HEALTH SERVICES & OUTCOMES RESEARCH

HSOR

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2011

National Healthcare Group

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FOREWORD

In 2011, Health Services & Outcomes Research (HSOR) continued its mission of providing best available evidence to stakeholders and partners to inform decisions, policy and planning. The year was noted for a discernible shift and an increasing involvement in programmes related to community health. This included needs assessment surveys among the elderly and the planning and evaluation of various care integration services and programmes within NHG and beyond. To support decisions with evidence requires the department to balance pragmatic issues on the ground with the need for scientific rigour, using multi- and inter-disciplinary skills of knowledge of a diverse team. Maintaining this balance has been critical in engaging stakeholders and delivering practical solutions relevant to their needs.

The increasing demand for operations and systems research is testimony to the level of awareness amongst our partners and stakeholders. The skills and knowledge in healthcare operations research is increasingly recognised and valued. The team of healthcare operations research specialists has grown to meet the increasing demand. Together with stakeholders and colleagues in epidemiology, informatics and economics, they use analytical, simulation models and systems analyses to describe, explain, predict and control systems to help improve service and performance of our institutions.

2011 was a year with structural changes to the department. The functions of medical education research and chronic disease registries under HSOR were reassigned to the Education Development Office and Corporate Development Office, respectively. Both sections have grown and have become competent at what they do, ready to contribute to NHG's future challenges under their new leadership.

The publications, conference presentations and awards, and research grants attest to the strength that is only possible with collaborations with partners from various NHG departments and institutions and with agencies outside of NHG. This report summarises some of these work.

Prof Chee Yam Cheng
Chief Executive Officer
National Healthcare Group

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MANAGEMENT OF DISEASES & CONDITIONS

EVALUATION OF THE INTEGRATING SERVICES AND INTERVENTIONS FOR STROKE (ISIS) PROGRAMME

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OBJECTIVES

The Integrating Services and Interventions for Stroke (ISIS) programme was introduced in February 2008 to address the need for coordinating post-discharge services for stroke patients. Initiated at specialist outpatient clinics in three restructured hospitals and nine polyclinics, case managers in the ISIS programme provided patients with stroke education, monitored their risk factors and complications, screened for depression, function, and referred patients to specialist and community services if required.

This study examined the effectiveness of the ISIS programme in: reducing the risk of recurrent stroke and complications, detecting depression early, and improving physical function.

METHODS

A non-randomised prospective control study design was applied. Study eligibility was limited to patients who were discharged after hospitalisation for a new stroke. The intervention group included patients who were in the ISIS programme for at least 1 year. The control group were patients who did not participate in the ISIS programme.

Outcomes assessed included: readmission (stroke, and stroke-related) at 30 days, 90 days and 1 year, readmission due to all causes at 1 year, complications, depression and physical function at 1 year. Univariate analyses were done to compare baseline differences between the intervention and control group. Multivariate analyses (linear and logistic regression) were performed adjusting for all baseline differences at $p < 0.25$.

RESULTS

There were 480 patients in the ISIS group and 725 patients in the control group. Comparisons of baseline variables showed that the ISIS group was younger, more educated, had better function, and a lower proportion had stroke-related complications, diabetes and a higher proportion had hyperlipidemia and obesity.

Table 1 shows the results for all outcomes. After adjusting for baseline differences, only depression rates differed significantly. The ISIS group had 3.7 times (95% CI: 2.0–6.7) higher odds of being clinically depressed or taking antidepressants.

Table 1 – Outcomes between ISIS and Control group

	ISIS N (%)	Controls N (%)	Unadjusted p-value	Adjusted p-value
Depression				
Yes	29 (6.4)	26 (3.7)	0.03	< 0.0001
No	422 (93.6)	681 (96.3)		
Function (Modified Rankin Scale)				
≤ 1	337 (71.4)	341 (47.1)	< 0.0001	0.83
> 1	135 (28.6)	383 (52.9)		
Presence of complications				
Yes	70 (14.6)	176 (25.1)	< 0.0001	0.54
No	410 (85.4)	526 (74.9)		
Readmission (all causes)				
Yes	128 (26.7)	264 (36.4)	0.0004	0.58
No	352 (73.3)	461 (63.6)		
Readmission (stroke) – 30 days				
Yes	4 (0.8)	12 (1.7)	0.22	-
No	476 (99.2)	713 (98.3)		
Readmission (stroke) – 90 days				
Yes	13 (2.7)	18 (2.5)	0.81	-
No	467 (97.3)	707 (97.5)		
Readmission (stroke) – 1 year				
Yes	41 (8.5)	42 (5.8)	0.07	-
No	439 (91.5)	683 (94.2)		
Readmission (stroke & related complications) – 30 days				
Yes	7 (1.5)	26 (3.6)	0.03	0.28
No	473 (98.5)	704 (96.4)		
Readmission (stroke & related complications) – 90 days				
Yes	21 (4.4)	50 (6.9)	0.07	-
No	459 (95.6)	675 (93.1)		
Readmission (stroke & related complications) – 1 year				
Yes	65 (13.5)	112 (15.5)	0.36	-
No	415 (86.5)	613 (84.5)		

CONCLUSION

ISIS was introduced to bridge a service gap by coordinating post-discharge services for stroke patients. In comparison to the control group, the ISIS group did not significantly differ on readmission, function, and complications. Given the ISIS group was younger, more educated, functionally better and had lower complication rates than the control group, the intended effect of the intervention may not have been realised in a patient group who were relatively stable. Perhaps the use of a targeted approach for higher risk patients may prove more effective. Regular depression screening may explain the higher rates of depression detected.

PROGRESSION RATE OF NEWLY DIAGNOSED IMPAIRED FASTING GLYCAEMIA TO TYPE 2 DIABETES MELLITUS: A STUDY USING THE NATIONAL HEALTHCARE GROUP DIABETES REGISTRY IN SINGAPORE

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BACKGROUND

The prevalence of Type 2 diabetes mellitus (T2DM) among adults is high in Singapore. T2DM has increased from 8.2% among adults aged 18 to 69 years old in 2004 to 11.3% among adults aged 18 to 79 years old in 2010. Conventionally, the gold standard of diagnosing diabetes is by an Oral Glucose Tolerance Test (OGTT). Pre-diabetes is the state in which some but not all of the diagnostic criteria for diabetes are met. It is often described as the "grey area" between normal blood sugar and diabetic levels. In this range, patients are at risk for developing not only T2DM, but also cardiovascular complications.

There are 2 different forms of pre-diabetes:

1. Impaired glucose tolerance (IGT), a condition associated with insulin resistance and increased risk of cardiovascular pathology. According to the World Health Organisation and the American Diabetes Association's criteria, IGT is defined as two-hour glucose levels of 7.8 to 11.0 mmol/L on the 75g OGTT.

2. Impaired fasting glycaemia (IFG), refers to a condition in which the fasting blood glucose is elevated above what is considered normal levels ($\geq$ 6.1mmol/L but $<$ 7.0 mmol/L). Although IFG is also associated with insulin resistance and increased risk of cardiovascular pathology, it has lesser risk than IGT. IFG sometimes progresses to T2DM; a systematic review and meta-analysis of prospective studies has reported the annualised incidence of T2DM in individuals with IFG to be between 1.6% and 34.0%.

The aim of the study was to estimate the rate of progression from newly diagnosed IFG to T2DM in Singapore, and to identify the factors associated with progression to T2DM in subjects with newly diagnosed IFG.

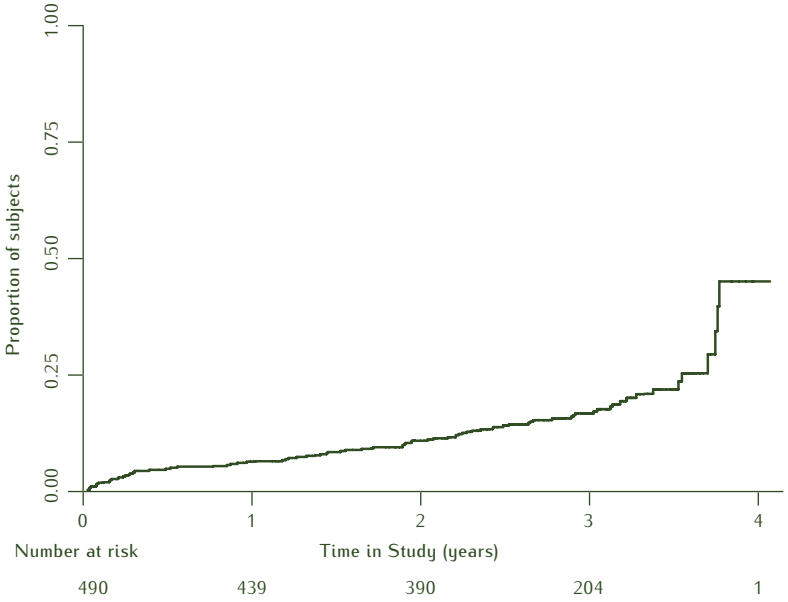
METHODS

This was a retrospective cohort study of newly diagnosed IFG from the National Healthcare Group Diabetes Registry between 1 January 2006 and 31 December 2007. The rate of progression to T2DM was estimated. Univariate survival analysis, followed by multivariate survival analysis, were performed and interactions tested in the final model.

RESULTS

During a mean follow up of 1.65 ± 0.13 years, 85 out of 490 participants with newly diagnosed IFG developed T2DM, giving an annual progression rate of 6.8% (Figure 1). The factors associated with the development of T2DM were higher fasting plasma glucose level in the year of diagnosis of IFG (HR = 14.6, 95% CI: 5.66–37.50), of Chinese ethnicity (HR = 2.70, 95% CI: 1.44–5.06), and body mass index (HR = 1.11, 95% CI: 1.06–1.15).

Figure 1 – Progression from IFG to T2DM



CONCLUSION

The progression rate to T2DM was high in subjects with newly diagnosed IFG (6.8%). Intensive lifestyle modification could be incorporated into current yearly follow-ups to prevent the progression to T2DM, which is a growing problem in Singapore.

AN EVALUATION OF THE CONTROL OF CORONARY RISK FACTOR INITIATIVE (LIVE) PROGRAMME

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BACKGROUND

Integrated, team-based multi-dimensional packages of complementary interventions are among the key elements of successful disease management programmes. The objective was to evaluate the effectiveness of the LIVE programme in controlling low density lipoprotein (LDL) and blood pressure (BP) levels, reducing risk of re-infarctions, and facilitating referral of patients with stable coronary artery disease to primary care.

METHODS

Patients with coronary artery disease who were admitted to the Cardiology Department of three restructured hospitals in Singapore between 2005 and 2009 were eligible for enrolment in the programme. Interventions were delivered by a team of physicians, case managers and other health care professionals. Case managers conducted patient education and were empowered to carry out titration of lipid-lowering medications.

The evaluation utilised a cohort design comparing outcomes between patients enrolled in the programme and those who were eligible but not enrolled in the programme. Patients were followed-up for 12 months, at which point differences in BP, LDL levels and risk of re-infarctions were compared.

RESULTS

A total of 8,028 patients were enrolled in the LIVE programme, of whom 78.0% were male, 30.0% were 65 years or older, 66.0%, 16.0% and 14.0% were Chinese, Malay and Indian, respectively.

Among patients with an elevated baseline LDL, a greater proportion of programme patients achieved target (LDL $\leq$ 2.6mmol/l) within 12 months (53.1% vs 25.1%) than controls (Figure 1). Propensity score-matched average treatment effect was significantly higher for programme patients (ATE = 0.160, SE = 0.019). Figure 2 shows that mean time-to-normal LDL was significantly shorter for programme patients (95% CI: 164–173 days vs 245–258 days). A greater proportion of programme patients achieved target BP ($\leq$ 130/80mm Hg) compared to controls (ATE = 0.028, SE = 0.019) (Table 1). Mean time-to-BP target was shorter for programme patients, but was not statistically significant (95% CI: 206–217 days vs 214–226 days). Propensity score-matched results for surviving patients showed no difference in the risk of re-infarction between programme and control patients (ATE = 0.005, SE = 0.017). At the end of programme implementation, 16.7% of enrolled patients were referred to primary care.

Figure 1 – Distribution of patients with elevated LDL on enrolment, by follow-up LDL result (n = 6,243)

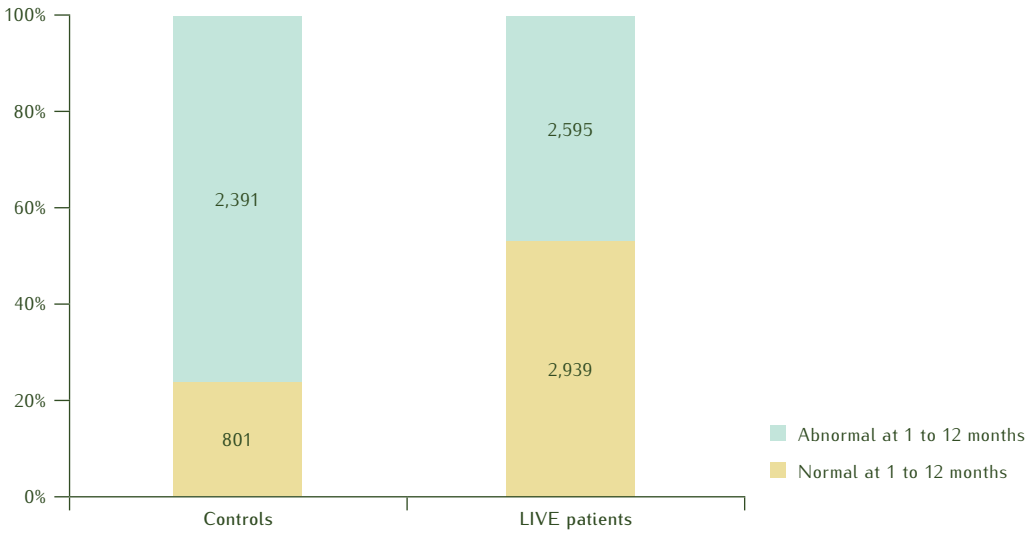

Figure 2 – Time-to-normal LDL for control and LIVE patients (n = 5,218)

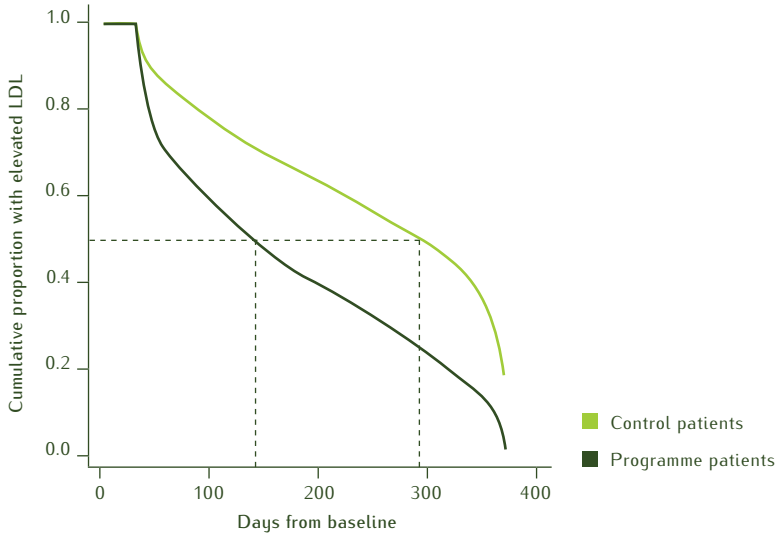

Table 1 – Blood pressure control among patients with at least 1 BP reading at 1 to 12 months*

	LIVE patients (n = 2,068)	Control patients (n = 1,791)
No. (%) whose last BP measurement at 1 to 12 months was normal	1,382 (66.8)	1,141 (63.7)

*p = 0.042

CONCLUSION

While results did not show an effect on the risk of re-infarction, the programme's favourable effects on LDL and BP suggested the potential usefulness of an evidence-based, multi-modal, multi-disciplinary disease management strategy on short- to intermediate-term outcomes. The evaluation of outcomes such as re-infarction may require longer periods of follow-up.

EVALUATION OF THE AIRWAY PROGRAMME (TAP)

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BACKGROUND

Chronic obstructive pulmonary disease (COPD) is a global health concern, and is a major cause of chronic morbidity and mortality in Singapore and worldwide. The Airway Programme (TAP) was started in 2008 in three hospitals — National University Hospital (NUH), Tan Tock Seng Hospital (TTSH) and Alexandra Hospital (AH). The programme aimed to optimise resources to enable better management of patients afflicted with COPD. The objectives of TAP were to reduce hospitalisations for acute exacerbations; reduce the average length of stay (ALOS); and improve quality of life of patients with COPD.

This study was conducted to assess the impact of TAP on patients' length of stay and mortality.

METHODS

TAP patients were compared with controls, who were COPD patients but were not included in the programme. Control patients were identified from the Central Clinical Research Database (CCRD) and Operations Data Store (ODS) database. Patients who refused the programme or had hospitalisations after enrolment till December 2009 were analysed.

Outcomes of interest were hospital length of stay, and mortality. Risk of death was estimated using Cox regression. T-tests were used to compare continuous variables, chi square tests were used to compare categorical variables.

RESULTS

There were 334 TAP patients and 904 control patients with 540 and 1,238 hospitalisations respectively. TAP patients and controls were similar with regards to age and gender. Two hundred and six TAP patients and 334 control patients had more than one admission during the follow up period (Table 1). TAP patients had significantly lower length of stay when compared to the control patients (Table 2).

Table 1 – Comparison of characteristics between TAP patients and Controls

Variables	TAP patients (n = 334)	Controls (n = 904)	p-value
Mean age ± SD (yrs)	73 ± 9	72 ± 10	0.88¶
Males %	88.0	82.0	0.15
Episodes	540	1,238	
Total hospital days	2,366	5,840	
Total person years of follow up	326	487	
Hospital days per patient	7.1	6.5	
Total hospital days per person year of follow up	7.3	12.0	0.0001‡
No. of deaths (%)	35 (10.5)	173 (19.1)	0.0001
CMR* per person year of follow up	0.11	0.36	0.0001‡
Age adjusted℘ mortality rate per person year follow up	0.76	12.1	0.0001‡

*Crude mortality rate, ¶T-test, Chi-square test, ‡Mid-P Exact test
℘Adjusted using 2010 Singapore resident population

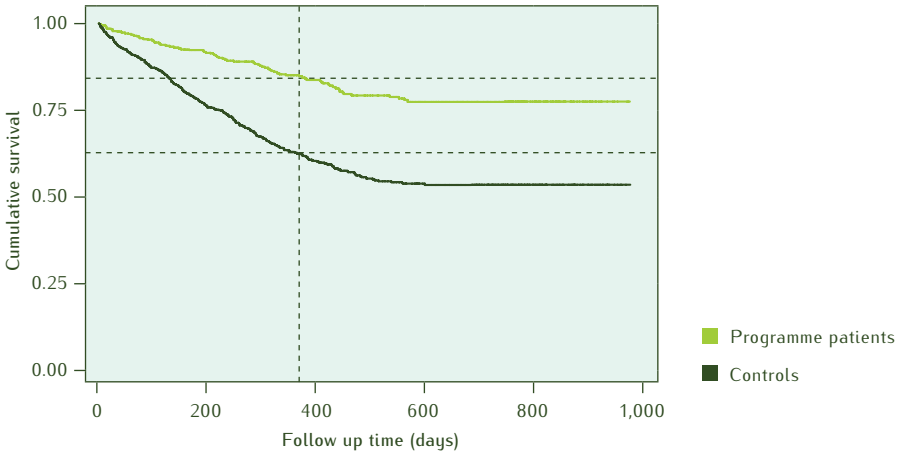
Table 2 – Average length of stay per hospital episode

ALOS (days)	TAP patients (Mean ± SD) (Episodes n = 540)	Controls (Mean ± SD) (Episodes n = 1,238)	p-value
Unadjusted	3.9 ± 3.8	4.7 ± 5.4	0.011
Adjusted	4.4 ± 1.5	4.8 ± 1.1	0.0001†

†Adjusted for age, gender, hospital, comorbidities, mortality, readmission and patient class using linear regression

TAP patients lived longer than control patients, cumulative 1 year survival was 85.0% among TAP patients and 61.0% among control patients (Figure 1).

Figure 1 – Kaplan-Meier survival curve among TAP patients and control patients



CONCLUSION

Enrolment on a management programme for COPD was associated with fewer hospital days and lower mortality rate. Evaluation of such a programme by means of administrative databases may yield meaningful results. Further studies are required to ensure corrections for case mix and time bias.

5-YEAR MORTALITY AND STROKE RECURRENCE OF PATIENTS HOSPITALISED WITH ACUTE STROKE FROM 2000–2004

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BACKGROUND

Stroke is the fourth leading cause of death and the leading cause of disability-adjusted life years (DALYs) lost in Singapore. This study aimed to investigate the risk of death and rehospitalisation in 5 years for stroke patients.

METHODS

This was a multi-center retrospective cohort study. Patients with a primary diagnosis of stroke (ischemic stroke [IS], intracerebral haemorrhage [ICH], subarachnoid haemorrhage [SAH] and unspecific cerebrovascular accident [CVA]), who were admitted and subsequently discharged from three tertiary public hospitals from January 2000 to December 2004 were included.

Stroke presentation was identified by the primary ICD-9-CM codes (International Classification of Diseases, Ninth Revision, Clinical Modification). All study patients were followed up for 5 years. Age, race, gender and stroke types were studied. The primary outcomes of interest were mortality and rehospitalisation due to stroke. Logistic regression and proportional Cox model were applied to study the adjusted risks of stroke patients.

RESULTS

A total of 14,750 patients were included in the study. Among them, 40.8% of the patients died within 5 years, 13.4% were rehospitalised due to recurrent stroke. The crude association between patient demographics and their risks of mortality and readmission due to recurrent stroke are shown by stroke subtypes in Table 1.

Table 1 – Percentage of death and recurrence with respect to variables

	IS		ICH		SAH	
	Death No. (%)	Rehospitalisation No. (%)	Death No. (%)	Rehospitalisation No. (%)	Death No. (%)	Rehospitalisation No. (%)
Race						
Chinese	3,111 (40.1)	1,138 (14.7)	889 (44.5)	174 (8.7)	201 (44.5)	21 (4.6)
Malay	439 (45.0)	124 (12.7)	130 (45.9)	30 (10.6)	32 (47.1)	3 (4.4)
Indian	233 (40.0)	85 (14.6)	32 (36.4)	9 (10.2)	9 (37.5)	2 (8.3)
Others	114 (46.3)	44 (17.9)	37 (54.4)	5 (7.4)	11 (52.4)	1 (4.8)
Gender						
Female	1,859 (42.0)	619 (14.0)	465 (44.9)	103 (9.9)	147 (45.8)	16 (5.0)
Male	2,038 (39.7)	772 (15.0)	623 (44.4)	115 (8.2)	106 (43.4)	11 (4.5)
Age						
< 45	9 (9.9)	6 (6.6)	20 (22.2)	8 (8.9)	6 (15.0)	0
45–64	361 (21.2)	256 (15.0)	190 (30.3)	62 (9.9)	60 (33.5)	7 (3.9)
65–84	1,928 (39.0)	742 (15.0)	515 (45.1)	98 (8.6)	104 (46.8)	17 (7.7)
≥ 85	1,599 (56.7)	387 (13.7)	363 (62.7)	50 (8.6)	83 (66.9)	3 (2.4)

After adjustment, older stroke patients had a higher risk of rehospitalisation and mortality. Malays and patients from the other racial groups who suffered from IS had a higher risk of rehospitalisation and mortality than the Chinese. Males had a higher adjusted relative risk of rehospitalisation and death in the IS and CVA group (Tables 2 & 3). Cerebrovascular cause of death was the most common, followed by pneumonia and ischemic heart disease.

Table 2 – Readmission due to stroke in 5-year follow-up by Fine-Gray model

	IS		ICH		SAH	
	Crude ratio	Adjusted ratio	Crude ratio	Adjusted ratio	Crude ratio	Adjusted ratio
Age	1.03 (1.03–1.03)	1.03 (1.03–1.03)	1.02 (1.02–1.03)	1.02 (1.02–1.03)	1.03 (1.02–1.04)	1.02 (1.02–1.04)
Gender [Ref: Female]						
Male	0.96 (0.91–1.02)	1.10 (1.04–1.17)	0.97 (0.87–1.09)	1.07 (0.96–1.20)	0.96 (0.75–1.22)	1.12 (0.88–1.44)
Race [Ref: Chinese]						
Malay	1.09 (0.99–1.20)	1.19 (1.08–1.31)	1.05 (0.89–1.24)	1.09 (0.92–1.29)	1.11 (0.79–1.57)	1.14 (0.81–1.60)
Indian	0.98 (0.87–1.11)	1.08 (0.96–1.22)	0.84 (0.62–1.13)	0.85 (0.62–1.16)	1.01 (0.54–1.88)	1.20 (0.67–2.16)
Others	1.20 (1.01–1.42)	1.23 (1.04–1.46)	1.28 (0.93–1.76)	1.30 (0.94–1.80)	1.35 (0.76–2.39)	1.39 (0.83–2.30)

Table 3 – Relative risk of 5-year mortality rate by Cox model

	IS		ICH		SAH	
	Crude ratio	Adjusted ratio	Crude ratio	Adjusted ratio	Crude ratio	Adjusted ratio
Age	1.04 (1.03–1.04)	1.04 (1.04–1.04)	1.03 (1.02–1.03)	1.03 (1.02–1.03)	1.03 (1.02–1.04)	1.03 (1.02–1.04)
Gender [Ref: Female]						
Male	0.92 (0.87–0.98)	1.10 (1.03–1.18)	0.99 (0.88–1.11)	1.12 (0.99–1.26)	0.94 (0.74–1.21)	1.11 (0.86–1.43)
Race [Ref: Chinese]						
Malay	1.18 (1.07–1.30)	1.33 (1.20–1.47)	1.03 (0.86–1.24)	1.09 (0.91–1.31)	1.07 (0.74–1.55)	1.09 (0.75–1.58)
Indian	0.99 (0.87–1.14)	1.13 (0.99–1.30)	0.77 (0.54–1.09)	0.78 (0.55–1.12)	0.86 (0.44–1.68)	1.03 (0.52–2.01)
Others	1.19 (0.99–1.44)	1.25 (1.04–1.51)	1.35 (0.97–1.87)	1.38 (0.99–1.91)	1.30 (0.71–2.39)	1.34 (0.73–2.45)

CONCLUSION

The risks of death and rehospitalisation of stroke increased with age and were different for different stroke types. Race and gender influenced stroke outcomes for specific stroke types.

DERIVATION AND VALIDATION OF A RISK INDEX TO PREDICT ALL-CAUSE MORTALITY IN TYPE 2 DIABETES MELLITUS

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BACKGROUND

Diabetes mellitus is a complex chronic illness that is strongly associated with increased risk of microvascular and macrovascular complications, and premature death. An easy-to-use risk index to quantify the risk of mortality would help clinicians identify patients who might benefit from more intensive therapy. The study aimed to develop a risk index to predict all-cause mortality for a cohort of Type 2 diabetes mellitus (T2DM) patients seen at primary care clinics in Singapore.

METHODS

In a retrospective cohort study, 28 patient-level variables were extracted from an automated clinical and administrative registry for T2DM who had at least two visits to the same National Healthcare Group polyclinic in 2007. Demographic characteristics, inpatient and outpatient diagnoses, laboratory results, and prescription, were included. Mortality data were provided by the Ministry of Health. A split-sample design was used to derive and validate an index to predict the risk of death within 2 years of the index attendance. The c-statistic was used to assess model discrimination.

RESULTS

Out of the 59,747 patients in the study, 2,977 (5.0%) patients died during the 2-year follow-up. Age ("A"); diabetes-related complications as measured by the Diabetes Complication Severity Index ("C"); and cancer history ("C") were found to independently predict all-cause mortality (from which the mnemonic "ACC" was derived) (Table 1). The ACC risk index ranged from 0 to 20 (Table 2) with expected risk of mortality of 0.3% to 80.6%. The discriminatory accuracy of the ACC risk index for the validation data was excellent (c-statistic = 0.83, 95% CI: 0.82–0.84).

Table 1 – Final logistic regression model for risk of mortality (derivation group only, n = 29,877)

Variable	Odds ratio (95% CI)
Age ("A")	1.07 (1.06–1.07)
Cancer history ("C")	6.97 (5.81–8.36)
Diabetes-related complications (Diabetes Complication Severity Index) ("C")	
1	1.95 (1.65–2.30)
2	2.69 (2.28–3.18)
3	3.93 (3.22–4.80)
4	7.13 (5.79–8.80)
5+	13.88 (11.28–17.09)

Table 2 – ACC index for the quantification of risk of 2-year all-cause mortality

Risk factor	Value	Points
Age ("A")	< 40	0
	40–49	1
	50–59	3
	60–69	5
	70–79	6
	80+	8
Cancer history ("C")	Yes	5
Diabetes-related complications (Diabetes Complication Severity Index) ("C")	0	0
	1	2
	2	3
	3	4
	4	5
	5+	7

CONCLUSION

A simple risk index for all-cause mortality was successfully developed, and validated using routinely collected registry data. The risk index can be used to stratify T2DM patients into varying risk of mortality. Further external validation of the risk index is needed before using it in a clinical setting.

PROJECTS

HEALTH & WELFARE ECONOMICS

EFFECTIVENESS AND COST IMPACT ANALYSIS OF A POST ACUTE CARE AT HOME (PACH) PROGRAMME

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BACKGROUND

With a rapidly ageing population, the burden on hospital resources is expected to increase. To reduce the pressure on inpatient wards, a new initiative called the Post Acute Care at Home (PACH) programme was offered to patients discharged from Tan Tock Seng Hospital (TTSH). This is a home-based post-acute-care service run by a multidisciplinary team of doctors, nurses, therapists and dieticians. The objective of this study was to evaluate the effectiveness of PACH in reducing hospital readmissions and costs to the health system.

METHODS

A retrospective non-randomised trial was designed to examine the costs and outcomes of PACH. All patients referred to PACH from January 2009 and December 2010, and met the programme's inclusion criteria were included as the intervention group. Patients from the intervention group received PACH services for an average of 3 months post-discharge. Patients who declined PACH or were not enrolled because they resided outside the programme's catchment area formed the control group.

The primary outcomes were the number of hospital readmissions and total costs at 3 and 6 months post-discharge. Secondary outcomes included 15-day readmission rate, time to first readmission, cumulative hospital length of stay (LOS), Emergency Department (ED) visits and mortality. Costs were calculated from a health system perspective that considered only direct medical costs. These included costs of hospitalisation, ED visits, specialist outpatient clinic (SOC) visits, polyclinic visits and PACH home visits.

Univariate analyses were conducted for both primary and secondary outcomes. To account for uncertainty in mortality for the control group, patients who had not utilised any health services at 3 and 6 months were assumed to have died. Multivariate analyses adjusted for age, gender, Charlson Comorbid Index, index hospital LOS, hospital admissions in the past 1 year and mobility were performed for the primary outcomes. The multivariate analyses were repeated for patients who were known to have survived beyond 3 and 6 months, to account for the uncertainty in mortality.

RESULTS

There were 409 patients in the PACH group and 201 patients in the control group. Both groups were similar in demographic and baseline characteristics. For the univariate analyses, no statistical differences were observed in all the primary and secondary outcomes, except for mortality, where the assumption was made that those with no utilisation of health services had died (Table 1).

Table 1 – Univariate analyses for mortality

	PACH n (%)	Control n (%)	p-value
Recorded			
3-month mortality	68 (17.0)	37 (18.0)	0.584¥
6-month mortality	95 (23.0)	51 (25.0)	0.559¥
Recorded & suspected			
3-month mortality[a]	68 (17.0)	63 (31.0)	0.000¥*
6-month mortality[b]	95 (23.0)	74 (37.0)	0.000¥*

*Statistically significant at 0.05; ¥chi-square test
[a]Included patients with no medical encounters in NHG after 3 months
[b]Included patients with no medical encounters in NHG after 6 months

Multivariate analyses for hospital admissions showed a statistically significant higher rate for patients in the PACH group after 6 months (Table 2). This result remained consistent when analyses were repeated for those who survived beyond 6 months. Total healthcare costs at 3 and 6 months showed no statistical differences both in the full sample and subgroup analyses (Table 3).

Table 2 – Multivariate analyses for hospital readmissions

Primary outcome	Rate ratio	95% CI
No. of readmissions at 3 months	1.23	0.96–1.58
No. of readmissions at 6 months	1.38*	1.11–1.71
No. of readmissions at 3 months[a]	1.27	0.91–1.75
No. of readmissions at 6 months[b]	1.39*	1.02–1.90

*Significance level at 0.05
[a]PACH (n = 341); Control (n = 148); [b]PACH (n = 314); Control (n = 127)
Zero inflated negative binomial regression, adjusted for: age; gender; Charlson Comorbid Index; index hospital LOS; admissions in past 1 year; mobility

Table 3 – Multivariate analyses for total costs

Primary outcome	Rate ratio	95% CI
Total healthcare cost at 3 months	0.77	0.55–1.08
Total healthcare cost at 6 months	0.91	0.68–1.21
Total healthcare cost at 3 months[a]	0.86	0.57–1.28
Total healthcare cost at 6 months[b]	1.00	0.72–1.40

*Significance level at 0.05
[a]PACH (n = 341); Control (n = 148); [b]PACH (n = 314); Control (n = 127)
Generalised linear model, family (Gamma) link(log), adjusted for: age; gender; Charlson Comorbid Index; index hospital LOS; admissions in past 1 year; mobility
Total cost (2011 dollars) included polyclinic, specialist outpatient, ED, hospitalisation, and PACH programme cost

CONCLUSION

Enrolment in PACH was associated with lower mortality and no difference in costs. However, hospital readmissions were higher among the PACH patients. These findings reflected the challenges faced when conducting programme evaluation in the local setting.

The results could be limited by incomplete data on health services utilisation and mortality. It was also uncertain if patients who rejected PACH could have been socioeconomically different from the PACH group, and could have received care from other healthcare providers or not sought health care as much. Finally, PACH patients could have improved on other patient-focused outcomes, such as quality of life measures or functional status.

A DECISION ANALYSIS TO SUPPORT UNIVERSAL SCREENING FOR MRSA COLONISATION IN A LARGE ACUTE HOSPITAL IN SINGAPORE

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BACKGROUND

Methicillin-resistant staphylococcus aureus (MRSA) is a rising public health threat in Singapore with significant inhospital morbidity and mortality causing a range of infections. Tan Tock Seng Hospital — a large acute hospital with 1,300 beds — planned for active surveillance through universal screening of all admitting patients and cohorting of MRSA colonised patients to reduce nosocomial transmission and potential subsequent infections. Patients were screened with culture assay with 2-day turnaround time. During this waiting period, the colonised patients in the general ward were a source of transmission via healthcare workers. Subsequent transfers to a cohorted ward were incomplete and increased exposure period to 3.5 days.

To reduce exposure and facilitate direct admission to the cohorted ward, rapid testing polymerase chain reaction (PCR) which is costlier was considered. To provide decision support on the choice of screening options, the cost-effectiveness using infectious disease modelling was studied. The study scope addressed the clinical outcome of infections volume, economics of incremental resource allocation and operational considerations.

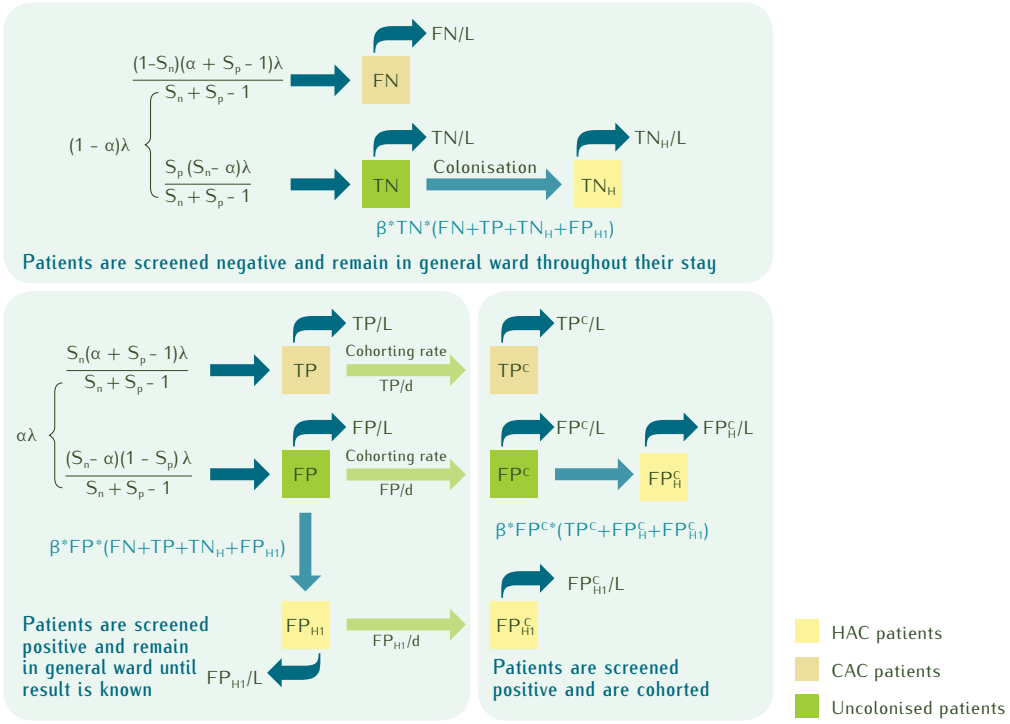
DATA

In the local setting, MRSA infected patients stayed 25 days longer, cost $17,680 more and had a 13.0% higher mortality rate than uninfected patients. Universal screening showed that about 7.6% of the patients admitted were estimated to be community acquired colonisations and an additional 4.3% were hospital acquired colonisations upon discharge. The unit test cost of PCR and culture was $52 and $28 respectively.

METHODS

To study the transmission of colonisation within the hospital, a deterministic infectious disease model was used to calibrate and predict the transmission of MRSA from the colonised patients to uncolonised patients (Figure 1). The model also considered the effects of test sensitivity and specificity on misclassification of patients, subsequent cohorting and transmission. The cost-effectiveness analysis was based on the perspective of inpatient setting in an acute hospital. Costs and outcomes were compared between the interventions and passive surveillance. The costs included the incremental costs due to additional length of hospital stay, manpower effort in universal screening and screening tests.

Figure 1 – Compartmental model of MRSA transmission



RESULTS

Universal screening with screening cultures and incomplete cohorting cost $11.5 million annually with the majority of the cost attributed to excess patient stay ($7.8 million) and testing ($2.9 million). Manpower costs of screening, transfer and cleaning efforts amounted to $0.78 million. The total cost of the interventions was $2 million higher than passive surveillance (~$9.4 million), but with a potential to save ~15 lives, the incremental cost-effectiveness ratio (ICER) was ~$140,000 per life saved. The total cost of universal screening with PCR was $11.4 million (ICER ~$80,000 per life saved). Also, it was estimated that the cohort ward capacity had to be expanded from 100 beds to about 140 beds to directly house the admitting colonised patients.

DISCUSSION

The PCR test cost is a high $4.2 million. But the increase in the test cost due to PCR was offset by the savings in inpatient stay cost due to infections reduced. With PCR, the exposure period was reduced from 3.5 days to about 0.35 days. This in turn reduced infections by ~80 per year through the reduction in hospital acquired colonisation from 4.0% to 1.1%. Due to the exposure of 0.35 days (which contributed about 0.4%) and the misclassification in test accuracy (which contributed about 0.7%), hospital acquired colonisation could not be eliminated completely.

The deciding factor that made PCR comparatively effective was the high MRSA attributed mortality rate of 13.0%. Sensitivity analysis showed that PCR remained cost-effective if the operational accuracy dropped to about 80.0% (sensitivity and specificity), excess length of stay and attributed mortality was reduced by half. If the community prevalence of MRSA were to be < 1.0%, the screening may not be cost effective.

CONCLUSION

Using an infectious disease model, it was concluded that using the more expensive PCR was more cost-effective than using screening cultures, which increased exposure period and hindered complete transfer.

RESULTS OF THE LIBERALISATION OF MEDISAVE FOR A POPULATION-BASED DIABETES MANAGEMENT PROGRAMME IN SINGAPORE

Tan Woan Shin, A/Prof Ding Yew Yoong, Christine Wu Xia, Dr Heng Bee Hoon

BACKGROUND

Consistent interventions and evidence-based treatment was thought to reduce morbidity, and therefore healthcare cost for chronic diseases. To improve patient compliance with the treatment protocol, Singapore allowed individuals to draw on their medical savings accounts to pay for outpatient treatment in October 2006. Previously, only inpatient care was covered.

In this study, the aim was to evaluate the impact of the Medisave for the Chronic Disease Management Programme (CDMP) on hospitalisation, and healthcare costs for Type 2 diabetes mellitus (T2DM) patients.

METHODS

A retrospective longitudinal T2DM cohort study was conducted using the National Healthcare Group Diabetes Registry (2006–2009). Singapore residents aged 21 years and above, with at least one diabetes-related consultation visit at a NHG primary care clinic in 2006 and 2007 were included. Enrolees and non-enrolees were propensity score-matched. Hospitalisation risk, and total healthcare cost incurred in 2007, 2008 and 2009 were compared between groups. A difference-in-difference strategy and generalised estimating equation approach were used. Baseline differences were adjusted for socio-demographics, cardiovascular risk factors, diabetes-related complications, blood sugar control, and insulin use.

RESULTS

There were 10,559 enrolees and 22,089 non-enrolees. Before matching, enrolees were younger; a larger share had hypertension, at least one diabetes-related complication, poor blood sugar control and used insulin. Relative to non-enrolees, the unadjusted hospitalisation rates and health care cost of enrolees were significantly lower in the post-policy years (Table 1).

Table 1 – Descriptive analyses of the impact of Medisave for CDMP

	Hospitalisation rate per 100 persons			Total healthcare cost, US$		
Unadjusted	Enrolees	Non-enrolees	Difference	Enrolees	Non-Enrolees	Difference
Unmatched						
2006	8.6	9.5	- 0.9	633.60	616.80	16.80
2007	8.1	12.6	- 4.5	645.90	807.10	- 161.20
2008	11.1	16.3	- 5.2	765.50	962.20	- 196.70
2009	15.3	17.5	- 2.2	1,037.70	1,040.30	- 2.60
Matched						
2006	9.0	9.3	- 0.3	619.90	648.50	- 28.60
2007	8.1	12.3	- 4.2	621.70	831.30	- 209.60
2008	11.2	15.8	- 4.6	744.10	988.00	- 243.90
2009	15.2	17.0	- 1.8	1,007.00	1,050.80	

After adjusting for baseline differences between propensity score-matched sample of 8,881 enrolees and 8,881 unique non-enrolees, hospitalisation risk for enrolees was significantly lower in 2007 (OR = 0.76; 95% CI: 0.65–0.88) and 2008 (OR = 0.79; 95% CI: 0.68–0.92). However, the difference was not statistically significant in 2009 (OR = 0.91; 95% CI: 0.79–1.05). While total healthcare cost was 14.0% to 15.0% lower for enrolees in 2007 and 2008, it was 3.0% (95% CI: - 8.0%–16.0%) higher in 2009 (Table 2).

Table 2 – Change in risk of hospitalisation and total annual healthcare cost between 2006 and 2009

		Hospitalisation†	Total healthcare cost#
Variable		**Odds ratio**	**Estimate**
CDMP		1.02	– 0.04
Policy effect			
CDMP*Baseline	(Reference)	–	–
CDMP*Post1		0.76***	– 0.15***
CDMP*Post2		0.79**	– 0.14**
CDMP*Post3		0.91	0.03
Age (years)		1.03***	0.02***
Male		1.00	0.05
Race			
Chinese	(Reference)	–	–
Malay		1.37***	0.05
Indian		1.43***	0.11**
Others		1.63***	0.14*
Risk factors			
Obesity		0.88***	– 0.09**
Hypertension		1.35***	0.22***
Hyperlipidemia		0.90	0.03
Complications			
DCSI: 0	(Reference)	–	–
DCSI: 1		1.63***	0.36***
DCSI: 2		2.20***	0.50***
DCSI: ≥ 3		4.05***	1.01***
Glycemic control			
HbA1c: < 7	(Reference)	–	–
HbA1c: 7–7.9		1.00	0.03
HbA1c: ≥ 8		1.39***	0.17***
Time trend			
2006	(Reference)	–	–
2007		1.25***	0.23***
2008		1.51***	0.39***
2009		1.67***	0.50***
Insulin		1.33***	0.32***

*p < 0.05; **p < 0.01; ***p < 0.001
CDMP: Chronic Disease Management Programme; DCSI: Diabetes Complications Severity Index; HbA1c: hemoglobin A1c
†Generalised Estimating Equation with the logit link function, binomial distribution, and unstructured covariance structure
Note: odds ratio greater than 1 indicates higher odds of hospitalisation
#Generalised Estimating Equation with the log link function, gamma distribution and unstructured covariance structure
Note: positive coefficient indicates higher cost and negative coefficient indicates lower cost.

CONCLUSION

Disease management promises to achieve cost savings by reducing the risk of hospital admission and improving the control of risk factors. However, our results showed that by setting an outpatient care protocol for diabetes, and encouraging compliance by allowing Medisave to be utilised, absolute costs did not go down. However, in the comparative analysis, the likelihood of hospitalisation, and healthcare cost incurred by CDMP enrolees were lower in the first two years post-policy but the reduction was not sustained in the third year. While the policy change was a necessary step towards addressing the misalignment in health and economic incentives, it was insufficient in reducing relative healthcare cost beyond the short-term.

STRATIFYING HEALTHCARE COSTS USING THE DIABETES COMPLICATION SEVERITY INDEX

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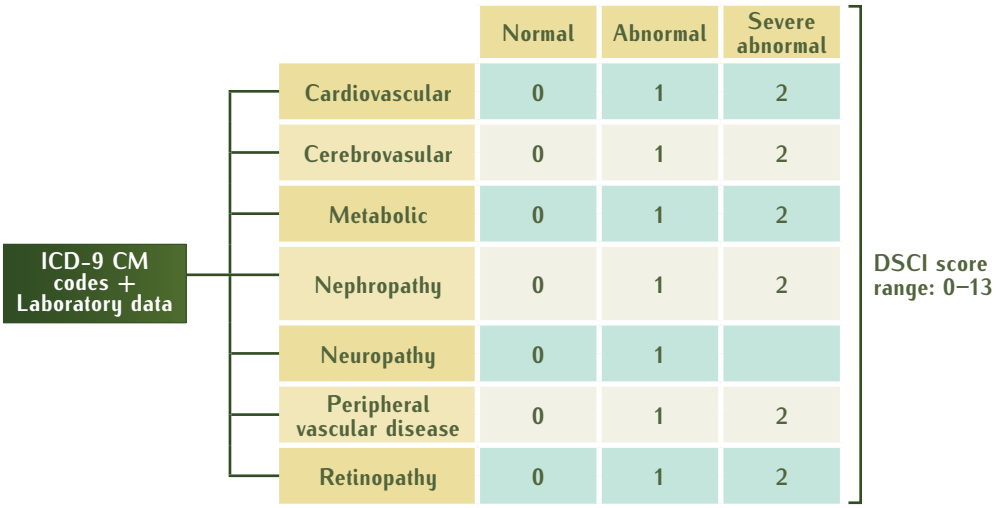
BACKGROUND

Recognising the burden of diabetes, the healthcare sector has developed various initiatives to improve compliance with pharmacotherapy, preventive screening, and support for self-care for patients with diabetes. However, cost-intensive disease management efforts become inefficient when they are directed at the entire diabetes mellitus population. Since managing healthcare costs and reducing morbidity requires targeting "at risk" patients to the appropriate treatment interventions to ameliorate the comorbidities of the disease, it is important to develop tools to systematically stratify patients into the different risk categories.

The objective of this study was to determine whether healthcare costs for patients diagnosed with Type 2 diabetes mellitus (T2DM) were associated with the severity of diabetes complications as measured by the Diabetes Complications Severity Index (DCSI) (Figure 1).

Figure 1 – Constructing Diabetes Complication Severity Index in the Chronic Disease Management Registry



*ICD-9 CM codes indicate International Classification of Disease, Ninth Revision, Clinical Modification.

*Severity index is based on a severity scale for each complication (ICD-9 CM codes) as follows: 0 = normal, 1 = abnormal, 2 = severe abnormal.

*Diabetes complication severity score was developed and validated by Young et al. (2008)

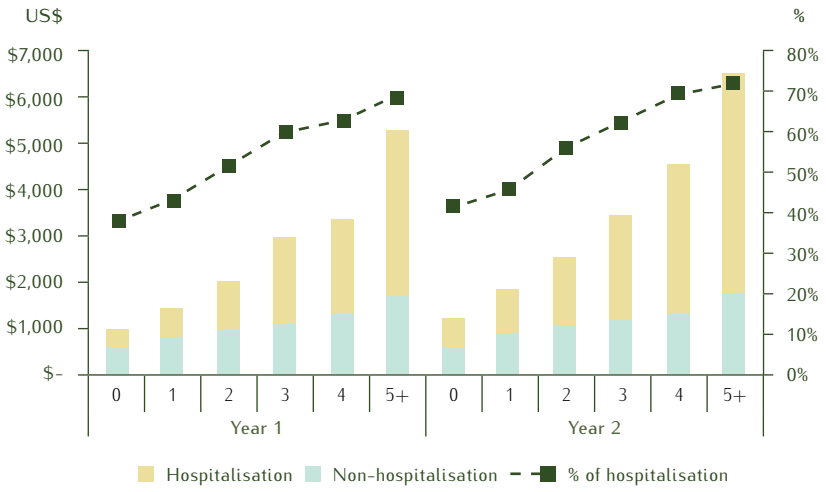
METHODS

Retrospective cohort analysis was performed on a 2007 primary care cohort of T2DM patients. The DCSI is a 13-point scale, which comprises 7 categories of complications and their severity levels. Healthcare cost data from 2008 and 2009 were used as the primary outcome. Inpatient and outpatient cost incurred for services consumed by patients within the provider network were included. Generalised linear model with log-link and gamma distribution was used to predict healthcare costs.

RESULTS

Of the 59,767 T2DM patients, 2,977 (5.0%) deaths occurred and 1,336 (2.2%) were lost to follow up. Healthcare cost was strongly associated with an increase in DCSI score (Figure 2). Compared to patients without complications, those with more complications (higher DCSI score) had an increased risk of higher healthcare cost. Risk ratio increased from 1.25 (95% CI: 1.19–1.32) for DCSI = 1 to 1.61 (95% CI: 1.51–1.72) for DCSI = 2; 2.10 (95% CI: 1.91–2.31) for DCSI = 3; 2.52 (95% CI: 2.21–2.87) for DCSI = 4 and 3.62 (95% CI: 3.09–4.25) for DCSI = 5+. As a continuous score, a one-point increase in the DCSI was associated with a cost increase of 27.0% (95% CI: 1.25–1.29).

Figure 2 – Effect of Diabetes Complication Severity Index on mean costs[a b]



[a]Costs are reported as 2010 U.S. dollars (Singapore dollar per unit of US$ is 1.2875)
[b]Non-hospitalisation includes visit to specialist outpatient clinic, Emergency Department, day surgery and primary clinic visits

CONCLUSION

This study showed that the DCSI as a diabetes complication severity score of T2DM patients was strongly associated with healthcare costs, even after adjusting for the other medical conditions and factors. The DCSI can be used to triage high-risk patients for more focused secondary prevention interventions at primary care level, in a bid to lower overall healthcare cost.

PROJECTS

ORGANISATION & DELIVERY OF SERVICES

EVALUATING PATIENT SATISFACTION IN THE INTEGRATING SERVICES AND INTERVENTION OF STROKE (ISIS) PROGRAMME

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BACKGROUND

In February 2008, the National Healthcare Group initiated the Integrating Services and Interventions for Stroke (ISIS) programme. The programme aimed to provide coordination of post-discharge services for stroke patients, a service that was much needed but did not exist prior to this.

Through this programme, case managers (CMs) provided patients with stroke education, monitored their risk factors and complications, screened for depression, cognitive impairment, function, and referred patients to specialist and community services if required. Follow-ups were done either during clinic visits or through the telephone. As part of the programme evaluation, the objective of this study was to evaluate patient satisfaction with the ISIS programme.

METHODS

Eligibility to participate in the study was limited to ISIS patients who had received at least two sessions in the programme, were able to communicate and had a contact number. A telephone survey was done using a 13-item structured questionnaire adapted from the Consumer Assessment of Healthcare Provider and System (CAHPS) (Table 1). Patients were contacted over a 2-week period. A maximum of six calls were made before determining the patient was not contactable.

RESULTS

A total of 1,379 ISIS patients were eligible for the survey. Among these, 47.1% completed the survey, 29.8% refused, 18.6% were not contactable and 4.5% were unable to respond due to other reasons. Majority of the respondents (84.1%) understood why they needed to see the CM. Most (76.7%) were satisfied with the waiting time (Figure 1). Majority felt the CMs were courteous (77.0%), listened attentively (96.5%) and encouraged them to talk about their concerns (87.0%).

Information provided by the CMs was perceived as useful by 86.4% of respondents while 72.5% responded that they were able to understand explanations given by the CMs (Figure 2). Of the patients who received a telephonic follow up, 97.9% found the service useful. Slightly more than half (57.5%) of the patients knew how to contact the CM. Overall, 87.7% of respondents rated the care provided by their CM as good or excellent (Figure 3).

Figure 1 – Satisfaction with waiting time to see CM

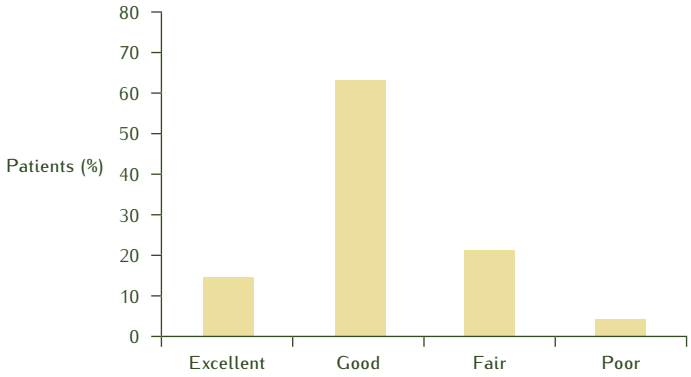


Figure 2 – Able to understand explanations given by the CMs

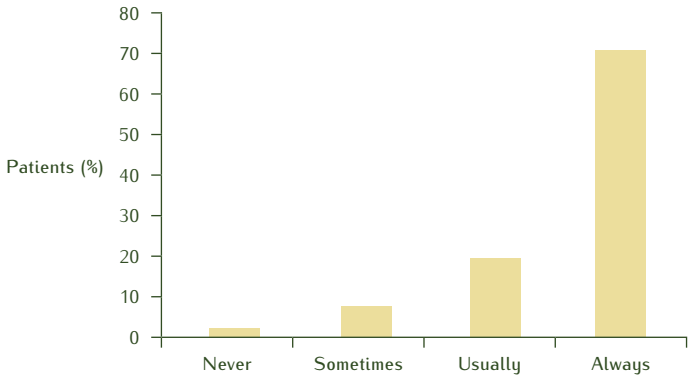
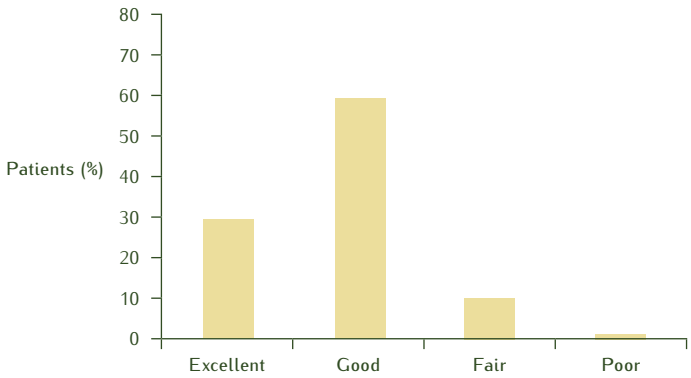


Figure 3 – Overall ratings of care provided by CM



CONCLUSION

Patients in the ISIS programme were highly satisfied with the services provided by the CM. One area that required further improvement was in ensuring that patients or caregivers knew how to contact the CM for matters related to stroke management. The survey results were limited by a low response rate. Future surveys may consider financial incentives to encourage better responses.

MARINE PARADE ELDERLY NEEDS SURVEY — UNDERSTANDING THE HEALTH, SOCIAL AND LIVEABILITY ISSUES OF ELDERLY RESIDENTS

Charis Ng Wei Ling, Wong Lai Yin, Dr Heng Bee Hoon, A/Prof Ding Yew Yoong, Tan Woan Shin, Dr Joseph Antonio D. Molina, Pradeep Paul George, Chong Wai Fung, Cheryl Lobo, Anusha Govinda Raj, Dr Wee Shiou Liang[1], Koh Kai Tian[2], Stefan Ma Sze Lok[3], Lily Chua[4], Lee Cher Farn[5], Shirin Wadia[6], Cindy Tang Yue Yan[7]

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BACKGROUND

In Singapore, persons over 65 years old consumed close to 20.0% of public sector primary care and hospital services. The healthcare utilisation by this group of seniors is estimated to have a four-fold increase by 2030. To effectively deliver good quality health and social care, service providers need to accurately identify the multiple needs of the elderly and the existing gaps in health and social services in the community.

A survey was developed to comprehensively review the health, social, financial and environmental aspects of elderly residents in Marine Parade. Marine Parade was chosen as the site for the survey as approximately 20.0% of the total resident population in the estate were aged 66 and above, and this was comparable to the projection of 18.7% for Singapore in 2030.

The survey aimed to derive data regarding residents' physical health, mental health, wellbeing, social function, needs for various services, liveability, financial status, receptivity towards new interventions, and socio-demographic profile.

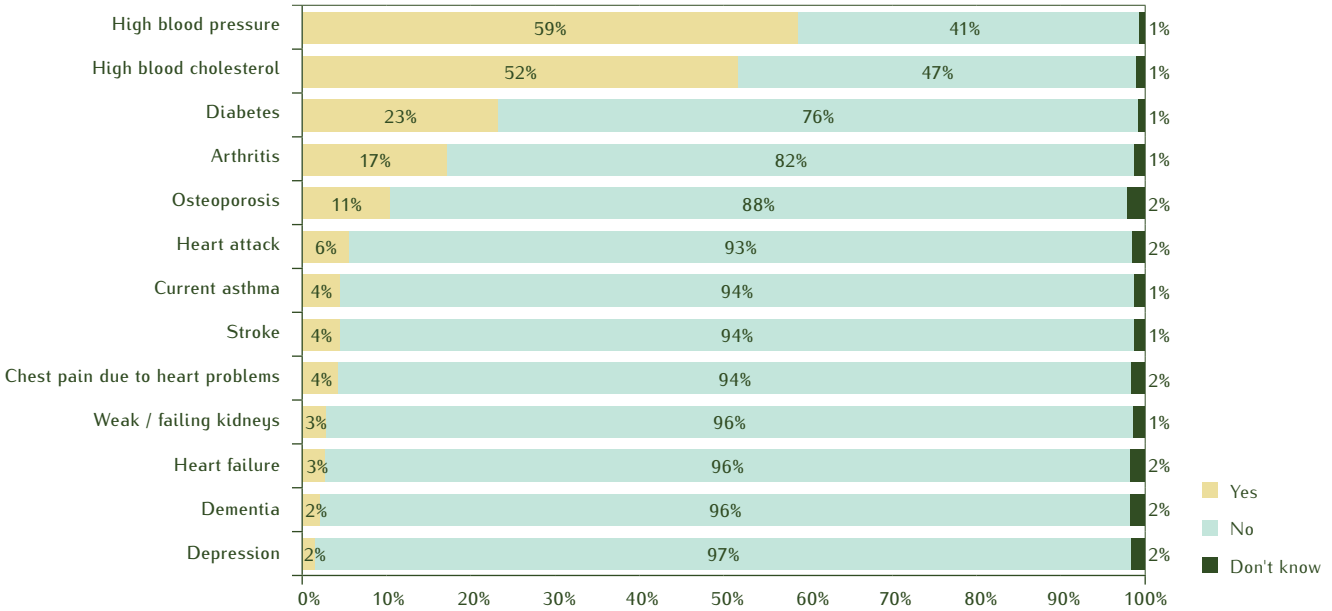
METHODS

A random sample of 4,200 Singaporeans and Permanent Residents aged 60 and above were identified, following the minimum sample size computation of confidence interval, response rate, margin of error and prevalence of at least one activity of daily living dependency by age groups (60–64, 65–74, 75–84, and 85+). Trained interviewers administered the survey from April to May 2011 through face-to-face interviews with residents in their homes.

RESULTS

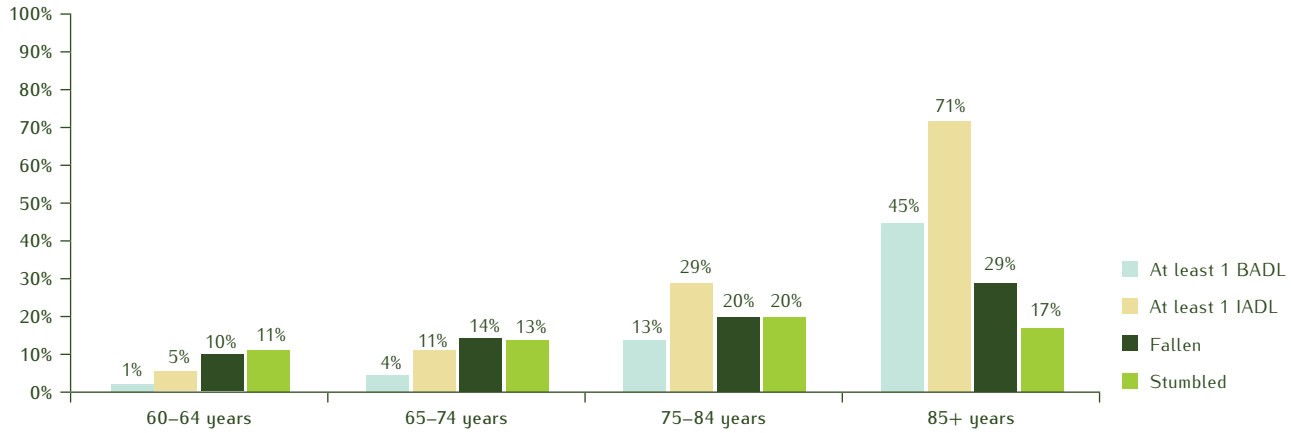
A total of 2,558 respondents were interviewed, yielding an overall response rate of 68.2%. Among them, 78.4% had at least one chronic disease. The most commonly reported chronic diseases were high blood pressure, high blood cholesterol, and diabetes (Figure 1).

Figure 1 – Prevalence of 13 chronic diseases



About 8.0% of elderly respondents needed help in at least one basic activity of daily living (BADL), and 17.4% in at least one instrumental activity of daily living (IADL). Nearly 15.0% of respondents had fallen in the past 12 months, and another 14.3% had ever stumbled or lost their balance. The proportion of respondents with functional difficulties increased with age (Figure 2). In terms of mental health, about 7.5% of respondents were suggestive of depression and 7.8% were indicative of cognitive impairment.

Figure 2 – Functional difficulties by age groups



More than 75.0% of respondents had blood glucose and blood cholesterol screenings in the last 3 years, and had their blood pressure checked in the last 2 years. More than half regularly did moderate- or vigorous-intensity exercises as recommended by the Health Promotion Board.

About a third of the respondents indicated that they required at least one community healthcare or social service. Of these, 33.5% had an unmet need. Among those with unmet needs, a significantly higher proportion were aged 85 and above and resided in 2-room apartments. The top access barrier was a lack of awareness of where or how to get the service.

CONCLUSION

The survey provided a baseline measurement of health as well as an insight into the broad range of factors that impacted the needs of elderly residents in Marine Parade. This information would aid in the planning and designing of interventions to improve outcomes, quality of life, and well-being for elderly residents in Singapore.

REAL-TIME PREDICTION OF WAITING TIME IN EMERGENCY DEPARTMENT USING QUANTILE REGRESSION

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BACKGROUND

Waiting times at the Emergency Department (ED) can affect patient satisfaction and quality of care. The objective of this study was to develop and validate a model that predicted the range [median–95th percentile] of a patient's waiting time in the ED based on data available at triage.

METHODS

ED visits in January 2011 were used for model development, and the model was retrospectively validated with June 2010 data and prospectively validated with April to June 2011 data. All data were extracted from the ED information system. Variables extracted were the end date and time of triage, the start time of consultation, and patient acuity category (PAC, 1 = most emergent, 3 = least emergent).

Quantile regression was applied for model development and parameter estimation. The model was assessed for the absolute prediction error, defined as the median difference between the 50th percentile (median) predicted waiting time and the actual waiting time; and the proportion of under-estimated prediction, defined as the percentage of patients whose actual waiting time exceeded the 95th percentile prediction. The model represented by the regression equations had been integrated with the existing ED information system.

RESULTS

There were 13,200 ED visits in January 2011. 903 (6.8%) were PAC1, 5,530 (41.9%) were PAC2 and 6,767 (51.3%) were PAC3. The predicted median and 95th percentile waiting times were 17.0 and 57.0 minutes for PAC2; 21.0 and 89.0 minutes for PAC3, respectively.

The developed models for predicting median and 95th percentile waiting time are shown in Tables 1 and 2 respectively. The median absolute prediction error for 50th percentile waiting time in retrospective validation data was 11.9 minutes (IQR: 5.9–22.1) for PAC2; and 15.7 minutes (IQR: 7.5–30.1) for PAC3; while in prospective validation data, it was 9.2 minutes (IQR: 4.4–15.1) for PAC2; and 12.9 minutes (IQR: 6.5–22.5) for PAC3. In the retrospective validation data, 5.9% PAC2 and 5.4% PAC3 95th percentile waiting times were under-estimated, while in the prospective validation data, the under-estimated proportion was 4.3% in PAC2 and 5.8% in PAC3.

Table 1 – The adjusted association between the predictors and the 50th percentile (median) waiting time

	50th percentile Log (PAC2 waiting time)			50th percentile Log (PAC3 waiting time)		
Predictors	**B coefficient**	**95% CI**		**B coefficient**	**95% CI**	
PAC1 queue size	–	–	–	0.071	0.217	0.121
PAC2 queue size	0.092	0.083	0.101	0.059	0.051	0.067
PAC3 queue size	0.019	0.014	0.024	0.070	0.066	0.074
PAC2 flow rate	– 0.009	– 0.015	– 0.002	– 0.010	– 0.016	– 0.004
PAC3 flow rate	–	–	–	– 0.010	– 0.014	– 0.006
Constant	2.587	2.568	2.689	2.912	2.866	2.959

"–": if the predictor was not identified in the model, its coefficients were left blank

Equation for PAC2 50th percentile (median) waiting time:
Y = exp (2.587 + 0.092*[PAC2 queue size] + 0.019*[PAC3 queue size] - 0.009*[PAC2 flow rate])

Equation for PAC3 50th percentile (median) waiting time:
Y = exp (2.912 + 0.071*[PAC1 queue size] + 0.059*[PAC2 queue size] + 0.070*[PAC3 queue size] - 0.010*[PAC2 flow rate] - 0.010*[PAC3 flow rate])

Table 2 – The adjusted association between the predictors and the 95th percentile waiting time

	95th percentile Log (PAC2 waiting time)			95th percentile Log (PAC3 waiting time)		
Predictors	**B coefficient**	**95% CI**		**B coefficient**	**95% CI**	
Day of week						
Monday	– 0.072	– 0.206	0.062	– 0.057	– 0.157	0.043
Tuesday	– 0.004	– 0.139	0.132	– 0.191	– 0.282	– 0.099
Wednesday	0.105	– 0.045	0.256	– 0.024	– 0.132	0.085
Thursday	0.030	– 0.108	0.167	– 0.057	– 0.140	0.026
Friday	– 0.088	– 0.234	– 0.060	– 0.108	– 0.212	– 0.004
Saturday	0.118	– 0.041	0.277	0.074	– 0.034	0.181
PAC1 queue size	0.099	0.020	0.177	–	–	–
PAC2 queue size	0.057	0.043	0.070	0.059	0.048	0.070
PAC3 queue size	0.019	0.012	0.026	0.052	0.045	0.058
PAC2 flow rate	– 0.011	– 0.021	– 0.001	–	–	–
PAC3 flow rate	–	–	–	– 0.010	– 0.016	– 0.004
Constant	3.698	3.567	3.838	3.828	3.727	3.928

"–": if the predictor was not identified in the model, its coefficients were left blank

Equation for PAC2 95th percentile waiting time:
Y = exp (3.698 + 0.099*[PAC1 queue size] + 0.057*[PAC2 queue size] + 0.019*[PAC3 queue size] - 0.011*[PAC2 flow rate] - 0.072*[Monday] - 0.004*[Tuesday] + 0.105*[Wednesday] + 0.03*[Thursday] - 0.088*[Friday] + 0.118*[Saturday])

Equation for PAC3 95th percentile waiting time:
Y = exp (3.828 + 0.059*[PAC2 queue size] + 0.052*[PAC3 queue size] - 0.010*[PAC3 flow rate] - 0.057*[Monday] - 0.191*[Tuesday] - 0.024*[Wednesday] - 0.057*[Thursday] - 0.108*[Friday] + 0.074*[Saturday])

CONCLUSION

The model predicted a patient's waiting time in ED at time of triage with good accuracy and with very little clinical information.

MAIN PHARMACY CAPACITY ANALYSIS AND SIMULATION

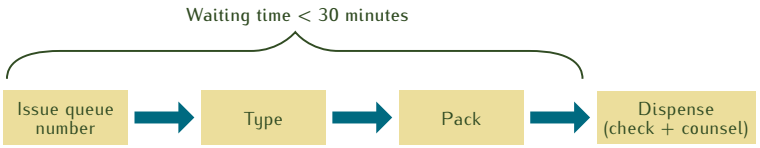
Dr Zhu Zhe Cheng

BACKGROUND

One of the key performance indicators (KPI) that the National University Hospital (NUH) main pharmacy is targeting to meet is the 95th percentile waiting time within 30 minutes. Currently the pharmacy can hardly meet the KPI with their present manpower configuration. Capacity analysis was conducted in the study to assist the pharmacy with a better manpower configuration.

Figure 1 illustrates the work flow in the main pharmacy. The work flow consists of four steps: issue queue number, type, pack and dispense. The waiting time is defined as the sum of time before dispensing starts.

Figure 1 – Work flow in NUH main pharmacy



METHODS

Figure 2 illustrates the daily prescription load of two prescription types – short Q and long Q. Short Q prescriptions consist of lesser items and require a shorter time, while long Q prescriptions are more time consuming. A two-peak pattern was observed in the workload distribution for both types. More manpower was needed during peak hours. Short Q and long Q prescriptions required an independent manpower configuration.

Figure 2 – Daily workload distribution of prescription load

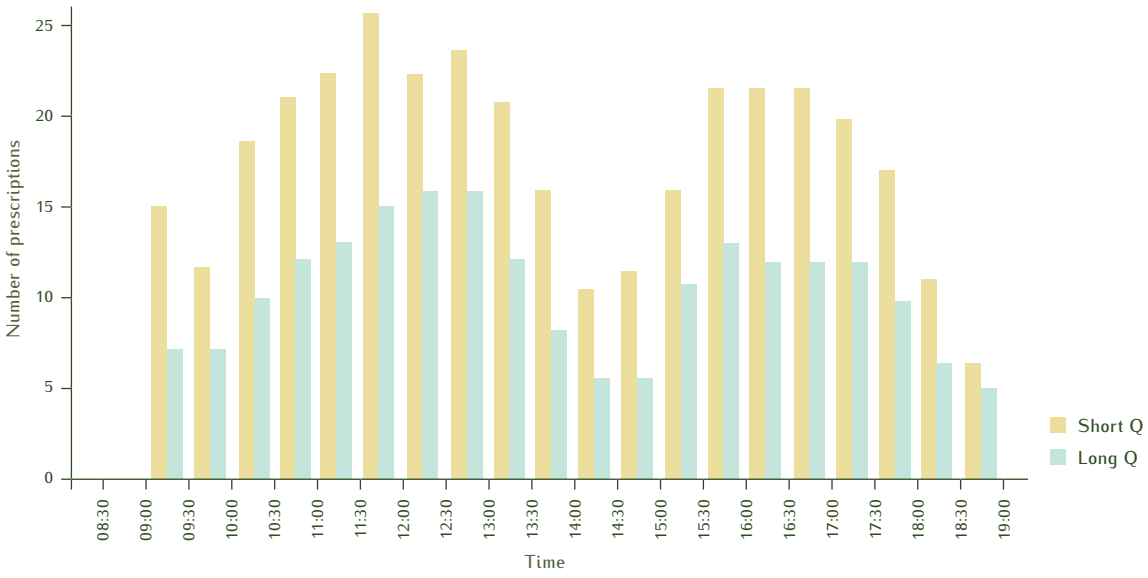


Figure 3 and 4 illustrates the manpower utilisation of the pack and dispense process based on the current manpower configuration. The bars represent the workload, and the asterisk marks represent the manpower available during that period.

Figure 3 – Manpower utilisation of pack

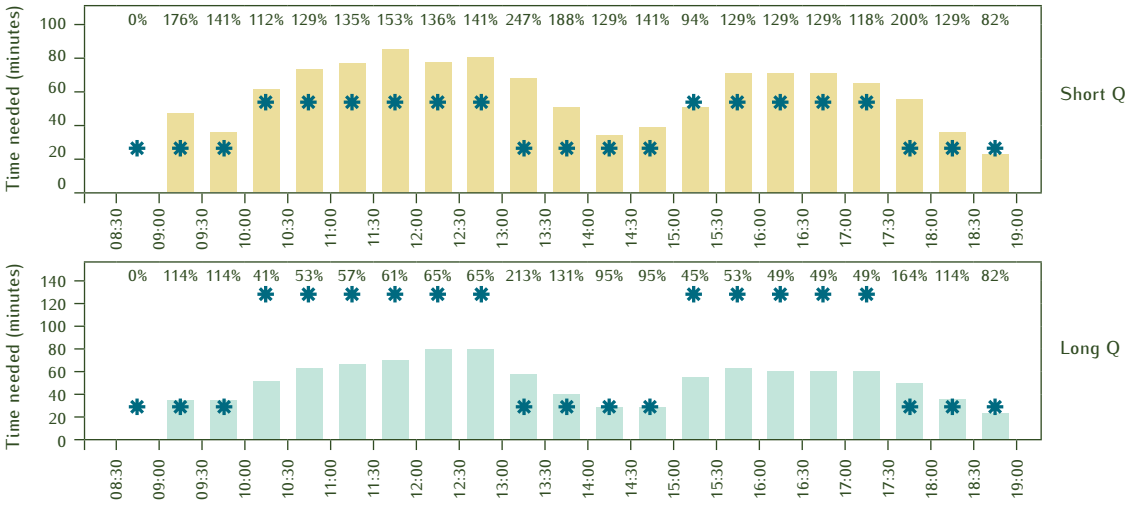
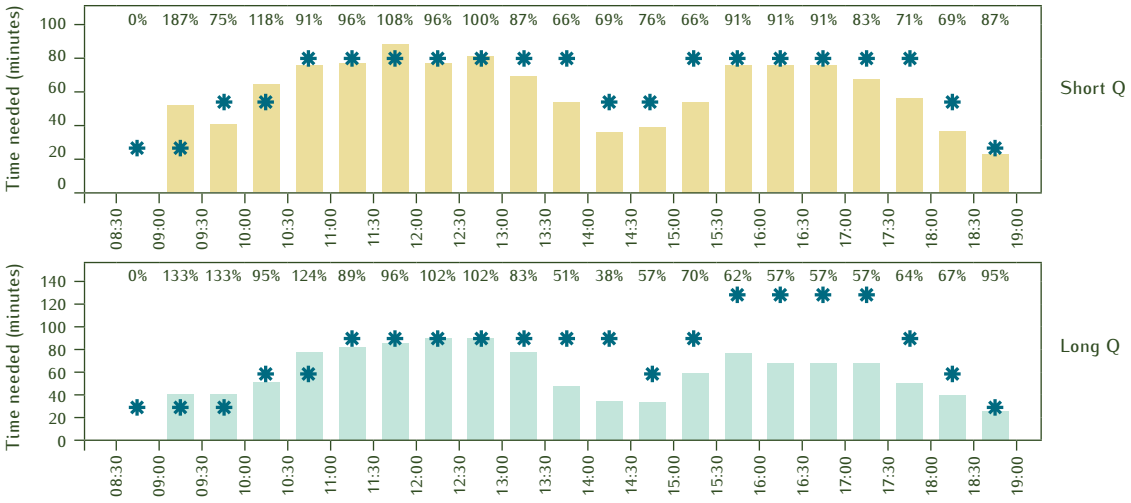


Figure 4 – Manpower utilisation of dispense



RESULTS

A simulation was conducted and the manpower configuration to meet the KPI is given in Table 1.

Table 1 – Simulation results of the manpower configuration to meet the KPI

		Time	8:30am	9:00am	9:30am	10:00am	10:30am	11:00am	11:30am	12:00am	12:30am	1:30pm
Main pharmacy	Pack	Short Q	1	1	1	1	1	1	1	1	1	2
		Long Q	1	2	2	3	3	3	3	3	3	2
	Dispense	Short Q	1	2	2	3	3	3	3	3	3	2
		Long Q	1	2	2	3	3	3	3	3	3	2

		Time	2:00pm	2:30pm	3:00pm	3:30pm	4:00pm	4:30pm	5:00pm	5:30pm	6:00pm	6:30pm
Main pharmacy	Pack	Short Q	2	2	3	3	3	3	3	3	2	1
		Long Q	2	2	3	3	3	3	3	3	2	1
	Dispense	Short Q	2	2	2	3	3	3	3	2	2	1
		Long Q	2	2	3	3	3	3	3	3	2	1

CONCLUSION

The capacity analysis conducted in this study helped the NUH main pharmacy detect the bottleneck within the workflow and reconfigure the manpower to meet the KPI.

APPLICATION OF DISCRETE EVENT SIMULATION ON WESTERN REGION ACUTE INPATIENT FLOW ANALYSIS

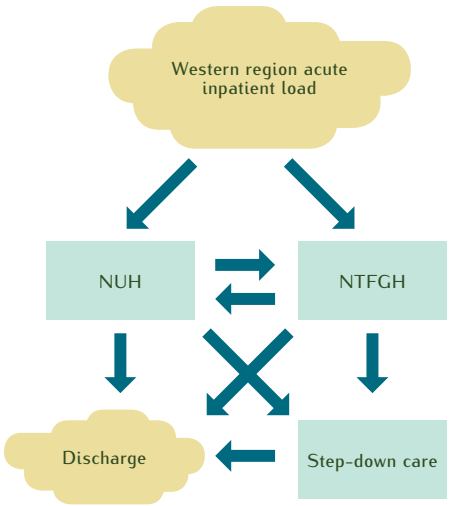
Dr Zhu Zhe Cheng

BACKGROUND

Due to the growing ageing population, the National University Hospital (NUH) is facing pressure in coping with the increased acute inpatient demand with their current bed capacity. The objective of this study was to use the Discrete Event Simulation (DES) model to identify system constraints and key resources required to meet the anticipated growth of acute inpatient load within the western region, consisting of NUH, Ng Teng Fong General Hospital (NTFGH) and step-down care facilities in the region.

Figure 1 illustrates the network of the acute inpatient flow of Singapore's western region. Acute patients are admitted to one of the two hospitals. After a few days' stay, most are discharged home. Some patients are discharged to step-down care facilities such as community hospitals (CH) and nursing homes (NH). There are also transfers between NUH and NTFGH.

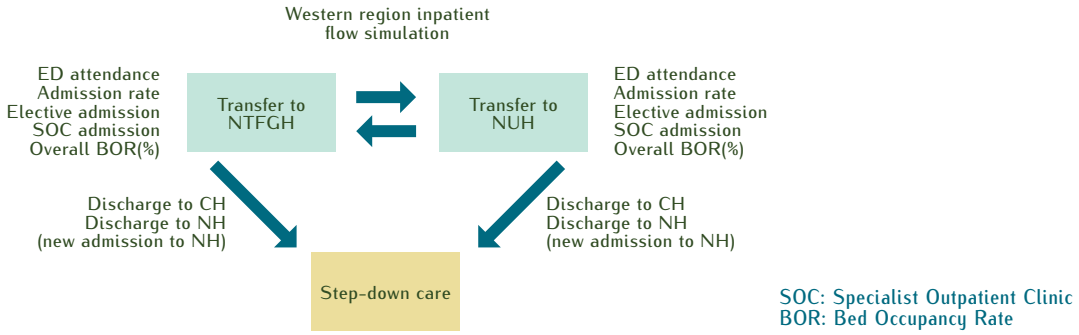
Figure 1 – Framework of the western region acute inpatient flow



METHODS

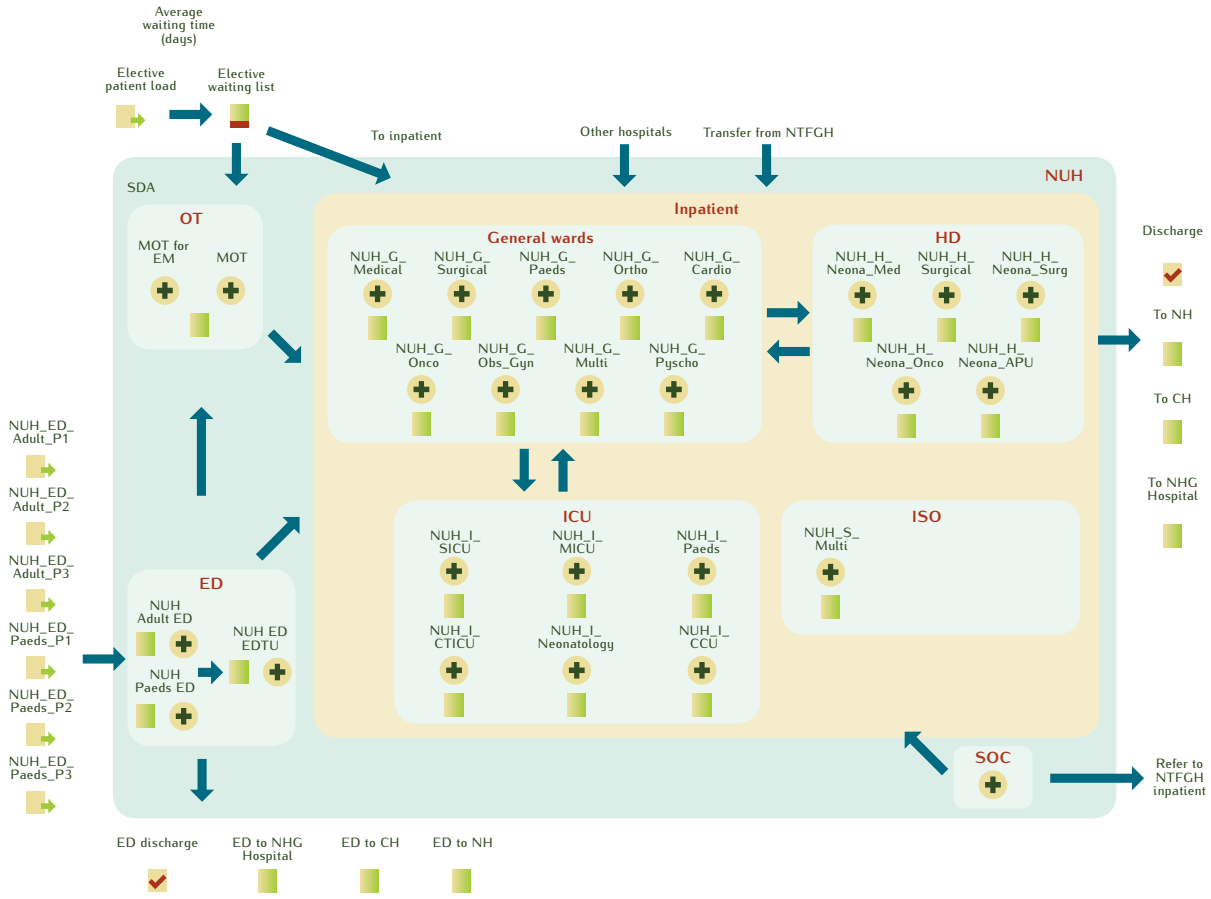
A DES model was constructed to quantify the relationship among different departments within an institution, and among different institutions. The software applied was Simul8 Professional. The model had two layers. The first layer modelled the relationship among different institutions (Figure 2), and also functioned as a dashboard for displaying the summarised information of each institution.

Figure 2 – First layer of the DES model



The second layer modelled the detailed patient flow within an institution (Figure 3). Departments related to acute inpatient flow such as Emergency Department (ED), inpatient departments, operating theatres and outpatient clinics were included in the second layer. As illustrated in Figure 3, each department can be modelled in further detail as necessary. For instance, the inpatient departments were further segregated into different clusters and disciplines.

Figure 3 – Second layer of the DES model (NUH part)



CONCLUSION

The DES model of the western region acute inpatient flow can be used to perform various what-if analyses regarding future capacity planning.

NATIONAL HEALTHCARE GROUP PRIMARY CARE SURVEY

Li Ruijie, A/Prof Thomas Lew[1], A/Prof John Abisheganaden[2], Dr Chong Yew Lam[3], Joe Hau[4], Dr Heng Bee Hoon
[1]Tan Tock Seng Hospital, Medical Board
[2]Tan Tock Seng Hospital, Department of Respiratory and Critical Care Medicine
[3]Tan Tock Seng Hospital, Department of Urology
[4]Tan Tock Seng Hospital, Primary Care Partners Office

BACKGROUND

In the unveiling of the proposed national primary care master plan in early August 2011, three new models of care were mooted to support and enhance the effectiveness, clinical expertise and capacities of general practitioners (GPs) in managing patients with chronic diseases, namely the Family Medicine Centre (FMC), the Community Health Centre (CHC), and the Medical Centre (MC).

The National Healthcare Group primary care survey therefore aims to fill this gap in the knowledge on doctors' perceptions towards these three new entities. Specifically, the survey aimed to establish a profile of our community service partners, the services that they use, and their perceptions towards the new infrastructures or models of care. The survey also studied initial knowledge, attitude and tangible expectations to a new health policy initiative within 3 months of its initial launch.

METHODS

A questionnaire was constructed with a few aims. The first aim was to establish the awareness of each of the new institutions. The second aim was to determine if the GPs would be willing to refer their patients to the CHC and MC, and their willingness to collaborate in a FMC. The third aim was to determine what services were most valued in each of the newly proposed institutions. Information was also collected on the GPs' existing use of external services. The survey was administered over the telephone by four trained interviewers.

RESULTS

A total of 197 GPs were approached, of whom 64 completed the survey and 10 declined. The doctors were primarily within the catchment area of Tan Tock Seng Hospital.

Amongst the services that GPs use, the most frequently referred out service category was diagnostics, followed by chronic disease management. When asked where GPs were referring these services to, 65.0% of the services being used were referred to other service providers, 20.0% to specialist outpatient clinics and 10.0% to polyclinics.

Of the three new institutions, the awareness was highest for the CHC (69.0%), followed by the FMC (36.0%), and the MC (22.0%). When asked about their willingness to refer patients to the CHC and MC, GPs were very supportive (Figures 1 & 2).

Figure 1 – GPs who expressed willingness to refer to CHCs by service categories

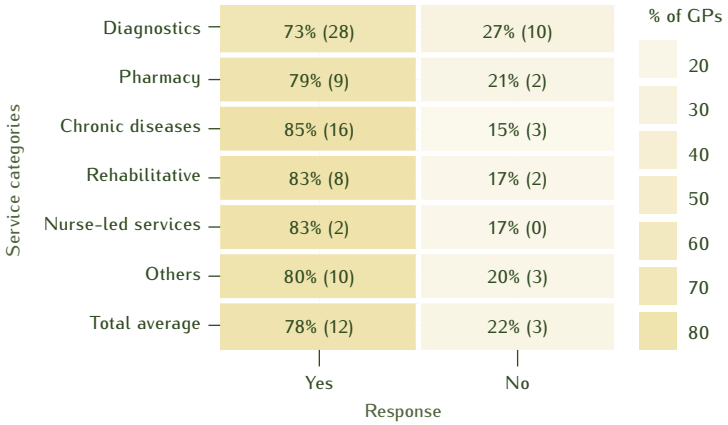
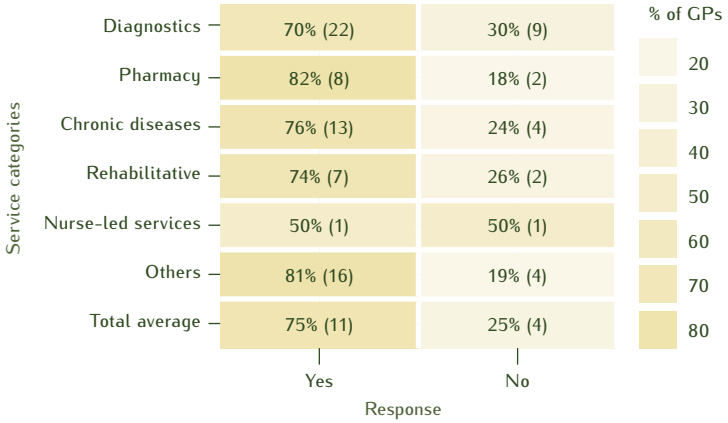


Figure 2 – GPs who expressed willingness to refer to MCs by service categories



For the FMCs, while it did not have a high awareness rate, 65.0% of GPs who were aware of it were willing to collaborate in a FMC venture. Amongst those unaware of it, after explaining what a FMC was, 50.0% indicated that they would be willing to collaborate in a venture. This suggested that with increased awareness, the concept of FMC could be more readily accepted.

Regarding services that GPs valued most, "diabetic screening", "rehabilitative services", and "dietician services" were the top three services for the CHC. For the MC, the GPs chose "cardiology", "gastroenterology", and "ophthalmology" as the three most important disciplines.

CONCLUSION

The GPs were generally receptive to the CHC and MC. A possible reason could be that these models of care are pre-existing in our current healthcare system. The FMCs appeared to be less well-received possibly due to a lack of awareness. The study suggested that with increased awareness, more GPs could possibly be more receptive to this new model of care.

PUBLICATIONS

ORIGINAL ARTICLES

1. Chong WF, Ding YY, Heng BH. A comparison of comorbidities obtained from hospital administrative data and medical charts in older patients with pneumonia. BMC Health Services Research 2011; 11: 105-113

2. Sun Y, Heng BH, Tay SY, Seow E. Predicting hospital admissions at emergency department triage using routine administrative data. Academic Emergency Medicine 2011; 18 (8): 844-850

3. Teo KWS, Tan WS, Chong WF, Abisheganaden J, Lew YJ, Lim TK, Heng BH. Economic burden of chronic obstructive pulmonary disease. Respirology 2012; 17 (1): 120-126

4. Teow KL, El-Darzi E, Foo C, Jin X, Sim J. Intelligent analysis of acute bed overflow in a tertiary hospital in Singapore. Journal of Medical Systems. 2011 January 10. [Epub ahead of print]

5. Ang YG, Wu XC, Toh MPHS, Chia KS, Heng BH. Progression rate of newly diagnosed impaired fasting glycemia to Type 2 diabetes mellitus: A study using the National Healthcare Group Diabetes Registry in Singapore. Journal of Diabetes. 2011 November 7. [Epub ahead of print]

SYSTEMATIC REVIEWS

6. Govinda Raj A, de Verteuil R. Systematic review of the diagnostic accuracy of the single, two and three field digital retinal photography for screening diabetic retinopathy. Joanna Briggs Institute Library of Systematic Reviews 2011; 9 (16): 491-537

BOOK CHAPTER / SERIES

7. Zhu ZC, Heng BH, Teow KL. Reducing consultation waiting time and clinic overtime in outpatient clinic: Challenges and solutions (Chapter 11). In Kolker A, & Story, P (Eds)., Management Engineering for Effective Healthcare Delivery: Principles and Applications, Hershey, USA: IGI Global, pp.229-245.

8. Tufanaru C, Tan WS. Synthesising economic evidence (Book 7). In Lippincott Williams & Wilkins/Joanna Briggs Institute, Synthesis Science in Healthcare Book Series, November 2011.

CONFERENCE PRESENTATIONS

JUN

28th AcademyHealth Annual Research Meeting (ARM), Seattle

1. George PP, Ma OHC, Heng BH, Seng F
   Right-siting chronic kidney disease care – A survey of general practitioners in Singapore

Institute for Operations Research and the Management Sciences (INFORMS) Healthcare, Montreal

2. Palvannan RK, Teow KL, Lew TWK, Lim S, Heng BH
   Impact of fixed bed capacity of stroke ward using Erlang loss model and modified stay distribution

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JUL

8th World Congress on Health Economics, Toronto

3. Teo KWS, Tan WS, Chong WF
   Economic burden of chronic obstructive pulmonary disease in the public health care system in Singapore

19th Triennial Conference of the International Federation of Operational Research Societies (IFORS), Melbourne

4. Zhu ZC
   Impact of different discharge patterns on bed occupation rate and bed waiting time: A simulation approach

45th Annual Singapore Malaysia Congress of Medicine, Singapore

5. Ang YG, Toh MPHS, Wu CX, Chia KS, Heng BH
   Progression from newly diagnosed impaired fasting glucose to Type 2 diabetes mellitus in Singapore

Operational Research Applied to Health Services (ORAHS), Wales

6. Teow KL, Sim J, Soh EF, Yap J, Palvannan RK, Zhu ZC, Brailsford S
   Integrated hospital simulation model

AUG

6th Singapore Public Health & Occupational Medicine (PHOM) Conference, Singapore

7. Sun Y, Heng BH, Choo SE, Ooi CK, Tay SY
   Decision tool on triaging patient acuity category at Emergency Department

8. Wu CX, **Tan WS**, Toh MPHS, **Heng BH**
Use of Diabetes Complication Severity Index to evaluate healthcare costs

9. **Ang YG**, **Li RJ**, **Heng BH**
Markov modelling of Type 2 DM using the Singapore Impaired Glucose Study

10. **Molina JAD**, **Heng BH**, Foo D, Yeo TC, Ong HY, Lim FS, Yeo LS, Rujia ASH
An evaluation of the LIVE (controL of coronary rIsk factor initiatiVE) programme

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NOV

Asia Pacific Conference on the Metabolic Syndrome, Sydney

11. **Ang YG**, **Heng BH**
The impact of obesity on progression rates of newly diagnosed impaired fasting glycaemia to Type 2 DM in Singapore

Joanna Briggs Institute (JBI) International Convention, Adelaide

12. **Ng KP**, **Ng CWL**
The effects of general practice size on quality of care

2nd Singapore Health & Biomedical Congress (SHBC), Singapore

13. **Palvannan RK**, Ang B, **Teo KWS**, **Heng BH**, Ho YM
Study of MRSA transmission using infectious disease model

14. **Tan WS**, Wu CX, **Ding YY**
An evaluation of Medisave liberalisation for diabetic patients in the National Healthcare Group

15. Wu CX, **Tan WS**, Toh MPHS, **Heng BH**
Derivation and validation of a risk index to predict all-cause mortality in Type 2 diabetes mellitus

16. **Govinda Raj A**, de Verteuil R
Systematic review of the diagnostic accuracy of the single, two and three field digital retinal photography for screening diabetic retinopathy

17. **Teow KL**, Tan A, Leong PQ, **Palvannan RK**
Understanding specialist outpatient clinics workload with a systems framework

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DEC

7th Health Services & Policy Research Conference, Adelaide

18. **Ng CWL**, **Heng BH**, **Molina JAD**, Wong LY, **George PP**, Cheah JTS
Demographic and lifestyle characteristics associated with non-willingness to participate in health promotion programmes among adults of a lower socioeconomic status in Singapore

AWARDS AND GRANTS

CONFERENCE PRESENTATION AWARDS

45th Annual Singapore Malaysia Congress of Medicine, Singapore
July 2011

Best Oral Presentation – Merit
Dr Gary Ang Yee
Progression from newly diagnosed impaired fasting glucose to Type 2 diabetes mellitus in Singapore

2nd Singapore Health & Biomedical Congress (SHBC), Singapore
November 2011

Young Investigator Award – Gold (Quality & Health Services Research)
Dr Sun Yan
Real-time prediction of waiting time in Emergency Department using quartile regression

Best Poster Award – Gold (Quality & Health Services Research)
Kelvin Teo Wee Sheng
Economic burden of chronic obstructive pulmonary disease in the public health care system in Singapore

TRAINING AWARDS

NHG Healthcare Manpower Development Programme
Palvannan R. Kannapiran (Infectious Disease Modelling)
Department of Infectious Disease Epidemiology, Imperial College London, UK
Pradeep Paul George (Health Economics)
Centre for Health Economics, The University of York, UK
Cheryl Lobo (Medical Library Science)
York Health Economics Consortium, The University of York, UK

RESEARCH GRANTS

MOH Health Services Research Competitive Research Grant

Integrated hospital simulation model
Teow Kiok Liang (Principal Investigator)
Palvannan R. Kannapiran (Co-investigator)
Dr Zhu Zhe Cheng (Co-investigator)
Dr Heng Bee Hoon (Co-investigator)
Tan Woan Shin (Co-investigator)
Dr Joseph Antonio D. Molina (Co-investigator)
Joe Sim, NUH (Co-investigator)
Heidi Rafman, NUH (Co-investigator)
Dr Eugene Fidelis Soh, TTSH (Co-investigator)
Dr Jamie Mervyn Lim, TTSH (Co-investigator)
Joanne Yap, JGH (Co-investigator)
Philip Heng, JGH (Co-investigator)
Prof Sally Brailsford, University of Southampton (Collaborator)
Prof David Matchar, Duke-NUS (Collaborator)
Dr Elia El-Darzi, University of Westminster (Collaborator)
Amount: $182,700

An automated telephone-administered hearing test for mass screening of hearing loss in Singapore
Dr Lynne Lim, NUHS (Principal Investigator)
Tan Woan Shin (Co-investigator)
Dr Heng Bee Hoon (Co-investigator)
Shyamala Thilagaratnam, HPB (Co-investigator)
Lau Kay Hock, SingTel (Technical support & industry partner)
Daniel Berg, HoerTech gGmbH (Technical support & industry partner)
Amount: $973,632

NHG Small Innovative Grant

An evaluation of Medisave liberalisation for diabetic patients in the National Healthcare Group
Tan Woan Shin (Principal Investigator)
A/Prof Ding Yew Yoong, TTSH (Co-investigator)
Christine Wu (Co-investigator)
Dr Heng Bee Hoon (Collaborator)
Amount: $49,600

TRAINING AND EDUCATION

Introduction to operational research (Master of Clinical Investigation Programme, NUS)

February 2011
Speaker: Teow Kiok Liang
The short lecture provided students with an introduction to the principles and practice of Operations Research (OR), and its role in human decision making. The focus was on understanding queue terminology, relations between parameters for planning, and the use of selected models and discrete event simulation for waiting time scheduling, resource planning and variability management.

9th Operations Research Appreciation Course (ORAC)

March 2011
Speakers: Palvannan R. Kannapiran
Teow Kiok Liang
Dr Zhu Zhe Cheng
The 2-day course introduced OR concepts with healthcare applications. It focused on building intuition around theory, walked through illustrative examples and showed insights from results that supported and informed decision making. Case studies showed applications of OR techniques as well as the process of problem solving during the engagement with the decision maker.

Operations research training (for Corporate & Infrastructure Planning Office, NUHS)

April 2011 – ongoing
Speakers: Palvannan R. Kannapiran
Teow Kiok Liang
Dr Zhu Zhe Cheng
Tan Woan Shin
Dr Joseph Antonio D. Molina
Kelvin Teo Wee Sheng
An extension course from the ORAC, specially conducted for CIPO, NUHS over a 10-day period spanning several months. The course covered OR topics in depth, which were illustrated with several case studies and hands-on sessions. Capstone exercises were planned for the trainees to demonstrate their understanding of the concepts. Additional health services research topics of economic evaluation, health economics and study designs were also shared.

Introduction to health services research (National Preventive Medicine Grand Round, Academy of Medicine Singapore)

April 2011
Speaker: Tan Woan Shin
The course aimed to provide an overview of the basic concepts, rationale, general and discipline-specific methods used in carrying out health services research. Designed to cover a broad range of topics at an introductory level, the main objective was to familiarise participants with a repertoire of methods that were often encountered in the conduct of health services research.

Data analysis in HSR – Working with large databases and regression models (NHG-KTPH Clinician Leadership in Research Programme)

October 2011

Speakers: Dr Sun Yan
A/Prof Ding Yew Yoong

This half-day workshop introduced participants to using large healthcare databases and regression models to improve health services. The focus of the short course was on research and evaluation using large observational databases as well as the practical issues of developing causal-effect and predictive regression models. Both conceptual and practical aspects were covered.

Introduction to qualitative methods and mixed methods research (NHG-KTPH Clinician Leadership in Research Programme)

October 2011

Speakers: Dr Ooi Chee Kheong
Issac Lim, NHG Education Development Office

This interactive and hands-on workshop was designed to introduce participants to the philosophical as well as nuts-and-bolts matters of qualitative research. Participants developed a qualitative/mixed-methods research proposal, constructed an interview protocol, and analysed qualitative data.

Evaluation of health programmes and economic evaluation (NHG-KTPH Clinician Leadership in Research Programme)

November 2011

Speakers: Dr Joseph Antonio D. Molina
Kelvin Teo Wee Sheng

This half-day course was designed to familiarise participants with the fundamentals of health programme and health service evaluation. The importance of evaluation in the broader context of programme implementation was discussed. The following topics were covered in the course: Criteria for evaluating health programmes and services, identifying relevant outcomes, designing and analysing the results of an evaluation, conducting an economic evaluation of a health programme or service as well as case studies.

Health services research (2nd Singapore Health and Biomedical Congress)

November 2011

Speakers: Dr Heng Bee Hoon
Tan Woan Shin
Palvannan R. Kannapiran
Dr Ooi Chee Kheong
Dr Sun Yan
Dr Gerald Koh, NUS
SN Teri Low, TTSH
Dr Eric Wong, TTSH
Foo Toon Seng, Integrated Health Information Services Pte Ltd
Tan Chiew Boon, IBM Singapore Pte Ltd

Held in conjunction with the 2nd Singapore Health and Biomedical Congress, the health services research track consisted of two sessions titled "HSR in policy, hospital and community", and "Finding evidence for need, translating evidence into action – HSR in ED". Topics included the study on the impact of financial policy on healthcare utilisation, triage and process improvement in emergency departments through prediction, analysis of hospital acquired infectious disease transmission and the impact of caregiver on rehabilitation potential of stroke patients. The second session focused on the applications of health services research in the emergency department, and the eclectic range of techniques used from social, clinical and physical sciences were also shared.

THE TEAM

1. **Dr Heng Bee Hoon**
   MBBS, MSc (Public Health), FAMS
   Director

2. **A/Prof Ding Yew Yoong**
   MBBS, FRCP, FAMS, MPH
   Visiting Consultant
   (Senior Consultant & Clinical Associate Professor, Geriatric Medicine, TTSH)

3. **Dr Ooi Chee Kheong**
   MBBS, MMed (Emergency Medicine), MRCS, MSc (Public Health)
   Research Fellow
   (Consultant, Emergency Department, TTSH)

4. **Dr Gary Ang Yee**
   MBBS, MPH
   Registrar

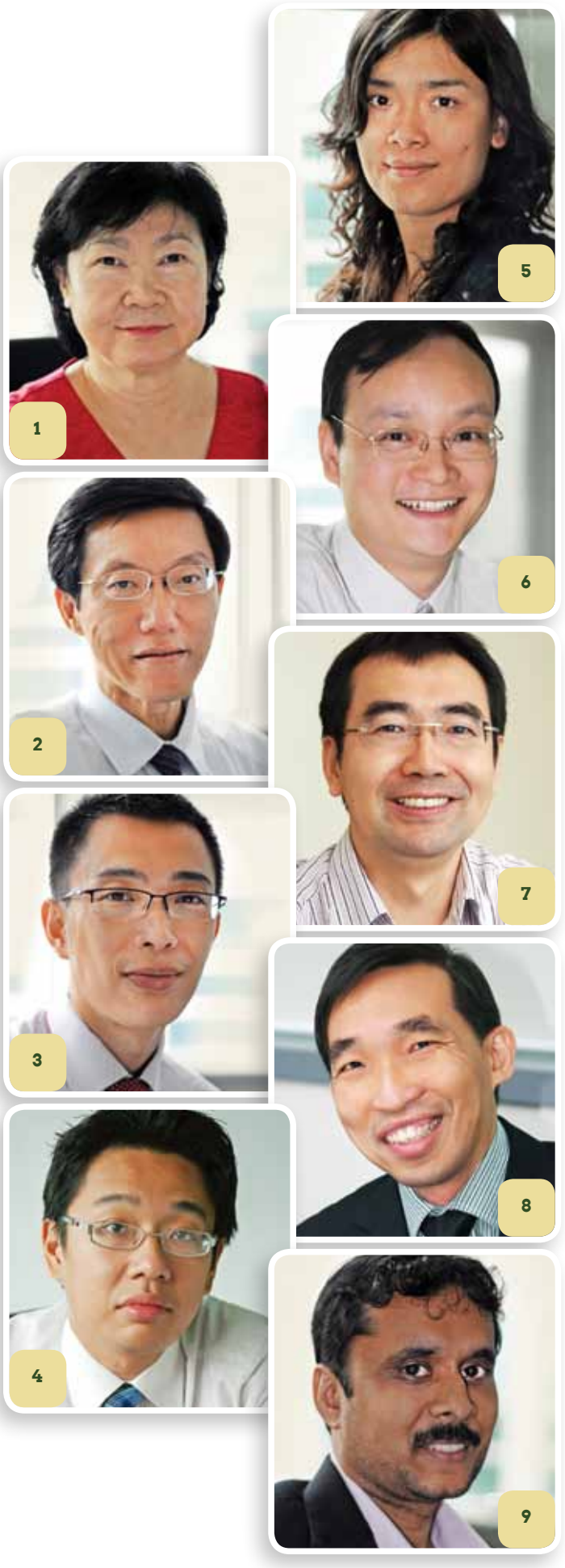
5. **Dr Sun Yan**
   MSc (Data Mining), PhD (Medical Informatics)
   Medical Informatics and Biostatistics Specialist

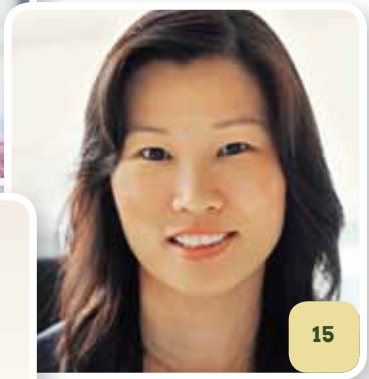
6. **Dr Zhu Zhe Cheng**
   MSc (Information Engineering), PhD (Industrial & Systems Engineering)
   Operations Research Specialist

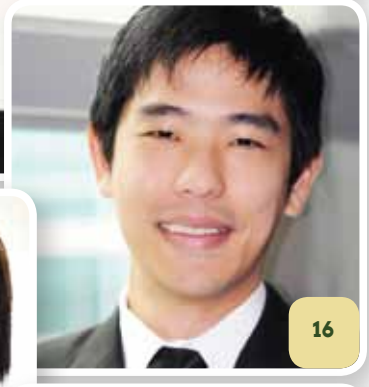
7. **Dr Meng Fan Wen**
   MSc (Operations Research), PhD (Operations Research)
   Operations Research Specialist

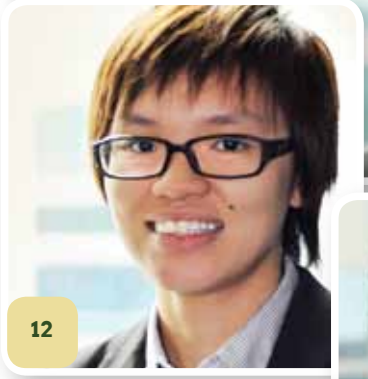
8. **Teow Kiok Liang**
   BEng (Electrical Engineering), MSc (Industrial & Systems Engineering)
   Operations Research Specialist

9. **Palvannan R. Kannapiran**
   BEng (Mechanical Engineering), MEng (Industrial & Systems Engineering)
   Operations Research Specialist









10. **Dr Joseph Antonio D. Molina**
MD, MSc (Public Health)
Principal Research Analyst

11. **Chong Wai Fung**
BN, MBA
Principal Research Analyst

12. **Tan Woan Shin**
BSocSc (Hons) (Economics),
MSocSc (Economics)
Principal Research Analyst

13. **Pradeep Paul George**
BSMS, MSc (Epidemiology)
Senior Research Analyst

14. **Anusha Govinda Raj**
BSc (Psychology),
MSc (Epidemiology)
Senior Research Analyst

15. **Charis Ng Wei Ling**
BA (Psychology & Communications)
Research Analyst

16. **Kelvin Teo Wee Sheng**
BA (Economics) (Magna Cum Laude),
MA (Economics)
Research Analyst

17. **Li Rui Jie**
MSc (Occupational Therapy)
Research Analyst

18. **Cheryl Lobo**
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Adding years of healthy life

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The evidence behind your decisions

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