis provided in Table 5. For patients attending larger hospitals (regional and provincial)-specialized diabetes clinics were substantially more successful in achieving the HbA1c examination relative to patients attending large hospital general clinics (OR regional=3.24, 95%CI: 2.06-5.06; OR provincial=2.55, 95%CI: 1.87-3.46).

This pattern extended to include all hospital types for the eye and foot examination with patients attending SDCs substantially more successful in achieving the eye and foot examination than those attending GMCs (eye examination: OR regional=1.35, 95%CI: 1.04-1.76; OR provincial=1.99, 95%CI: 1.48-2.69; and OR community=2.54, 95%CI:1.82-3.55); foot examination: OR regional=2.37, 95%CI: 1.73-3.24; OR provincial=7.01, 95%CI: 4.99-9.84; and OR community=2.25, 95%CI:1.61-3.13) (Table 5).

SDCs were also substantially more successful in achieving the All FACE than those attending GMCs (OR regional=1.68, 95%CI: 1.26-2.24; OR provincial=2.14, 95%CI: 1.50-3.06, respectively) in Table 5.

This pattern was also observed for Any FACE examination, but unlike the foot examination, eye examination, and All FACE examination, the odds of achieving Any FACE examination in SDCs was not statistically higher in regional, nor statistically lower in community hospitals.

That is, specialized clinics can only be shown to be significantly more successful in achieving Any FACE examination in provincial hospitals (OR provincial=1.76, 95%CI: 1.05-2.97). There is no evidence to suggest that the level of difference between specialist diabetes clinics and general medical clinics varied with the community hospitals for Any FACE or All FACE.

Processes of Care	Case mixed adjusted (across 595 hospitals)			Regional 26 hospitals			Provincial 70 hospitals			Community 499 hospitals		
	n	OR	95%CI	n	OR	95%CI	n	OR	95%CI	n	OR	95%CI
HbA1c exam	23,692	3.6	2.23, 5.80	2815	3.24	2.06, 5.06	4972	2.55	1.87, 3.46	13,965	0.98	0.68, 1.41
LDL-C exam	20,626	0.97	0.63, 1.51	2562	1.13	0.75, 1.69	4379	0.89	0.63, 1.25	15,077	1.33	0.94, 1.88
Eye exam	22,663	1.14	0.88, 1.48	2465	1.35	1.04, 1.76	4928	1.99	1.48, 2.69	14,961	2.54	1.82, 3.55
Foot exam	22,669	1.87	1.40, 2.51	2435	2.37	1.73, 3.24	4637	7.01	4.99, 9.84	15,594	2.25	1.61, 3.13
All FACE exam	20,600	1.89	1.42, 2.53	2507	1.68	1.26, 2.24	5388	2.14	1.50, 3.06	15,051	1.5	0.91, 2.45
Any FACE exam	20,777	3.24	0.87, 12.02	2886	2.52	0.91, 7.02	4225	1.76	1.05, 2.97	15,074	1.2	0.70, 2.03

*General medical clinics are as reference category

OR: odd ratio; CI: confident interval; HbA1c: glycated hemoglobin; LDL-C: low-density lipoprotein cholesterol; FACE: (Foot exam, HbA1c exam, LDL-C exam, Eye exam); GMCs: General medical clinics; SDCs: Specialist diabetes clinics.

Table 5: Mixed effect logistic regression for FACE of diabetes on differences between SDCs and GMCs* "Clinics Effect" at each hospital level and differences between clinic type effects across hospital levels (Clinics-Hospital Interaction Effect).

Discussion

We compared the processes of diabetes care of specialist diabetes clinics, and general medical clinics for different levels of hospital (regional, provincial, and community). We found that SDCs were often better at larger hospital, and only for LDL-C were SDCs not superior in this setting. Also, Any FACE was not different at regional hospitals, but was still superior for SDCs at provincial hospitals.

At community hospitals it was quite a different story, SDCs only outperformed GMCs for eye and foot examination in community hospitals, but it should be noted, again, were never inferior. Interestingly, SDCs were never inferior to GMCs in process of care indicator (any single or aggregate), regardless of the size of the hospital.

A previous study suggests that patients attending specialist clinics receive better quality of diabetes care than patients attending general medical clinics [18]. This present study adds new insights about how hospital types (regional, provincial, community) may relate to process of diabetes care, by itself, and how it may modify the efficacy of specialist clinics compared to general medical clinics in this regard.

This is the first study to consider this aspect of diabetes process of care. We demonstrate in the large hospital setting, specialist clinics were superior in many process of care indicators, and even when not, never inferior.

There are likely to be several reasons that account for the relative success of larger hospital-specialist diabetes clinics in terms of process of care. First, this may be due to the longer T2DM duration (on average) in patients attending large hospital SDCs compared to large hospital GMCs (Table 1).

Second, patients attending SDCs are more likely to be monitored according to the clinical guidelines compared to GMCs, regardless of the severity-of-disease [19].

Third, hospital-based annual check-ups have been implemented for the early diagnosis and to decrease the risk of diabetes complications [20]. Further research is needed is to identify which aspects of specialist clinics in a large hospital setting, lead to their superior process of care.

Our study did have some limitations. First processes of care were performed on admission, but which types of clinic and hospital a patient attends are allocated based on type of medical coverage (universal coverage, CSMB, social security scheme, and out of pocket) suggesting that medical coverage type potentially confounds the clinic type and/or hospital type effect.

However, our analysis did statistically control for the coverage type effect, and even after adjustment we demonstrate that specialist clinics still tend to outperform general medical clinics. Second, some important variables were omitted from our data collection process, a consequence of the medical record audit process we used for data collection. In particular, our retrospective study design led to the exclusion of important lifestyle variables like exercise and diet. Third, there was limited capacity for the researchers to control the introduction of missing values.

The approach used in this study focused on the complete-case analysis and consequently some information bias may have been introduced if data were not missing at random. To investigate this possibility we employed multiple imputation and found little evidence of missing value bias.

Now that we have identified the limitations of this study, we can note the strengths. The data used in this study were obtained from a large nationally representative sample of patients from 595 hospitals across Thailand. In addition, the modeling approach used in this study explicitly accounts for the clustering effect of hospital, a study design artifact that few studies in this area consider.

Also, very few studies of T2DM outcomes have used appropriate multilevel models to consider patient, clinic and hospital-level covariates in the same model. We demonstrated the use of the generalized linear mixed model for analysis of this clustered and multilevel data.

Conclusion

The present study demonstrates that specialized diabetes clinics perform better in process of care (singular or aggregated) than general medical clinics at regional and provincial hospital, for many indicators, and were never inferior. We showed the degree of superiority of specialized diabetes clinics compared to general medical clinics depends on the level of hospital.

However, smaller community hospital-general medical clinics perform care no worse than their specialist clinics counterparts. Future research should focus on teasing out what aspects of specialist diabetes clinics lead to superior process of care, whether they be due to personnel or infrastructure, or some combination, thereof.

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