HEALTH SERVICES & OUTCOMES RESEARCH

2017

HSOR@NHG

The evidence behind your decisions

FOREWORD

HSOR has contributed towards NHG strategies during the year. This was possible with (a) an alignment towards NHG vision and mission; (b) a clarity of purpose in a multi-disciplinary team and (c) a culture of innovation and objectivity in health services research. This report highlights our work in supporting diabetes initiatives, measuring population health and evaluating programs.

Diabetes had received national attention and response. Some of the contributions include a non-fasting screening tool using HbA1c; cost and outcome of outpatients in IMH in accessing primary care for chronic conditions; a diabetes progression model that used patient-level microsimulation to support several cluster-level policy decisions; and identification of factors that impact the lifetime cost of chronic disease prevention. To value risk and incentivize coordination of care across primary, acute and community providers, HSOR supported a bundled episode payment proposal led by the clinicians and finance stakeholders.

The Population Health Index is an attempt to construct a measure of a person's health, while pointing to underlying actionable drivers for interventions. This is a multi-year, prospective and longitudinal study of Central Region's residents. The baseline data of the first phase has enhanced our understanding of the nexus of frailty, multi-morbidity, depressive symptoms, social isolation and loneliness, especially among the elderly in the community. When validated further, it has the potential for wider adoption.

We continued to evaluate programs to inform their effectiveness and cost-effectiveness across institutions and care sites, mainly through support and funding by MOH. Some questions answered included: Is it feasible to implement geriatric principles of care in general wards? Can community eye care operators (optometrists) take on certain tasks carried out at Ophthalmology clinics? Is it cost-effective to provide continual monitoring of inpatient stroke patients for paroxysmal atrial fibrillation without compromising patients' safety and quality of care?

Finally, advancing knowledge and building capacity are the department's twin missions - PhD programs for three members were supported by NHG and NMRC, and a stochastic decision optimization model to improve clinical treatment protocol for diabetes was supported by a MOH-HSR grant. Training members of our healthcare community in Health Services Research, Big Data Analytics and Operations Research increased awareness and competencies in these areas. At the national level, the department supported capacity planning for new operational models of care; and were part of the development and roll out of predictive engines.

We hope you will enjoy reading some of the department's contributions in 2017 and find them useful.

Prof Philip Choo
Group Chief Executive Officer
National Healthcare Group

OUR VISION

To add years of healthy life to the people of Singapore through excellence in Health Services Research.

OUR MISSION

We will improve the quality of healthcare by providing best available evidence for decision making and knowledge translation; and building capacity and advancing knowledge in HSR.

CONTENTS

POPULATION HEALTH AND MANAGEMENT OF DISEASES

ORGANISATION AND DELIVERY OF SERVICES

HEALTH AND WELFARE ECONOMICS

RESEARCH DESIGN AND METHODOLOGIES

PROJECTS

POPULATION HEALTH AND MANAGEMENT OF DISEASES

PREVALENCE OF FRAILTY AND ASSOCIATION WITH DEPRESSIVE SYMPTOMS AMONG OLDER ADULTS IN SINGAPORE

Ge Lixia, Dr Yap Chun Wei, Dr Heng Bee Hoon

Highlights

Frailty, assessed using criteria converging less with somatic characteristics of depression, is associated with depressive symptoms among community-dwelling older adults.

Assessing frail older adults for the presence of depressive symptoms may help earlier detection of psychological problems.

Background

Physical frailty is highly correlated with depression among older adults as somatic symptoms of frailty (i.e. low physical activities, slowness, exhaustion, and unintentional weight loss) overlap with depression. This study examined whether frailty, when assessed using criteria that converge less with somatic characteristics of depression, remains associated with depressive symptoms.

Methods

Data of 721 participants aged 60 and above were derived from the baseline of the Population Health Index Survey conducted in the central region of Singapore from November 2015 – November 2016 and used in this study. Severity of frailty was determined using the Clinical Frailty Scale (CFS). A further stratification of CFS scores into four groups were made (CFS1-3: F1, CFS4: F2, CFS5: F3 and CFS6-7: F4). Depressive symptoms were assessed using the Patient Health Questionnaire-9. The association between frailty and depressive symptoms (dependent variable) was assessed using multiple linear regressions (unadjusted, adjusted for demographic information, and adjusted for demographics, number of non-mental chronic medical conditions and number of medications).

Results

Of the 721 older adults, 75.5% were in F1, 14.4%, 3.7% and 6.4% were in F2, F3 and F4 respectively. Results of all models showed that as frailty severity increased, older adults reported higher depressive symptom scores, even after controlling for demographic factors, number of non-mental chronic medical conditions, and number of medications taken regularly (Table 1).

Conclusion

Frailty remains associated with depressive symptoms among community-dwelling older adults, even when assessed using criteria selected to reduce overlap with somatic characteristics of depression.

Table 1: Association between level of frailty and depressive symptom score using multiple linear regressions (n=712)

Variables	Model 1			Model 2			Model 3		
	B	SE B	ß	B	SE B	ß	B	SE B	ß
Level of frailty									
F1	reference			reference			reference		
F2	1.26*	0.25	0.18	1.12*	0.26	0.16	0.93*	0.26	0.13
F3	2.56*	0.46	0.19	2.53*	0.48	0.19	2.29*	0.49	0.17
F3	3.62*	0.38	0.33	3.28*	0.41	0.30	2.91*	0.42	0.27

Model 1: unadjusted

Model 2: adjusted for socio-demographic variables (age, gender, marital status, employment status, living arrangement, money insufficiency, and smoking status)

Model 3: adjusted for socio-demographic variables + number of non-mental medical chronic conditions, and number of medications taken regularly

*p<0.001

ASSOCIATIONS BETWEEN MULTIMORBIDITY AND DOMAINS OF PHYSICAL FUNCTION AMONG COMMUNITY-DWELLING ADULTS

Ge Lixia, Dr Yap Chun Wei, Dr Heng Bee Hoon

Highlights

Multimorbidity had a stronger association with lower extremity function than upper extremity function.

The association between multimorbidity and physical function was stronger in women than men.

Interventions should target physical function in individuals with multimorbidity to keep them functionally independent and physically active in the community.

Background

Multimorbidity increases the likelihood of functional decline above the risk attributable to individual diseases among older adults. However, whether there is a gender disparity regarding the association of multimorbidity and physical functioning in community-dwelling adults is unknown.

Methods

Data for this study was derived from 1,940 participants in the Population Health Index Survey which was conducted in the central region of Singapore from November 2015 – November 2016. The prevalence of chronic medical conditions and multimorbidity was compared between men and women. Physical function was assessed using the Function Component of the Late-life Function and Disability Instrument and compared between men and women, and across three groups of chronic condition count (0, 1 and 2+ chronic conditions). Multiple linear regressions were conducted to examine associations between multimorbidity and individual physical function domains in men and women separately.

Results

The prevalence of multimorbidity in the sample were estimated to be 35.0% for adults aged 21 and above and 68.2% for those aged 60 years and above, without gender differences. Multimorbidity was associated with upper extremity function, basic and advanced lower extremity function, and overall function in men and women, even after adjusting for demographic factors. Multimorbidity was more strongly associated with lower extremity function than upper extremity function in both genders, and the association was stronger in women than men (Table 1).

Conclusion

Multimorbidity is highly prevalent among community-dwelling older adults and has significant associations with different domains of physical function. Effective interventions need to be implemented to maximize physical function in individuals with multimorbidity in order to keep them functionally independent and physically active in the community.

Table 1: Gender differences in association of multimorbidity with physical function domain scores using multiple linear regression

Variables	Male				Female			
	UEF	BLEF	ALEF	Overall function	UEF	BLEF	ALEF	Overall function
Number of chronic conditions (Ref: no condition)								
1	0.10	0.19	-2.08	-1.94	-0.37	-2.07	-4.70*	-3.64*
2+	-4.20*	-6.80*	-11.93*	-9.51*	-4.45*	-10.46*	-16.15*	-12.13*
Age group (Ref:21-44 years)								
45-64	-0.24	-0.62	-2.96	-2.64*	0.91	0.55	-4.12*	-3.42*
65&above	-5.59*	-10.39*	-20.45*	-15.24*	-4.15*	-7.48*	-17.59*	-12.92*
Ethnicity (Ref: Chinese)								
Malay	-0.24	-0.62	-2.96	-2.64*	0.91	0.55	-4.12*	-3.42*
Indian	-5.59*	-10.39*	-20.45*	-15.24*	-4.15*	-7.48*	-17.59*	-12.92*
Others	-2.32	-3.47	-6.99	-3.99	-2.21	-1.64	-2.90	-2.59
Highest education (Ref: No formal education)								
Primary	1.81	1.35	2.94	2.00	5.71*	7.52*	10.47*	6.82*
Secondary	2.91*	5.23*	9.11*	6.59*	6.86*	11.08*	14.49*	10.03*
Post-Secondary	2.15	4.67*	11.57*	8.45*	7.74*	11.99*	18.80*	13.34*

Note: UEF=Upper extremity functioning; BLEF= Basic lower extremity functioning; ALEF=Advanced lower extremity functioning

*p<0.05.

SOCIAL ISOLATION, LONELINESS AND ASSOCIATIONS WITH DEPRESSIVE SYMPTOMS: A POPULATION-BASED STUDY

Ge Lixia, Dr Yap Chun Wei, Reuben Ong, Dr Heng Bee Hoon

Highlights

Individuals with less social connectivity with relatives or friends and those who reported higher loneliness score exhibit more depressive symptoms.

The influence of loneliness on depressive symptoms was independent of and stronger than any indicator of social isolation in adults aged 21 and above.

Background

Social isolation and loneliness have been individually identified to be associated with depressive symptoms. However, it is uncertain which of the two plays a more important role in depression. The aim of this study is to examine the differential associations that social isolation indicators and loneliness have with depressive symptoms.

Methods

This study used data from 1,919 community-dwelling adults (21 years or older) collected using a representative health survey conducted in the central region of Singapore. The association between social isolation indicators (marital status, living arrangement, social connectedness with relatives and friends) and loneliness (measured using the three-item UCLA Loneliness scale) were assessed, and their differential associations with depressive symptoms (measured using the Patient Health Questionnaire-9) were examined. Multiple linear regressions, controlling for relevant covariates (age, gender, ethnicity, employment status, self-reported financial status, smoking status, alcohol consumption, previous diagnosis of depression, and number of self-reported chronic diseases), were used.

Results

Social isolation in terms of weak connectedness with relatives and with friends, and loneliness were associated with depressive symptoms. The association of loneliness with depressive symptoms ($\beta = 0.33$) was independent of and stronger than any social isolation indicators ($|\beta| = 0.00$~0.07) (Table 1).

Conclusion

This study establishes a significant and unique association of different social isolation indicators and loneliness with depressive symptoms in community-dwelling adults.

Table 1: Linear regression analysis for depressive symptoms

Variables	Coefficients		
	Regression 1	Regression 2	Regression 3
Age	-0.03	-0.05	-0.01
Female (Ref. Male)	0.07*	0.06*	0.06*
Ethnicity (Ref. Chinese)			
Malay	-0.03	0.02	0.02
Indian	0.00	0.01	0.01
Others	0.05*	0.05*	0.03
Employment status (Ref. Employed)			
Unemployed	0.15*	0.12*	0.09*
Inactive	0.01	0.00	-0.01
Money insufficiency	0.16*	0.13*	0.10*
Currently smoking (Ref. not smoking)	0.01	0.01	0.01
Alcohol abuse	0.08*	0.08*	0.07*
Previous diagnosis of depression	0.23*	0.22*	0.19*
Number of chronic conditions	0.18*	0.17*	0.14*
Marital status (Ref. Single)			
Married		-0.11	-0.06
Widowed /Divorced		0.01	0.00
Living arrangement (Ref. With spouse & children)			
Alone		-0.07*	-0.05
With spouse, no child		0.01	0.01
With child(ren), no spouse		-0.01	0.00
With others only		-0.04	-0.02
Social connectedness with relatives		-0.06*	-0.04
Social connectedness with friends		-0.11*	-0.07*
Loneliness			0.33*

*p<0.05

MONTREAL COGNITIVE ASSESSMENT: REGRESSION-BASED NORMATIVE DATA FOR AN ASIAN POPULATION

Reuben Ong, Dr Yap Chun Wei, Ge Lixia, Dr Heng Bee Hoon

Highlights

Demographically stratified normative MoCA scores were obtained in this study, and can be used as a reference for cut-off scores during screening of mild cognitive impairment.

An alternative method of determining screening cut-off scores was presented.

Background

The Montreal Cognitive Assessment (MoCA) is superior in screening for mild cognitive impairment (MCI) over the Mini-Mental State Examination (MMSE). Compared to the MMSE, the MoCA has higher sensitivity and specificity in discriminating medically diagnosed MCI patients from healthy controls. However, clinical case control studies conducted in Singapore differ in their suggested MoCA cut-off scores. Additionally, a single cut-off score may not be sufficiently generalizable for ethnically diverse populations.

This study aimed to provide normative MoCA performance values for a healthy Asian adult population comprising 4 major ethnic groups of Singapore to guide local screening protocols.

Methods

Demographics, lifestyle factors and MoCA scores of 1,103 healthy adults (aged 21 to 97) were obtained from the 2016 phrase of a community health study conducted in central Singapore. Participants were deemed eligible if they did not report any history of chronic medical or mental illness, had no vision or auditory problems, and had no disability in activities of daily living. In addition, the Patient Health Questionnaire (PHQ-9) was used to screen participants for depressive symptoms, and those who presented these symptoms were excluded from the study. Data from participants was analyzed using multivariate regression to determine significant factors related to MoCA scores. Regression ß coefficients of those factors were used to prognosticate normative mean MoCA scores for the population. Five-fold cross validation was used to validate the regression model.

Results

The regression model had an adjusted R^2 of 0.354 ($p<0.001$). Age and education level were the main contributors to the model ($R^2 = 0.347$), and ethnicity remained a significant factor, even after adjustment for lifestyle factors. The original MoCA screening protocol recommends a one point adjustment for those with 6 years of formal education or less. However, regression model coefficients obtained indicate that this is inadequate for our population. Frequency of physical exercise and social activity were not associated with MoCA scores in this sample. Postulated reasons include insensitivity of measurement tools used due to lack of information

regarding intensity and activity type, and that the causal pathway from lack of exercise and social activity to affected MoCA scores could be mediated through chronic medical or mental conditions (unrepresented in this healthy sample). Nevertheless, normative values were obtained using the model and tabulated, and screening for MCI can be done using the clinical standard of one standard deviation below the mean (Table 1).

Conclusion

This study reinforces the importance of validation of psychometric tools for local contextual use. An alternative methodology to the traditional case control method in determining population-specific screening cut-off values was presented in this study. MoCA scores were shown to be influenced by age, education level and ethnicity and should be accounted for during MCI screening. Normative data tables from this study provide cut-offs according to demographics and is likely to improve cognitive screening accuracy over a single cut-off score.

Table 1: Mean MoCA and screening cut-off scores*

Ethnicity	Age Group	Highest formal education qualification attained			
		No formal qualification	Primary	Secondary	Tertiary and beyond
Chinese	21-39	22.3 (19.6)	24.8 (22.1)	26.6 (23.9)	27.8 (25.1)
	40-59	21.9 (19.1)	24.4 (21.6)	26.2 (23.5)	27.4 (24.7)
	60-74	21 (18.3)	23.5 (20.7)	25.3 (22.6)	26.5 (23.8)
	≥75	19.5 (16.8)	22 (19.3)	23.8 (21.1)	25 (22.3)
Malay	21-39	21.2 (18.5)	23.7 (21.0)	25.6 (22.8)	26.7 (24.0)
	40-59	20.8 (18.1)	23.3 (20.6)	25.1 (22.4)	26.3 (23.6)
	60-74	19.9 (17.2)	22.4 (19.7)	24.2 (21.5)	25.4 (22.7)
	≥75	18.4 (15.7)	20.9 (18.2)	22.8 (20.0)	23.9 (21.2)
Indian	21-39	21.6 (18.9)	24.1 (21.4)	26 (23.2)	27.1 (24.4)
	40-59	21.2 (18.5)	23.7 (21.0)	25.5 (22.8)	26.7 (24.0)
	60-74	20.3 (17.6)	22.8 (20.1)	24.6 (21.9)	25.8 (23.1)
	≥75	18.8 (16.1)	21.3 (18.6)	23.2 (20.5)	24.3 (21.6)
Others	21-39	22.2 (19.5)	24.7 (22.0)	26.5 (23.8)	27.7 (25.0)
	40-59	21.8 (19.0)	24.2 (21.5)	26.1 (23.4)	27.3 (24.6)
	60-74	20.9 (18.1)	23.4 (20.6)	25.2 (22.5)	26.4 (23.7)
	≥75	19.4 (16.7)	21.9 (19.2)	23.7 (21.0)	24.9 (22.2)

*Cut-off score represent 1SD below mean

EFFECT OF MULTIMORBIDITY ON SURVIVAL OF PATIENTS DIAGNOSED WITH HEART FAILURE: A RETROSPECTIVE COHORT STUDY IN SINGAPORE

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Highlights

Heart failure patients with history of diabetes and chronic kidney disease had the highest risk for all-cause death and cardiovascular disease-specific death compared to patients with heart failure only.

Optimal care management of heart failure along with its associated multimorbidity is essential to improve survival among heart failure patients.

Background

Multimorbidity in heart failure (HF) patients results in poorer prognosis and is an increasing public health concern. We aim to examine the effect of multi-morbidity (focusing on type-2 diabetes (T2DM) and chronic kidney disease (CKD)) on all-cause mortality and cardiovascular disease (CVD)-specific mortality among patients diagnosed with HF in Singapore.

Methods

Patient demographics, clinical and death data were obtained from the Regional Health System (RHS) administrative database. All patient diagnosed with HF from 2003 to 2016 were included in this retrospective cohort study and were followed up until death or censor date (31st December 2016). HF patients were categorized based on their history of T2DM and CKD (Stages 1 to 5). Patients were categorized as follows: (1) history of HF only, (2) history of T2DM+HF, (3) history of CKD+HF and (4) history of T2DM+CKD+HF. Cox regression was used to determine the independent and combined effects of T2DM and CKD on risk of all-cause mortality and CVD-specific mortality in HF patients. Variables included in the model were age, gender, ethnicity, smoking status, history of atrial fibrillation, chronic obstructive pulmonary disease (COPD), dyslipidemia, hypertension and stroke, baseline medication (angiotensin-converting enzyme inhibitors (ACEi), angiotensin receptor blocks (ARB), beta-blockers and diuretic), and duration of T2DM prior to HF diagnosis.

Results

A total of 34,460 HF patients were included in the analysis. Median follow-up was 2.1 years (IQR: 0.5 to 4.9 years). Mean age of these patients was 70.2 years (SD 14.0) and 46.6% were female. Prior to HF diagnosis, 50.5% had T2DM and 41.1% had CKD. A total of 12,880 patients were diagnosed with HF only (37.4%), 7,430 (21.6%) had T2DM+HF, 4,186 (12.1%) had CKD+HF and 9,964 (28.9%) patients had T2DM+CKD+HF. T2DM and CKD were

independently associated with a 21% and 29% higher risk of all-cause death compared to HF patients without these conditions (Table 1). Likewise, the risk of CVD-specific death for T2DM and CKD was 21% and 19% higher than HF only referent group (Table 1). Having all three conditions (T2DM+CKD+HF) was associated with a 56% higher risk of all-cause death and 44% higher risk from CVD-specific death compared to HF patients only after adjusting for other variables (Table 2).

Conclusion

All-cause and CVD-specific mortality risks increased with increasing multimorbidity. This study highlights the need for new model of care which focuses on optimal care management of HF and its associated multimorbidity rather than disease-specific management alone to improve survival among HF patients with multimorbidity.

Table 1: Independent effect of diabetes and chronic kidney disease on all cause and CVD-specific mortality

	Primary endpoint[1]: All-cause mortality		**Secondary endpoint[2]: CVD-specific mortality**	
	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval
T2DM	1.21	1.17 to 1.26	1.21	1.14 to 1.28
CKD	1.29	1.25 to 1.34	1.19	1.13 to 1.26

[1]Adjusted for age, gender, ethnicity, smoking status, history of atrial fibrillation, COPD, dyslipidemia, hypertension and stroke, baseline medication (ARB, beta-blockers and diuretic) and duration of T2DM prior to HF diagnosis

[2]Adjusted for age, gender, ethnicity, smoking status, history of atrial fibrillation, COPD, dyslipidemia, hypertension and stroke, baseline medication (ARB, ACEi and diuretic) and duration of T2DM prior to HF diagnosis

Table 2: Effect of multimorbidity on all cause and CVD-specific mortality

	Primary endpoint[1]: All-cause mortality		**Secondary endpoint[2]: CVD-specific mortality**	
	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval
HF (Reference Group)	1		1	
HF + T2DM	1.15	1.10 to 1.20	1.17	1.09 to 1.26
HF + CKD	1.20	1.14 to 1.27	1.14	1.05 to 1.24
HF + T2DM + CKD	1.56	1.48 to 1.63	1.44	1.32 to 1.56

[1]Adjusted for age, gender, ethnicity, smoking status, history of atrial fibrillation, COPD, dyslipidemia, hypertension and stroke, baseline medication (ARB, beta-blockers and diuretic) and duration of T2DM prior to HF diagnosis

[2]Adjusted for age, gender, ethnicity, smoking status, history of atrial fibrillation, COPD, dyslipidemia, hypertension and stroke, baseline medication (ARB, ACEi and diuretic) and duration of T2DM prior to HF diagnosis

PSYCHOSOCIAL FACTORS ASSOCIATED WITH READMISSIONS AMONG HEART FAILURE PATIENTS: A SYSTEMATIC REVIEW.

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Highlights

Heart failure patients have one of the highest rates of readmission globally.

Psychosocial factors such as loneliness, being single and lacking social networks are correlated with higher rates of readmissions among heart failure patients.

These psychosocial factors are potentially modifiable and mediation of these factors alongside clinical interventions is essential to reduce readmission rates among heart failure patients.

Background

Heart failure (HF) patients typically report psychological distress, reduced social interactions, diminished quality of life, and have high rates of hospital readmissions. Intervening on potentially modifiable individual psychosocial factors, beyond clinical parameters, might help reduce readmission risk and tailor care pathways for sub-groups of HF patients with psychosocial issues.

This review aimed to synthesize current evidence on psychosocial factors associated with readmissions among HF patients.

Methods

A PubMed search was conducted on 16th August 2017 with key words including 'heart failure', 'congestive heart failure', 'hospital readmission', 'factors', 'psychosocial factors', 'loneliness', 'marital status', 'social isolation', 'bereavement' and 'social status'. The reference lists of the individual studies were also searched for additional references. All studies published over the last ten years from the date of the search were included. This restriction was applied so that the most recent evidence was summarized. For the purpose of this review, the following psychosocial factors were assessed: loneliness, marriage status, social disruption, bereavement, work environment, social status, and social integration. Studies assessing socioeconomic status, activities of daily living (ADL), mental health issues (clinically diagnosed dementia, depression and anxiety), non-adherence to medication and effects of sleep deprivation were excluded. Only observational studies (prospective and retrospective cohort studies and cross-sectional studies) assessing psychosocial factors published in English were considered. Two authors (NS and PPG) independently assessed the eligibility of each study.

Results

Figure 1 shows the prisma flow chart for study selection. Twelve studies, comprising a total of 8,080 HF patients, were included in the review. Mean age of the patients in the included studies ranged from 56.5 years to 78 years. Seven studies assessed marital status as a risk factor for hospital readmission following HF. Being single was associated with an increased risk (OR 1.47; 95%CI: 1.08 to 2.01) of 30-day readmission compared to married patients in one study while another reported a 28% increased risk (P = 0.021). However, the other five studies reported non-significant findings regarding marital status. Five studies assessed loneliness as a risk factor for hospital readmission following HF. Only 2 of these 5 studies showed that loneliness was associated with readmissions. Four studies assessed the effect of social support on the risk of readmissions following HF. These studies showed that patients having social support were at a decreased risk of readmission after adjusting for known risk factors (OR ranged from 0.45 (0.4 to 0.84) to 0.65 (0.43 to 1.00).

Conclusion

Psychosocial factors like being single, loneliness or lacking social support may be driving HF readmissions for a sub-set of HF patients. Though their readmission causal pathway is unclear, interventions to address these psychosocial issues may aid in preventing readmissions in this group. Further research on the link between these psychosocial factors and medication adherence as well as mental health issues need to be assessed to determine the pathways through which psychosocial factors affect readmissions.

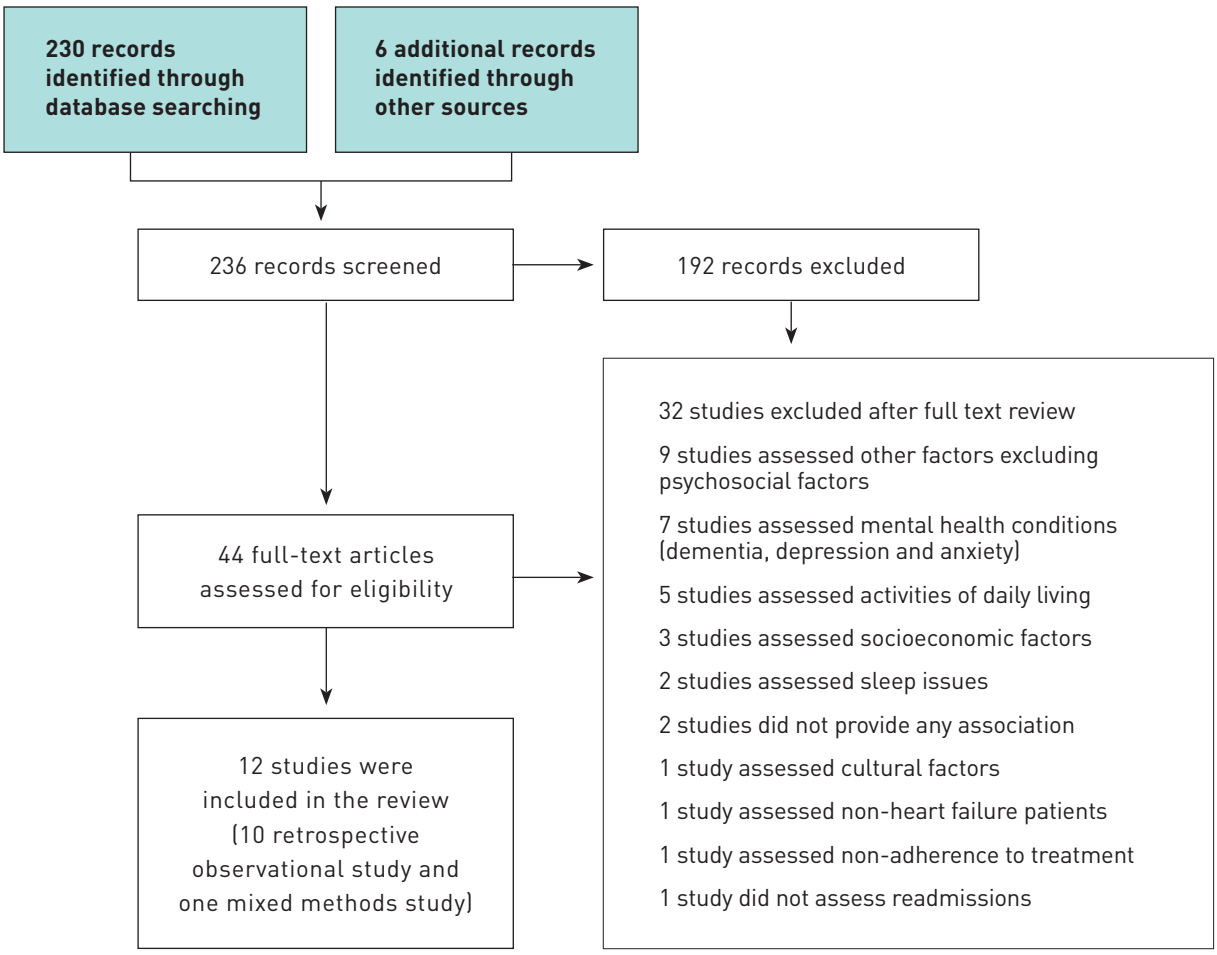

Figure 1: Study selection prisma flow chart

PROJECTS

ORGANISATION AND DELIVERY OF SERVICES

WHAT CAN ATTENDING PRIMARY CARE DO FOR PATIENTS WITH CO-EXISTING PSYCHIATRIC AND CHRONIC MEDICAL DISEASES?

Michelle Jessica Pereira, Dr Yap Chun Wei, Dr Joseph D. Molina

Highlights

Primary care attendance is associated with lower healthcare utilisation and costs for patients with co-existing psychiatric and chronic medical diseases.

A complex array of demographic factors and health conditions are associated with higher healthcare utilisation costs and would need to be addressed when implementing primary care services to reduce healthcare utilisation of these patients.

Introduction

Patients with mental illnesses have poorer health outcomes. Barriers to healthcare access and difficulties with healthcare provision have been proposed as potential factors. The aims of this study are to (1) investigate the effects of primary care attendance on healthcare utilisation and costs, for patients with concomitant psychiatric and certain non-mental chronic medical conditions (diabetes, hypertension or dyslipidemia), and (2) explore potential influences of individual characteristics on healthcare utilisation costs beyond primary care attendance.

Methods

A retrospective cohort study was performed. Data was acquired from the National Healthcare Group (NHG) Regional Healthcare System (RHS) database. Included patients: (i) were adult Singaporean residents living in 6 selected urban development planning areas; (ii) attended the Institute of Mental Health (IMH) at least once in 2013; and (iii) had a diagnosis of diabetes, hypertension or dyslipidemia in 2013 or prior. Patients, who visited any National Healthcare Group Polyclinic (NHGP) for a chronic medical condition two times or more in the year preceding their first IMH specialist outpatient clinic (SOC) visit in 2013 ("base patients"), were compared to those who did not ("non-base patients"). 1-year healthcare utilisation from baseline (first IMH SOC visit) comprising inpatient admissions and length of stay (LOS) at Tan Tock Seng Hospital (TTSH) and IMH, emergency department (ED) visits at TTSH; specialist outpatient clinic (SOC) visits at TTSH and IMH, and utilisation costs were extracted.

Furthermore, demographics (age, gender, ethnicity, financial assistance status) and diagnosis status of 7 psychiatric conditions (anxiety, depression, schizophrenia, dementia, alcohol addiction, substance addiction, bipolar disorder), plus diagnosis status of additional non-mental chronic medical conditions monitored in a chronic disease registry were obtained. These were used as covariates in the statistical analysis of utilisation outcomes. Logistic regressions were used for binary outcomes (inpatient hospital admissions), zero-inflated poisson regressions were used to examine ED visits and LOS, and generalised linear models (gamma family, log link) were employed for utilisation costs.

Results

3,842 IMH patients were included in this study. "Base patients" (48.6%) were older (mean=61.8; SD=11.9 versus mean=57.4; SD=14.4), marginally more likely to be female (52.5% versus 48.7%), had more medical conditions (2.75; SD=1.35 versus 1.96; SD=1.29), but fewer psychiatric conditions (1.21; SD=0.759 versus 1.35; SD=0.869).

"Non-base patients" fared poorer in several outcomes of interest. They were more likely to be admitted to TTSH (OR 1.40; 95%CI: 1.13 – 1.73) and IMH (OR 2.34; 95%CI: 1.85 – 2.96), have longer LOS at both institutions (IRR 1.49; 95%CI: 1.41 – 1.56 and IRR 2.13; 95%CI: 2.05 – 2.21 respectively), and attend TTSH ED more frequently (IRR 1.38; 95%CI: 1.23 – 1.53). Notably, 1-year adjusted mean utilisation costs was higher for "non-base patients" (Δ=$1,672.25) (table 1). Additionally, it was found that male gender, requiring financial assistance, specific medical conditions (heart failure, chronic obstructive pulmonary disease, diabetes, and hypertension) and specific psychiatric conditions (dementia, schizophrenia) were at risk of higher utilisation costs, even after the effect of primary care attendance was controlled for.

Conclusions

Patients with co-existing psychiatric and chronic medical conditions who make 2 or more primary care visits annually for their non-mental chronic medical conditions have lower healthcare utilisation and costs. Health policy makers need to promptly consider implementing new care models that can improve primary care access and attendance for this vulnerable patient group to manage rapidly burgeoning healthcare costs. Moreover, studies that evaluate the efficacy and cost-effectiveness of such services are required. Both demographic and specific health conditions were associated with higher healthcare utilisation costs. Thus, targeting potentially at-risk groups and mediating specific health conditions, alongside enhancing primary care access and attendance, would be essential to effectively manage healthcare utilisation of these patients.

Table 1: Adjusted means (95% CI) from generalised linear models for 1-year utilisation costs

Institution		"Base patients" (2,027)	"Non-base patients" (1,815)	Δ (Non-base – base)
TTSH	Inpatient	699.37 (533.78; 864.96)	1,006.61 (754.16; 1259.08)	307.24 (-0.42; 614.91)
	SOCs	347.15 (281.80; 412.49)	241.87 (193.72; 290.01)	-105.29 (-186.95; -23.62)
	Overall	1,238.43 (1,034.15; 1,442.72)	1,454.91 (1,200.99; 1,708.83)	216.48 (-112.72; 545.67)
IMH	Inpatient	366.20 (253.62; 478.78)	1,548.73 (1041.52; 2055.95)	1,182.53 (647.29; 1,717.78)
	SOCs	717.24 (683.53; 750.95)	855.99 (813.35; 898.62)	138.75 (83.12; 194.38)
	Overall	1,123.50 (981.96; 1,265.03)	2,468.20 (2,138.00; 2,798.40)	1,344.70 (974.19; 1,715.23)
NHGP		558.22 (518.65; 597.79)	95.56 (88.37; 102.74)	-462.66 (-503.41; -421.92)
Total System		3,049.81 (2,769.49; 3,330.14)	4,722.07 (4,262.02; 5,182.12)	1,672.25 (1,120.73; 2,223.78)

RE-EXAMINING THE SENSITIVITY OF HbA1c FOR DIABETES MELLITUS SCREENING

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Highlights

The sensitivity of HbA1c as a screening test for diabetes was significantly higher in this study, potentially due to the use of repeat testing to confirm the diagnosis of diabetes.

The results from this study support the inclusion of HbA1c as one of the screening tests for diabetes.

Background

HbA1c is one of the laboratory tests recommended by the American Diabetes Association (ADA) to screen for diabetes mellitus (DM), and is particularly suitable for individuals who are unable or unwilling to fast for a screening test. The aim of this study was to determine whether HbA1c would be useful to screen for DM in a real-world setting if ADA guidelines for repeat testing for confirmation of DM diagnosis is strictly adhered to.

Methods

A retrospective database study was performed using a chronic disease registry with data from three tertiary hospitals and nine large primary care clinics in Singapore. Demographic and laboratory data from 2005 – 2016 were extracted and analysed for adults not previously known to have DM, with HbA1c results, and at least two diagnostic tests for DM (fasting plasma glucose (FPG) or 2-h plasma glucose (2-h PG)) performed within 4 weeks after HbA1c determination.

The gold-standard diagnosis of DM was made when a combination of any two of the following diagnostic tests were positive: FPG test ⩾126 mg/dL (7.0 mmol/L) and 2-h PG test ⩾ 200 mg/dL (11.1 mmol/L). For adults with discordant results from two diagnostic tests, a third test was used for confirmation. If a third test was not available, these adults were assumed not to have DM.

Results

Data from 3928 adults were included in this study (Table 1). Most were Chinese (75.4%) and there was a nearly equal gender distribution (50.3% male, 49.7% female). The mean (± SD) age of the adults was 55.5 ± 12.6 years. The diagnosis of DM was confirmed in 203 (5.2%) adults.

The sensitivity, specificity, and area under the receiver operating characteristic curve for HbA1c at a threshold of 6.5% were 85.2%, 82.3%, and 0.914, respectively (Table 1). A higher sensitivity was found in younger and non-Chinese individuals.

In this study, the sensitivity of HbA1c as a screening test for DM was significantly higher than in earlier studies. One possible reason could be the lack of repeat testing to confirm the diagnosis of DM in many of those studies (as recommended by ADA guidelines), resulting in an over-diagnosis of DM. To test this hypothesis, another analysis where any one positive FPG or 2-h PG test within 4 weeks after the HbA1c measurement would constitute a diagnosis of DM was conducted. This resulted in an additional 441 diagnoses of DM, bringing the total number of diabetic adults to 644 (16.4%). In this additional analysis, the sensitivity and specificity of HbA1c were 49.4% and 84.3%, respectively. These results supported the hypothesis that the previously reported low sensitivity of HbA1c could be due to the lack of repeat testing to confirm the diagnosis of DM in earlier studies.

Conclusion

Our results show that using the ADA recommended HbA1c cut-off of 6.5% will correctly identify 85.2% of adults with DM. This is higher than reported in most other studies, which have found the sensitivity of HbA1c as a screening test for DM to be between 58.7% and 65.5%. One possible explanation for this apparent discrepancy could be the lack of repeat testing to confirm the diagnosis of DM in earlier studies. The present study provides additional, strong evidence to support the inclusion of HbA1c as one of the screening tests for DM.

Table 1: Adult demographics and the sensitivity, specificity, and area under the receiver operating characteristic curve (AUROC) of HbA1c for the diagnosis of diabetes mellitus (DM)

	No. adults	No. adults diagnosed with DM	Sensitivity (%)	Specificity (%)	AUROC
Overall	3928	203	85.2 (79.6, 89.8)	82.3 (81.0, 83.5)	0.914 (0.905, 0.923)
Gender					
Female	1954	166	86.7 (80.6, 91.5)	80.6 (78.7, 82.5)	0.917 (0.904, 0.929)
Male	1974	37	78.4 (61.8, 90.2)	83.8 (82.1, 85.5)	0.886 (0.871, 0.900)
Ethnicity					
Chinese	2963	110	83.6 (75.4, 90.0)	83.2 (81.8, 84.6)	0.905 (0.894, 0.915)
Malay	510	48	87.5 (74.8, 95.3)	80.7 (76.8, 84.2)	0.932 (0.908, 0.953)
Indian	455	45	86.7 (73.2, 95.0)	77.6 (73.2, 81.5)	0.909 (0.880, 0.935)
Age (years)					
<45	732	102	85.3 (76.9, 91.5)	85.9 (82.9, 88.5)	0.931 (0.911, 0.949)
45–54	995	62	90.3 (80.1, 96.4)	78.8 (76.0, 81.4)	0.929 (0.911, 0.944)
55–64	1256	27	77.8 (57.7, 91.4)	82.3 (80.0, 84.4)	0.893 (0.875, 0.910)
≥65	945	12	75.0 (42.8, 94.5)	83.5 (81.0, 85.8)	0.851 (0.826, 0.873)

Data show mean with 95% confidence interval in parentheses.

OPTIMIZING HOSPITAL CARE FOR SENIORS – EVALUATION OF THE FRAMEWORK FOR THE INPATIENT CARE OF THE FRAIL ELDERLY (FIRST YEAR RESULTS)

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Highlights

Implementing geriatric principles of care across general wards of the hospital is feasible.

Preliminary results suggest favourable findings, such as timely identification and referral of geriatric problems, as well as improved quality of care through a reduction in the incidence of pressure ulcers and use of restraints in intervention wards.

Introduction

While the elderly comprise a large proportion of hospitalized patients, acute hospitals often fall short of standards consistent with geriatric principles of care. Consequently, after hospitalization, many elderly patients experience functional decline. The Framework for the Inpatient care of the Frail Elderly (FIFE) program aims to enable Tan Tock Seng Hospital (TTSH) to provide senior-friendly care encompassing comprehensive assessments to identify the needs of elderly patients and provision of appropriate and timely interventions according to geriatric principles of care. The objectives of FIFE are to: (1) prevent or reduce complications (2) facilitate timely discharge and appropriate care transition with tight coordination across settings; (3) ensure that appropriate goals of care are set for elderly patients with advance disease.

A 5-year program, FIFE is currently in its 3rd year of implementation. The effectiveness of FIFE in terms of quality of inpatient care, reduction in complications, and reduction in unnecessary utilization of health services were assessed in this evaluation.

Components of FIFE

FIFE consists of 4 components: (1) development and deployment of Geriatric Resource Nurses (GRNs) and Ward Resource Nurses (WRNs); GRNs receive specialized training in geriatric nursing and serve as a resource for other nurses in the general wards, while WRNs are the frontline nurses who perform key roles of preventing complications from immobility, risk stratifying patients and coordinating early discharge planning; (2) a geriatric support network consisting of a mobile geriatric assessment team (GeriCARE team) led by Advanced Practice Nurses (APNs) and advised by a geriatrician who guides and supports WRNs; (3) regular education sessions for WRNs, and; (4) liaison with internal and external partners to facilitate care transitions.

Design of the Evaluation

A total of 20 general wards were included in the study. These were randomized as clusters into 10 FIFE and 10 control wards. The following outcomes were compared between the FIFE and Control wards: in-hospital falls, pressure ulcers and use of physical restraints; average length of stay (ALOS), timeliness of referral to allied health services, number of geriatric syndromes identified, proportion with discharge services, proportion of those who failed nutrition screening and referred to a dietician, and 7- and 30-day readmission rate. Data on falls, pressure ulcers and restraint use were collected at the ward level whereas the rest were collected at the individual level from case notes or administrative systems. As there were patients who were transferred between different ward types (FIFE, Control and non-study wards) during the period of hospitalization, only patients who remained at the same ward type throughout their hospital stay were included in the analysis. Interim analyses consist of unadjusted results including point and interval estimates of average differences as well as effect measures (Odds ratios – ORs, Relative risks – RRs).

Results

The results presented are for the first year of program implementation. There were 1,728 patients admitted to the FIFE and Control wards (864 per group). During their hospital stay, 311 patients were transferred across wards, with the maximum number of transfers being 4. Ultimately, 696 (80.6%) patients from FIFE and 721 (83.4%) from control wards were analysed. Age, gender, ethnicity and medical complexity (based on Charlson Comorbidity Index) were not different between the groups. Ward level results showed that the risk of pressure ulcers was 40% lower for FIFE patients (Table 1).

A greater proportion of FIFE patients were discharged to community hospitals (9.9% vs. 2.2%), and were detected to have at least one geriatric syndrome (5.2% vs. 2.5%). The number of days to an occupational therapist referral was shorter for FIFE patients (1.96 vs. 2.37 days). In addition, the referral rate to a dietician was higher for FIFE patients who failed nutrition screening (66.2% vs. 61.3%). Although ALOS was higher for FIFE (7.9 vs. 7.0 days), there was no significant difference in ALOS by specific discharge disposition (Figure 1). There were no significant differences in the average number of days to next admission, 7- and 30-day re-admission rates between FIFE and Control (153.6 vs. 155.9 days, 6.4% vs. 6.7% and 18.8% vs. 18.1%, respectively).

Table 1: Ward level results-Restraint use, falls, pressure ulcers

	FIFE		Control		RR (95%CI)
	N	n (%)	N	n (%)	
On restraints	4,625	118 (2.6)	4,739	152 (3.2)	0.88 (0.77, 1.01)
Fell	11,209	77 (0.69)	13,196	81 (0.61)	1.06 (0.90, 1.25)
With pressure ulcer	11,209	18 (0.16)	13,196	47 (0.36)	0.60 (0.41, 0.89)*

** Significant difference*

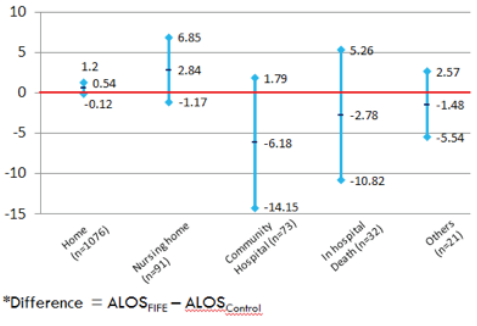

Figure 1: 1.95% CI of the difference* in ALOS, by discharge disposition

Conclusion

The interim results in this evaluation generally favour FIFE patients. Although ALOS was longer for FIFE, subgroup differences were not significant, with ALOS varying according to discharge disposition. Furthermore, some contamination of effects may have taken place due to challenges in isolating the intervention to the FIFE wards.

HOW MUCH DOES IT COST TO CARE FOR ADVANCED DEMENTIA PATIENTS AT THE END-OF-LIFE IN THEIR OWN HOMES?

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Highlights

The cost of delivering home-based palliative care for each advanced dementia patient at end-of-life is estimated to be approximately $SGD 4,436 from a health service provider's perspective.

A societal perspective of home-base palliative care costs for patients with AD, cost-effectiveness analysis of such services and a closer examination of home-based palliative care costs considering proximity to death are required in future studies.

Introduction

The prevalence of dementia is increasing. It is costly to care for patients with advanced dementia (AD). Additional to costs, the physical and emotional burden of care for caregivers is the highest for AD patients at the end-of-life (EOL). Hence patients with AD tend to receive institutionalised care at this stage. Importantly, most individuals prefer to be cared for, and to die at home. Optimum palliative care for AD at EOL requires all-hours, integrated care provided by a multidisciplinary team. Such a service, named Program Dignity (PD), which is delivered at patients' homes, was launched in Singapore in October 2014. The aim of this study is to estimate the average cost of providing home-based palliative care from the perspective of a health service provider.

Methods

A health service provider's perspective was used. Fixed and variable costs of PD were tabulated. Fixed costs consisted of overheads (establishment, administration, depreciation, non-clinical equipment, staff benefits, volunteer management) and variable costs comprised mainly manpower cost of clinical staff members (medical, nursing, counselling). Information on fixed costs was provided by the finance department of DPH. PD clinical manpower costs were computed by estimating the time spent on PD tasks multiplied by the frequency of these tasks and manpower unit costs. Categories of these tasks and examples are presented in Table 1. A recall-survey was used to estimate time allocated to these tasks. The frequency staff members performed these tasks were estimated using a clinical log database. Manpower unit costs were provided by the human resource department of DPH.

The mean cost of providing home-based palliative care was estimated by dividing the sum of fixed and variable costs by the total number of unique patients billed for PD every calendar month from April 2016 to March 2017 (1 calendar year) and the number of invoices each unique patient received. Patients were invoiced a PD bill each month if they had at least 1 home visit that month. It was assumed that the patient required home-based palliative care for the whole month and costs were assigned fully for the month. This enabled the estimation of the average cost of providing home-based palliative care per month.

Results

During the study period, fixed and equipment costs of PD amounted to approximately $SGD 249, 388. The corresponding manpower costs for the same period were approximately $SGD 589,056. The number and estimated duration of home visits and phone calls performed by medical and nursing staff members are reported in table 2. Other tasks that were accounted for were travelling time of 30 minutes each leg allocated to each home visit, weekly case conferences of 4 hours, and indirect care patient time of 30 minutes per direct patient care encounter. A total of 189 AD patients were billed from April 2016 to March 2017. These patients received an average of 4.78 (SD=3.75) invoices during this period. Administrative tasks like teaching, research, administrative meetings and quality improvement activities performed by clinical staff members were not costed for due to their ad-hoc nature. The cost of delivering home-based palliative care for each AD patient at EOL is conservatively estimated to be approximately $SGD 4,436 and the average cost per patient per month is approximately $928.

Table 1. Program Dignity tasks performed by staff members

Categories	Examples
Direct patient care	Home visits for assessment and treatment
	Patient-care-related phone calls
Indirect patient care	Travel
	Handovers to colleagues
	Inter-professional liaison
	Case notes documentation
Administrative tasks	Meetings
	Quality improvement activities
Others	Case conferences

Table 2. Program Dignity Medical and Nursing clinical encounters

		PD clinical staff members	
		Medical staff	Nursing staff
Home visits			
	Frequency	625	1600
	Estimated duration in minutes	75	90
Phone calls			
	Frequency	353	3247
	Estimated duration in minutes	15	10

Conclusions

The cost for home-based palliative care program for an individual AD patient at EOL was estimated from a health service provider's perspective. This amount was less than estimates from the United States. This difference could be resulting from using a societal perspective, differing EOL definitions, different cost estimation methods, like costing retrospectively from time of death versus cross-sectionally, or varying costs components included. Future studies should look into the cost of home-base palliative care for patients with AD from a societal perspective and the cost-effectiveness of such services. Also, a closer examination of home-based palliative care costs for more accurate cost estimates by considering proximity to death, as this factor can affect present results obtained using a cross-sectional methodology.

IS THERE SCOPE FOR A ROLE EXPANSION? – A SURVEY OF OPTOMETRISTS AND OPTICIANS IN SINGAPORE.

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Highlights

Singapore's ageing population has led to greater eye care demands.

Task-shifting from ophthalmologists to opticians and optometrists has been proposed to handle growing care demands.

This study highlights the need to increase the level of confidence of opticians and optometrists in screening and managing common eye conditions before a role expansion can be considered.

Background

In Singapore, the roles of Optometrists and Opticians are limited compared to their counterparts elsewhere. This study investigated their current roles, views on extended role, self-reported levels of primary eye care knowledge, needs for continuing professional education (CPE) and views on suitable modes for CPE.

Methods

Members of the Optometrist and Optician Board (OOB) of Singapore were invited via email to participate in an anonymous online survey. The survey covered the following areas: current scope of practice, self-rated primary eye care knowledge, confidence in screening and co-managing age-related ocular conditions such as cataract, chronic glaucoma, macular degeneration and diabetic minor eye conditions, CPE and referral patterns.

Results

A total of 237 optometrists and opticians completed the survey (response rate 30%). Their current roles were limited to diagnostic refraction (92%), colour vision assessment (65%), contact lens fitting and dispensing of spectacles. (62%) amongst others. Average self-rated primary eye care knowledge was 8.2 ± 1.4, score range 1-10 (1-Very poor, 10-Excellent). Self-rated confidence scores for screening for cataract, diabetic retinopathy, chronic glaucoma and age-related macular degeneration were 2.7 ± 1.5, 3.7 ± 1.9, 4.0 ± 1.0 and 2.7 ± 1.5 respectively (table 1). Approximately three-quarters of respondents felt that they should undertake regular CPE to improve their primary eye care knowledge. Blended learning (eLearning and traditional face-to-face lectures) (46.8%) was the most preferred mode for CPE delivery.

Table 1: Self-rated knowledge and confidence in co-managing eye conditions by optometrists' credentials.

Variables	Overall	Credentials (Mean ± SD)				p-value‡
	n=237	Diploma	Bachelors	Masters	Doctorate	
Self-rated primary eye care knowledge score‖	8.2 (1.4)	7.7 ± 1.6	8.5 ± 1.1	9.0 ± 0.7	9.0 ± 0.0	0.0001
Confidence in screening for eye conditions						
Cataract	2.7 (1.5)	3.2 ± 1.7	2.2 ± 1.0	1.8 ± 0.9	1.7 ± 1.2	0.0001
Diabetic retinopathy	3.7 (1.9)	4.4 ± 2.0	4.4 ± 2.0	2.7 ± 1.4	2.7 ± 0.6	0.0001
Chronic Glaucoma	4.0 (1.9)	4.6 ± 2.1	3.6 ± 1.6	3.2 ± 1.4	2.7 ± 0.6	0.0040
Age related macular degeneration	3.8 (1.8)	4.4 ± 2.0	3.3 ± 1.4	3.0 ± 1.4	2.7 ± 0.6	0.0001
Confidence in co-managing eye conditions in primary eye care set up with guidance from ophthalmologist						
Cataract	2.7 (1.7)	3.1 ± 1.8	2.3 ± 1.5	1.8 ± 0.8	2.3 ± 1.2	0.0001
Diabetic retinopathy	3.3 (1.8)	3.9 ± 1.9	3.0 ± 1.5	2.2 ± 1.1	2.3 ± 1.2	0.0001
Chronic Glaucoma	3.5 (1.9)	3.9 ± 1.9	3.2 ± 1.7	2.4 ± 1.1	2.3 ± 1.2	0.0060
Age related macular degeneration	3.4 (1.8)	3.9 ± 1.9	3.1 ± 1.6	2.4 ± 1.2	2.3 ± 1.2	0.0020

‖scale range 1 to 10. (1=very poor; 10=excellent); ‡Median test

Conclusion

Optometrists and opticians in Singapore represent a skilled, yet underutilized primary eye care provider. Though their self-reported primary eye care knowledge is high, their confidence in screening and co-managing chronic eye conditions is modest. Enabling them for an extended primary eye care role would require further training.

PROJECTS

HEALTH AND WELFARE ECONOMICS

DOES PREVENTING CHRONIC CONDITIONS INCREASE OR DECREASE LIFETIME COST OF HEALTHCARE UTILIZATION?

Palvannan R. K.

Highlights

Literature shows that lifetime healthcare costs may decrease if a non-fatal chronic disease is prevented, and may increase if fatal chronic conditions are prevented but the patient succumbs to costly conditions in years of extended life.

A mathematical model shows similar results. If the relative lifetime treatment to prevention cost is greater than the relative mortality risk of the chronic disease, there is a potential to reduce lifetime cost by further prevention (since the health system is spending more relatively). If not, further prevention of disease, may increase lifetime cost as the health system is already cost efficient, but this is worthwhile if additional efforts are cost effective.

Background

Prevention and delaying of chronic diseases are public health goals. Public health administrators may ask 'Do prevention efforts increase or decrease lifetime healthcare utilization cost of a person?' The evidence from scientific literature is mixed. (A) Lifetime healthcare utilization costs may decrease, if we are preventing relatively non-fatal diseases while the risk of other diseases remains the same. This is assuming the preventive interventions are not costly which may outweigh the savings. The following article in this report 'Lifetime direct medical cost of diabetes in Singapore' is an example. (B) Lifetime healthcare utilization costs may increase, if the disease prevented had fatal complications, which reduce treatment cost and mortality, increasing lifespan. However, during additional years of survival, the patient may succumb to other costly diseases, which can increase lifetime healthcare utilization cost. A mathematical model of chronic disease progression was built to understand the conditions under which lifetime cost may increase or decrease.

Methods

The disease progression model in Figure 1 shows 2 states of a chronic condition: healthy (H) and diseased (D). We can derive the relationship between the disease incidence risk (i), disease specific mortality risk (d) and all-cause mortality risk (m) on the lifetime cost of prevention on the healthy person (C_P) and lifetime treatment cost on the diseased person (C_T). Note that incidence and mortality risks may have units of %/year. For brevity, we will call the ratio of disease specific mortality risk to all cause mortality risk as the relative mortality risk of the disease.

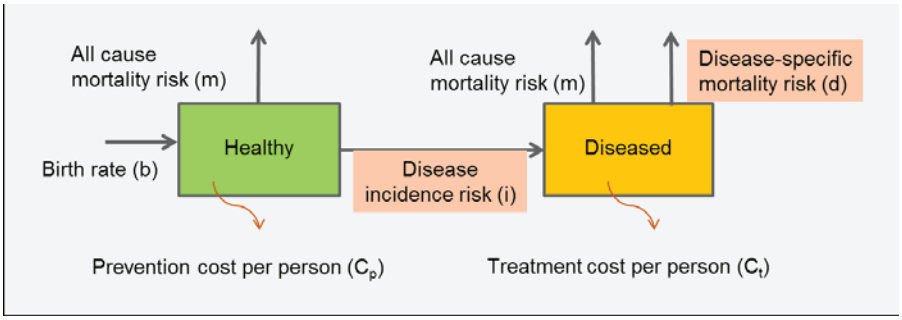

Figure 1: Healthy and diseased groups, risks of incidence, disease specific and all-cause mortality.

Results

At steady state, the time spent in healthy state (T_H), disease state (T_D) and the lifetime healthcare cost (LC) of a person is shown in Eqn 1-3. When we prevent or delay a chronic condition, we are reducing the incidence risk (i). And we want to see the effect of reducing incidence risk (i) on the lifetime healthcare cost (LC). We differentiate the lifetime healthcare cost (LC) with respect to the incidence risk (i) to get the rate of change, as shown in Eqn 4. When the rate of change is positive/negative, the lifetime cost can decrease/increase with a decrease in incidence risk, as shown in Eqn (5a) and Eqn (5b) respectively.

A. Eqn (5a) shows that if the ratio of incremental treatment to prevention cost is higher than the relative mortality risk, then there is excess expenditure relative to mortality outcomes. So efforts to reduce chronic disease incidence can decrease lifetime healthcare cost, if program cost of prevention is not large.

B. Eqn (5b) shows that if the ratio of incremental treatment to prevention cost is lower than the relative mortality risk, then currently it is cost efficient, so any further efforts to reduce chronic disease incidence will increase lifetime healthcare cost. However, this is worthwhile if the efforts are cost-effective against a willingness to pay threshold criterion.

$$T_H = \frac{1}{i+m} \quad (1)$$

$$T_D = \frac{i}{(d+m)(i+m)} \quad (2)$$

$$LC = C_P T_H + C_T T_D \quad (3)$$

$$\frac{d(LC)}{d(i)} = \frac{(C_T - C_P)m - C_P d}{(d+m)(i+m)^2} \quad (4)$$

$$\frac{\text{Treatment cost} - \text{Prevention cost}}{\text{Prevention cost}} > \frac{\text{disease mortality risk}}{\text{all cause mortality risk}} \quad (5a)$$

$$\frac{\text{Treatment cost} - \text{Prevention cost}}{\text{Prevention cost}} < \frac{\text{disease mortality risk}}{\text{all cause mortality risk}} \quad (5b)$$

Conclusion

The mathematical model shows the relationship between cost structure and mortality outcomes for a chronic condition. The impact of preventive healthcare on lifetime healthcare utilization cost depends on how the current levels of spending on disease prevention and treatment compare with how fatal the disease complications are compared with all-cause mortality risk outcomes. This estimation can identify chronic diseases where the health system can be spending more on preventive interventions.

LIFETIME DIRECT MEDICAL COSTS OF TYPE 2 DIABETES MELLITUS IN SINGAPORE

Dr Gary Ang Yee, Dr Yap Chun Wei, Alex You Xiaobin

Highlights

Lifetime direct medical costs of type 2 diabetes mellitus (T2DM) in Singapore, previously unknown, was estimated to be approximately $SGD 70,110 – 132,506.

Delaying the onset of T2DM may lead to lower lifetime medical spending, especially when the target population is younger.

Background

The mean annual direct medical cost of type 2 diabetes mellitus (T2DM) in Singapore was estimated to be approximately $SGD2, 034 using a prevalence-based approach. However, the direct medical cost of T2DM over the lifetime of an individual in Singapore is unknown. The aim of this study was to determine the lifetime direct medical cost attributable to T2DM and provide estimates of potential savings if T2DM can be prevented or delayed.

Methods

An incidence-based approach was used which looked at the amount of direct medical costs over a person's lifetime from when the disease first occurs until death. A retrospective study was performed by extracting demographic, comorbidity, and utilization data on adults living in the central region of Singapore, and alive as of 31 December 2015. For T2DM patients, they must have at least 2 diabetes consultations in both 2014 and 2015 and for non-T2DM patients they must have non-diabetes consultations in both 2014 and 2015.

Subsequently, the lifetime direct medical cost of non-T2DM patients was predicted with a regression model using predictors included in another study1, Gender- and age-specific annual survival rates of T2DM and non-T2DM patients were obtained and survival-adjusted yearly expenses over the estimated remaining life span were added to obtain lifetime direct medical costs. The difference between T2DM and non-T2DM patients was attributed to additional direct medical costs related to T2DM.

Results

A total of 39,128 T2DM patients and 144,860 non-T2DM patients were included in this study. The characteristics of the study population by diabetes status are shown in Table 1. The survival probability by gender and age between T2DM patients and non-T2DM patients is shown in Table 2. Unsurprisingly, T2DM patients have higher

mortality compared to non-T2DM patients irrespective of age or gender. The excess lifetime medical expenses for T2DM patients were $SGD132,506; 108,589; 83,326; and 70,110 when the age of T2DM diagnosis was 40, 50, 60, and 65 years, respectively.

Conclusion

T2DM is associated with substantially higher lifetime direct medical costs, despite the lower life expectancy of T2DM patients. Delaying the onset of T2DM, especially in the young, may lead to lower lifetime direct medical expenses. If prevention costs can be kept sufficiently low, effective T2DM prevention efforts would likely lead to a reduction in long-term direct medical costs.

Table 1: Patient characteristics

Characteristics	**Type 2 Diabetes Mellitus**	
	Yes (n=39,128)	No (n=144,860)
Age in years, mean (SD)	67.3 (11.4)	55.2 (17.3)
Gender, n (%) Male	19,127 (48.9)	65,445 (45.2)
Ethnicity, n (%)		
Chinese	31,176 (79.7)	120,210 (83.0)
Malay	2,462 (6.3)	9,575 (6.6)
Indian	4,366 (11.2)	9,799 (6.8)
Others	1,124 (2.9)	5,276 (3.6)
Selected comorbid conditions, n (%)		
Dyslipidemia	38,318 (97.9)	58,272 (40.2)
Hypertension	33,024 (84.4)	45,220 (31.2)
Cancer	1,973 (5.0)	3,773 (2.6)

Table 2: Survival of T2DM patients and non-T2DM patients

Age	**T2DM patients**		**Non-T2DM patients**	
	Male	Female	Male	Female
40	1.000000	1.000000	1.000000	1.000000
50	0.940578	0.960590	0.984755	0.990798
60	0.872989	0.915499	0.942492	0.965828
70	0.750243	0.831935	0.839507	0.908196
80	0.519058	0.659269	0.600370	0.743053
90	0.176913	0.306420	0.238564	0.383603

COST-EFFECTIVENESS OF INPATIENT MONITORING FOR PAROXYSMAL ATRIAL FIBRILLATION AMONG ISCHEMIC STROKE PATIENTS

Dr Sun Yan and Dr Lee Sze Haur[1]

[1] Department of Neurology, National Neuroscience Institute, Tan Tock Seng Hospital Campus

Highlights

Inpatient monitoring of paroxysmal atrial fibrillation among hospitalized ischemic stroke patients in Singapore is cost-effective compared to outpatient monitoring and no monitoring.

Continuous inpatient monitoring up to 9 days is the most cost-effective strategy at 77% probability, given a willingness to pay of SGD$50,000.

Background

Detection of paroxysmal atrial fibrillation (pAF) is important for optimal prevention of recurrent stroke. However, the cost-effectiveness of inpatient (IP) monitoring compared to outpatient monitoring and no monitoring is unclear in the Singapore context. This study aimed to bridge this gap.

Methods

Markov decision modeling was applied to model disease transition from ischemic stroke to stroke recurrence to death. The transition cycle was 1 year. A cohort of 10,000 hospitalized ischemic stroke patients was simulated and followed up for 20 years. Microsimulation was applied to handle the uncertainty of parameters and great heterogeneity of patients. Model parameters of disease transitions were estimated through primarily collected patient data. Cost parameters were derived from the financial database of a particular hospital. Transition probabilities, costs and utilities were sampled from distributions, instead of using constant values. Incremental cost effectiveness ratios (ICERs) as measured by cost per QALY gained were used to compare cost-effectiveness of different monitoring strategies..

Results

The median age of the simulated cohort was 67 years old. 95% of them died within 20 years. The estimated prevalence of pAF among these patients was about 15%. The cost and effectiveness were approximately S$34,621 and 5.71 QALYs for 1-day IP monitoring; S$34,688 and 5.70 QALYs for 24h outpatient monitoring; and SGD$34, 575 and 5.68 QALYs for no pAF monitoring.; The ICER of IP monitoring compared to no monitoring was SGD$1, 683 per QALY gained. Outpatient monitoring was dominant.

Conclusion

Inpatient pAF monitoring is cost-effective compared to outpatient monitoring and no monitoring. Continuous IP monitoring up to 9 days is the most cost-effective strategy at 77% probability, given a willingness to pay of SGD$50,000. The study provides healthcare providers evidence that hospitalized ischemic stroke patients should undergo continuous IP monitoring of pAF.

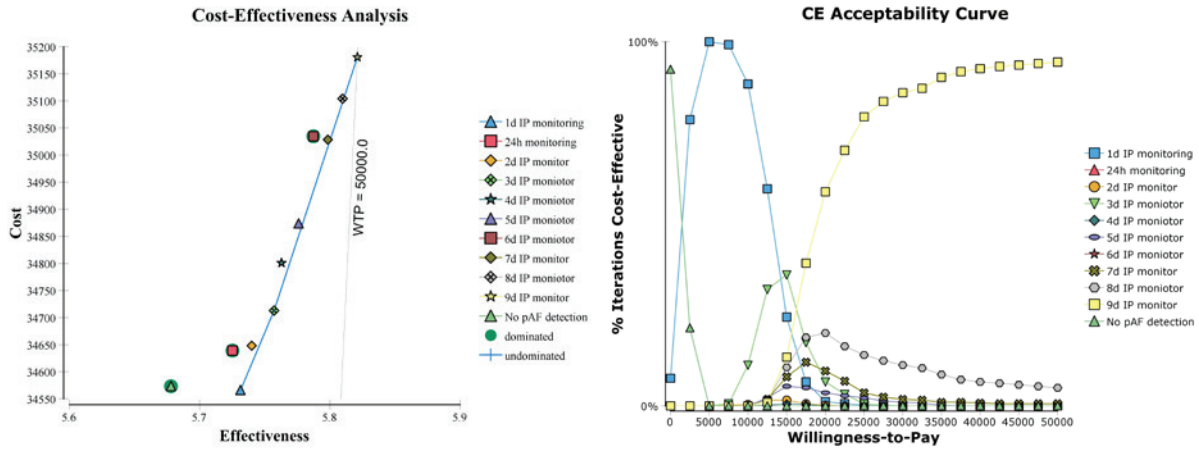

Figure 1: Results of cost effectiveness analysis for various pAF monitoring strategies: (a) cost effectiveness analysis; (b) CE acceptability curve at various willingness-to-pay

PROJECTS

RESEARCH DESIGN AND METHODOLOGIES

DISEASE TRAJECTORY FINDER AND ITS APPLICATION FOR DIABETES PATIENTS

Alex You Xiaobin, Dr Yap Chun Wei, Dr Gary Ang Yee

Highlights

The effects of risk factors and intervention variables, such as body mass index, HbA1c and drug use on diabetes complications and mortality were quantified in this study.

An R-shiny analytic tool was developed to calculate and visualize the trajectory of complication progression and mortality.

Background

Predicting the trajectory (Figure 1) of disease progression for an individual is useful for the management of diabetes. The objective of this study is to create an Artificial Intelligence (AI) machine that can conduct prescriptive analytics to assist the decision making of clinicians in the care of diabetes patients. Compare to existing diabetes risk calculators, the objectives of this AI were to achieve:

- Prediction and visualization of trajectories of complications and mortality
- Quantification of effects of interventions
- A prototype that can be deployed and generalized to other diseases

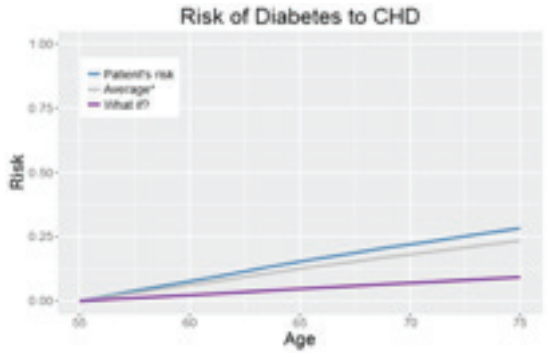

Figure 1: Risk of Diabetes patient progress to Coronary Heart Disease (CHD)

Methods

The Disease Trajectory Finder (DTF) was developed using data from 143,786 diabetes patients who visited the National Healthcare Group (NHG) in 2014. More than 4,300 variables, including patients' demographics, comorbidities, complications, utilizations, laboratory test results, diagnoses and medications were used for the development of the DTF. Markov Random Field, Generalized Linear Mixed Effects and Lasso Regressions were applied to train the AI for mortality and disease progression for seven diabetes complications such as renal, cardiovascular, cerebrovascular and retinal complications (Figure 2).

ANALYTIC ARCHITECTURE

The analytic system architecture that was designed was built with R. The architecture consolidated the four dimensions in big data analytics: domain knowledge, data ETL (data extraction, transformation and load) machine learning and front end development. It aimed to achieve systematicity, flexibility and reproducibility. Currently, the DTF analytic system architecture includes the following 5 modules (Figure 3). The DTF was trained to model the trajectories from diabetes to seven complications and mortality.

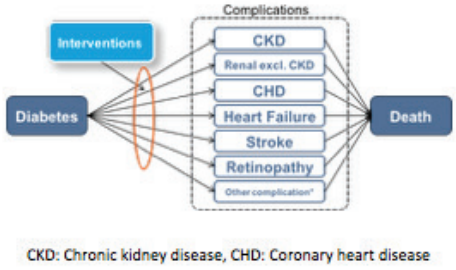

Figure 2: DTF Overview

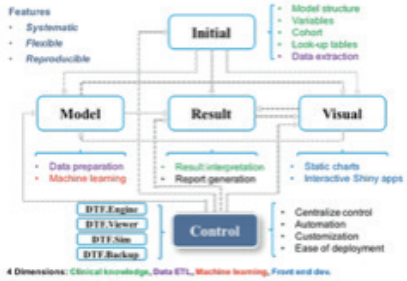

Figure 3: DTF Analytic Architecture

RESULT

The AI achieved a concordance index (AUC) of 84.6% and a lift of 6.1 over randomized sampling. For the rest of the seven complications, the AI had an average AUC of 71.7% and an average lift of 5.1.Higher body mass index (BMI) is associated with higher risk of chronic kidney disease, and other renal complications, with the estimated odds of BMI (27.5-32.4kg/m2), BMI (32.5-39.9kg/m2) and BMI (above 40kg/m2) on mortality being 1.46, 1.64 and 1.51 respectively. Higher HbA1c is associated with chronic kidney disease, other renal complications, coronary heart disease and heart failure. The estimated odds of HbA1c levels of 6-7, 7-8.5 and above 8.6 (unit: mmol/l) on mortality were 1.43, 2.42 and 4.43 respectively. Lastly, medication use was significantly associated with all complications.

Table 1. BMI, HbA1c and Drug effect on diabetes complications

	CKD	Renal excl. CKD	CHD	Heart Failure	Stroke	Retinopathy	Other compl.
BMI(Below 18.5)	1.51	1.66	1.67	(NS)	(NS)	1.47	1.42
BMI(18.5-22.9)	1.69	1.70	1.91	(NS)	1.40	1.74	1.57
BMI(23-27.4)	1.85	1.84	1.59	(NS)	(NS)	1.74	1.60
BMI(27.5-32.4)	1.94	2.06	1.45	(NS)	(NS)	1.53	1.63
BMI(32.5-39.9)	2.13	2.21	1.43	(NS)	(NS)	1.46	1.78
BMI(above 40)	2.30	2.18	(NS)	(NS)	(NS)	(NS)	1.54
HbA1c<=5	(NS)	(NS)	(NS)	(NS)	(NS)	(NS)	(NS)
HbA1c5.1-6	1.44	1.50	(NS)	0.53	(NS)	(NS)	(NS)
HbA1c6.1-7	1.79	1.81	0.70	0.55	(NS)	(NS)	(NS)
HbA1c7.1-8.5	2.41	2.38	0.77	0.54	(NS)	(NS)	(NS)
HbA1c>8.6	3.41	3.55	(NS)	0.75	(NS)	1.63	(NS)
Drug score	4.04	3.31	6.05	181.31	4.50	10.57	2.01

CONCLUSION

An AI machine, the DTF was developed that can perform prescriptive analytics on seven diabetes complications and mortality. The interactive feature of the Shinyapp is useful for guiding appropriate interventions in circumstances when decision variables (e.g. BMI) are changed, as the resultant changes in the disease progression trajectory can be easily presented. The analytic system architecture for building the DTF is a prototype that can be generalized to study the progression of other diseases.

OPTIMAL TREATMENT STRATEGIES FOR HbA1c CONTROL FOR TYPE 2 DIABETES MELLITUS PATIENTS USING A MARKOV DECISION PROCESS

Dr Meng Fanwen, Dr Sun Yan, Dr Melvin Khee Shing Leow[1, 2, 3, 4]

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Highlights

A Markov decision process model was developed to determine optimal treatment decisions for HbA1c control for type 2 diabetes mellitus.

Treatment strategies derived from numerical studies of the Markov decision process model could remarkably increase the total expected QALYs gained, compared with a conventional Markov model.

Background

A central focus of managing diabetes is HbA1c control which measures the level of glycation of hemoglobin and hence reflects the integrated regulation of blood glucose levels over time. This study aims to determine optimal treatment decisions for HbA1c control for type 2 diabetes mellitus (T2DM) patients.

Methods

Data of HbA1c levels, diabetes-related key risk factors (Table 1) and dispense of medication to T2DM patients seen at National Healthcare Group Polyclinics (NHGP) and Tan Tock Seng Hospital (TTSH) during 1 January 2008 to 31 December 2015 were extracted. A Markov decision process (MDP) which is an optimisation model of discrete-stage, sequential decision making in a stochastic environment was used to create a mathematical optimisation model. This MDP optimisation model was developed to determine the optimal treatment policy concerning medication management for controlling blood glucose of T2DM patients over a long-term treatment period. The performance of this model was assessed by comparing the Quality Adjusted Life Years (QALYs) gained with QALYs gained estimated with a conventional Markov model informed by current clinical guidelines.

In the MDP optimisation model, the treatment planning period was discretized into 3-month treatment intervals. Patient health states comprised of 10 HbA1c ranges (Table 2) and an absorb state consisting of 6 major diabetes-related complications (ischemic heart disease, myocardial infarction, congestive heart failure, stroke, limb amputation, and blindness). Three common medications for HbA1c control were considered (metformin, sulfonylureas, and insulin). At the start of each 3-month treatment interval, the selection of medication initiation or not was actioned. The decision criterion in this model was to maximise the total expected QALYs gained over the treatment planning horizon.

Transition probabilities from the present health state with certain treatment selections to another health state were calculated based on transition probabilities among different patient health states without medications and the probabilities of diabetes-related complications at any HbA1c state if any of the 3 medications considered

was initiated. The former was obtained from the existing scientific literature and the latter was estimated using proportional hazards Weibull regression based on UKPDS (United Kingdom Prospective Diabetes Study) risk model1 related to diabetes complications. Lastly, numerical in silico experiments were conducted by considering different scenarios of key risk factors of diabetes-related complications with various treatment planning periods (20, 25 and 30 years).

Results

The results show that (1) the derived treatment policy obtained from numerical experiments using the MDP optimisation model could increase potential QALYs gained by as much as 0.27, compared with the conventional Markov model; (2) the improvements in QALYs gained for T2DM patients who are smokers or previous smokers are higher than non-smokers; (3) the improvements in QALYs gained are higher for males than females; (4) the improvements in QALYs gained for T2DM patients with HbA1c levels of 9% and above are higher than those with lower HbA1c levels; (5) the improvements in QALYs gained for older patients are higher than younger ones; (6) the longer the treatment period, the greater the QALYs gained and the higher the improvements in QALYs gained when the MDP optimisation model was compared with the Markov model; (7) female patients would initiate insulin at lower HbA1c levels than males under the same health states.

Conclusion

The proposed Markov decision process model would help clinicians make evidence-based treatment decisions for T2DM patients.

Table 1: Mean and standard deviation of key risk factors

Characteristics	Overall	Female	Male
Age at diagnosis	56.71(12.28)	57.84(12.50)	55.44(11.90)
Total cholesterol level (mmol/L)	5.34(1.17)	5.45(1.16)	5.22(1.17)
High density cholesterol level (mmol/L)	1.26(0.35)	1.36(0.36)	1.16(0.31)
Systolic blood pressure (mmHg)	134.59(17.68)	135.39(17.79)	133.64(17.51)
Glycated hemoglobin (HbA1c) percentage (%)	7.88(1.83)	7.78(1.70)	7.99(1.95)
Body mass index	26.68(4.81)	27.13(5.16)	26.16(4.32)

Table 2: HbA1c states

State	1	2	3	4	5	6	7	8	9	10
HbA1C range(%)2	<6	[6, 6.5)	[6.5, 7)	[7, 7.5)	[7.5, 8)	[8, 8.5)	[8.5, 9)	[9, 9.5)	[9.5, 10)	>=10

PREDICTING BED WAITING TIME WITH EMPIRICAL BED OCCUPANCY RATE

Teow Kiok Liang, Dr Kelvin Bryan Tan[1]

[1] Ministry of Health, Singapore

Highlights

A complex array of factors like the dynamics of bed demand and capacity, and patient overflow management affect bed waiting time (BWT).

A 'bending' of BWT at higher Bed Occupancy Rate (BOR) was shown when a BWT-BOR function based on empirical data was fitted. This indicates potential intervention by hospital management at high BOR.

Background

Bed waiting time (BWT) commences when an emergency department physician deems a patient requires an acute hospital admission until the patient is admitted at an inpatient ward. BWT is a surrogate measure for patients' access to inpatient care. Bed allocation is dependent on bed availability, affected by 'time' and 'space' factors. The 'time' factor refers to the variation of admissions and discharges by day of week and time of day. 'Space' factor refers to the matching of patients to beds by medical specialty and payment class, cohorting requirements for infectious control, and use of temporary beds. The bed management unit has to balance between BWT and obtaining the most appropriate bed, especially during surges. BWT is significantly affected by bed occupancy rate (BOR) when other factors are kept consistent. Hence the primary aim was to propose a mathematical link between these two factors. The secondary aim was to estimate additional BWT without additional interventions at high BOR (approximately > 92%).

Methods

One year data of daily mean BOR, BWT (median and 95th percentile) for 5 hospitals was analysed. Guided by the Queueing principle, the following expression was proposed to fit BWT (w) against BOR (r):

$$W = \frac{a + br + cr^2}{1 - r}$$

The effect of additional interventions during high BOR was investigated using data from Hospital-5 (H5). The same expression was used and a curve fitted only on days in 'normal' BOR range (approximately 50% of the daily operations). The curve was then extrapolated to the higher BOR levels to examine differences between the fitted and empirical function. These functions could be used to estimate the change in BWT due to change in admission number or average length of stay, assuming other factors were held constant.

Results

The fitted median and 95th percentile BWT curves are shown in Figure 1 to Figure 2. Hospitals had different BWT, and different relative ranking between median and 95th percentile BWT at the same BOR. This suggests that each hospital might have its own constraints and priorities. Figure 3 and 4 suggest that at higher BOR, Hospital-5 might have introduced interventions to 'bend' BWT down, especially for patients with longer BWT (95th percentile). This 'bending' would probably come at a 'cost' such as higher patient overflow to different medical specialties.

Conclusion

BWT prediction is a challenging issue because of the stochastic nature of bed requests and patient discharges, and the many considerations in bed allocation. Using queueing principle, a function that links BOR and BWT was mapped. In addition, it was shown that hospital management probably intervened to reduce BWT at higher BOR.

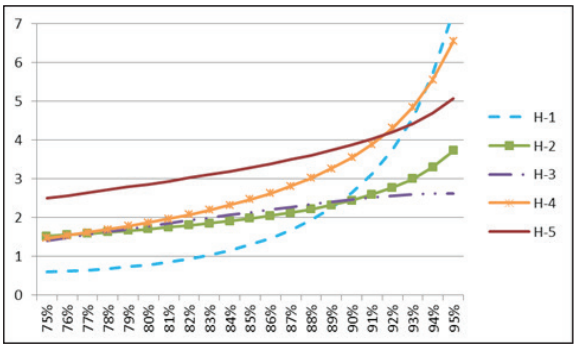

Figure 1: Fitted median BWT (in hours) against (BOR) for 5 hospitals

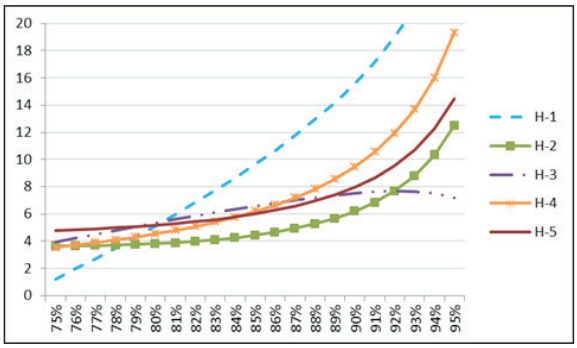

Figure 2: Fitted 95th percentile BWT (in hours) against (BOR) for 5 hospitals

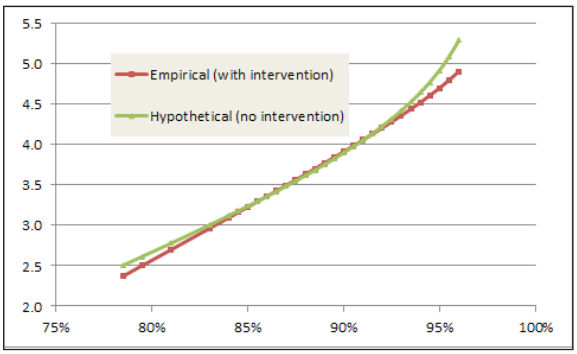

Figure 3: Empirical (with intervention) and Hypothetical (no intervention) median BWT (in hours) against (BOR) for Hospital-5

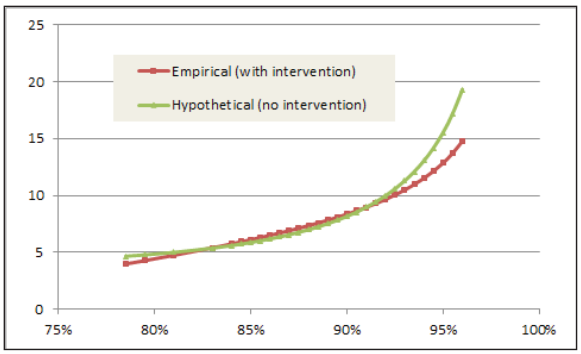

Figure 4: Empirical (with intervention) and Hypothetical (no intervention) 95th percentile BWT (in hours) against (BOR) for Hospital-5

LONGITUDINAL ANALYSIS OF PATIENT FIRST VISITS AND REPEAT VISITS AT SPECIALIST OUTPATIENT CLINICS

Dr Zhu Zhecheng

Highlights

A longitudinal analysis to estimate the number of appointment slots needed per new patient case is more accurate when compared to the conventional, cross-sectional first visit/repeat visit ratio.

Background

Computing a first visit/repeat visit (RV/FV) ratio is a common and straightforward proxy used to estimate the number of appointment slots needed for each new patient referred to a specialist outpatient clinic (SOC).

The equation is: RV/FV = Total RV/total FV (within a certain period, e.g., a calendar year)

However, this approach has limitations. Notably, it is a cross-sectional approach, and is subjected to left and right censoring issues. Hence, it may be inaccurate. The objective of this study is to obtain more precise estimates of appointment slots needed per new patient at SOCs.

Methods

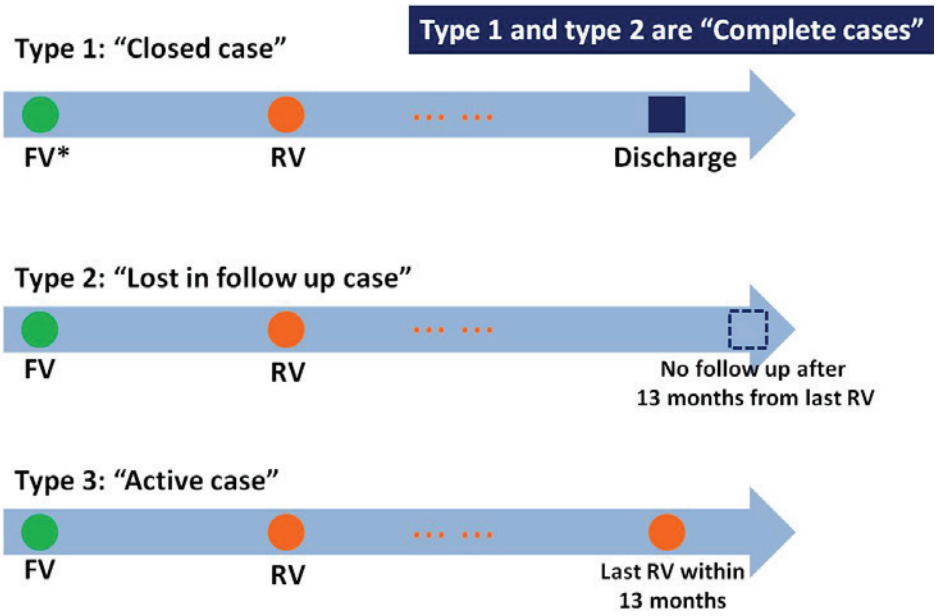

Figure 1. Three types of SOC cases

Results

Figure 2 shows the retention rate of new patient cases of a particular SOC for 10 years based on longitudinal tracking and case categorisation ("complete" versus "active"). Retention rate in the first six years (2010-2016) was calculated using available observed data. Retention rate from the seventh year onwards was extrapolated by curve fitting. The resulting fitted curve can be used to estimate the expected number of slots needed for each new patient case within a specific timeframe.

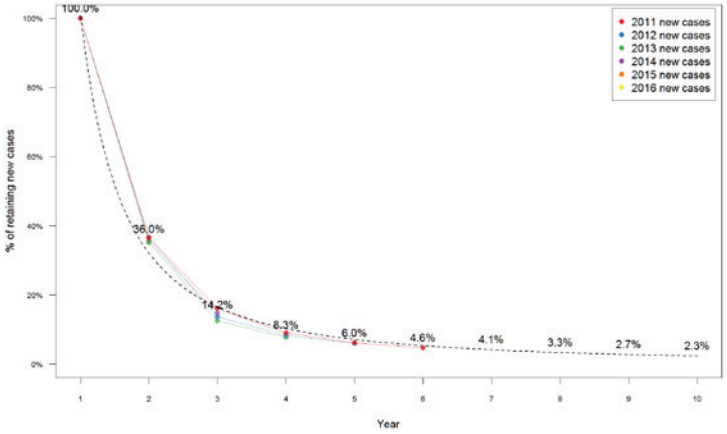

Figure 2. Retention rate of new cases over time

Figure 3 illustrates an interactive chart of visit slot calculation under different settings. Available filtering parameters include SOC department, visit type and referral type. For instance, it can be used to estimate the number of appointment slots needed for subsidised visits referred from National Healthcare Group Polyclinics to the Tan Tock Seng Hospital Ophthalmology department. It is observed that the RV/FV ratio ("crude RV/FV ratio") underestimates the number of appointment slots needed per new patient case, compared to the 20-year extrapolated value.

Figure 3. Interactive chart of visit slot calculation

Conclusion

The estimation of appointment slots needed for "active cases" is complex and cannot be comprehensively accounted for using the conventional RV/FV ratio.

Compared to the RV/FV ratio, a longitudinal analysis of FVs and RVs at SOCs can provide more precise estimates of appointment slot numbers needed for each new patient case. Results will assist with accurate projection of future patient appointment slot numbers and capacity planning of SOCs resource use.

WHY DOES A REDUCTION IN DISEASE INCIDENCE NOT LEAD TO A RESULTANT DELAY IN DISEASE ONSET?

Teow Kiok Liang, Palvannan R.K., Dr Zhu Zhecheng

Highlights

Disease incidence rates and onset (time-to-event) are ways to examine disease progression.

This study explores the paradox of how a reduction in disease incidence may not result in an observed delay in disease onset in computer simulation models.

Background

When modeling the effect of an intervention on a disease, two similar measures may be used. They are a delay of disease onset, or a decrease in the incidence rate (or transition probability from healthy to diseased state). The results of these two measures should be congruent. However, in some computer simulations, no difference in mean time-to-delay may be observed though an incidence rate reduction has been included in the models. This study seeks to explain this paradox.

Methods

Concepts of probability and exponential distribution were used to explain the relationship between transition probabilities and mean-time-to-event of a disease. Examples were illustrated to explain the apparent paradox.

Results:

If 1-year transition probability or incidence rate = p, then mean-time-to-event of a disease, t = 1/p in a scenario using an infinite observation period.

For example, if p1 = 2%, then t1 = 1/ (2% per year) = 50 years.

If this yearly probability is reduced to, p2 = 1.6%, then t2 = 62.5years. Hence it can be said that a reduction from 2% to 1.6% in disease incidence rates delays disease onset by 12.5 years.

A more realistic scenario is when the observation period is finite or truncated due to life expectancy and a more probable timeframe during which a disease can develop.

Two scenarios with 20% reduction in incidence rate were constructed using different baseline incidence rates at 2% and 5% (Table 1 and Table 2 respectively). A truncated exponential distribution was used for different time horizons (10 years to infinity) [1].

Table 1: Baseline incidence rate of 2%

	Mean-time-to-event (year)		
Observation period	**Baseline (p=2%)**	**Improved (p=1.6%)**	**Difference**
infinite	50.0	62.5	12.5
200	46.3	54.0	7.7
100	34.3	37.2	2.9
50	20.9	21.7	0.8
30	13.5	13.8	0.3
20	9.3	9.5	0.1
10	4.8	4.9	0.0

Table 2: Baseline incidence rate of 5%

	Mean-time-to-event (year)		
Observation period	**Baseline (p=2%)**	**Improved (p=1.6%)**	**Difference**
infinite	20.0	25.0	5.0
200	20.0	25.0	5.0
100	19.3	23.1	3.8
50	15.5	17.2	1.6
30	11.4	12.1	0.7
20	8.4	8.7	0.3
10	4.6	4.7	0.1

It can be seen that the observable gains in mean-time-to-event years, or the duration in a disease-free state, becomes lower as the observation period gets shorter, and when the baseline incidence rate is lower.

This means that when a disease is uncommon (low incidence rate), it will take on average many years before one will develop this disease. Hence when the observation period is truncated, the full impact of the reduction in incidence rates will not be apparent, and the simple "reciprocal" law does not apply.

Conclusion:

The paradox of an unchanged time-to-event measure from a reduction in disease incidence rate is the result of low incidence of the disease and a truncated observation period. In such a scenario of low disease incidence rates, "survival analysis" concepts like risk-ratios, rate-ratios (ratio of person-time incidence rates), healthy life-years gained (HLY, which combine number of people without disease and duration-with-disease), lifetime costs associated with a disease, or a time-to-event comparison should be used to model the intervention for the two groups.

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7. **Ge L, Ong RJ, Yap CW, Heng BH.** Social isolation and loneliness and their relationships with depressive symptoms - a population-based study. PLOS One 2017; 12(8): e0182145.

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9. Goh LML, Wong AXY, **Ang YG,** Tan ASL. Effectiveness of nutrition education accompanied by cooking demonstration. British Food Journal 2017; 119(5): 1052-66.

10. Joshi A, Cox EK, Sedano MJ, Punke EB, Lee RTC, Maurer-Stroh S, **Kaur P,** Ng OT, Garg H. HIV-1 subtype CRF01_AE and B differ in utilization of low levels of CCR5, Maraviroc Susceptibility and potential N-glycosylation sites. Virology 2017; 512: 222-33.

11. Lin LK, **Sun Y, Heng BH,** Chew DEK, Chong PN. Medication adherence and glycemic control among newly diagnosed diabetes patients. J Open Diabetes Research & Care 2017; 5(1): e000429.

12. **Pereira MJ,** Johnston V, Straker LM, Sjøgaard G, Melloh M, O'Leary SP, Comans TA. An Investigation of Self-reported Health-related Productivity Loss in Office Workers and Associations with Individual and Work-related Factors Using an Employer's Perspective. Journal of Occupational and Environmental Medicine 2017; 59(7): e138-44.

13. **Saxena N, George PP, Teo KW, Tan WS, Ng C, Heng BH,** Yeo CY, Anthony P, Tan C, Low KY, Wu V, Ali NB, Chong MS. Evaluation of an Integrated Primary Care-led Dementia Shared Care Program in Singapore – an effectiveness and cost-effectiveness study. Geriatrics & Gerontology International 2018; 18(3): 479-86.

14. **Teow KL,** Tan KB, Phua HP, **Zhu ZC.** Applying Gravity model to predict demand of public hospital beds. Operations Research for Health Care 2017.

15. Wee XT, Ho LM, Ho HK, Lee JY, **Yap CW,** William H, Chan LCE, Tay HC, Goh CEM, Tan DS. Incidence of thromboembolic and bleeding events in patients with newly diagnosed nonvalvular atrial fibrillation: An Asian multicenter retrospective cohort study in Singapore. Clinical Cardiology 2017; 40(12): 1218-26.

16. **Yap CW, Ang YG,** Quek TPL, Heng BH, Chew DEK. Re-examining the sensitivity of glycated hemoglobin to screen for diabetes mellitus. Journal of Diabetes 2017.

AWARDS

Conference Presentation Awards

Singapore Health & Biomedical Congress 2017

Singapore Young Investigator Award (Health Services Research) - Gold

Reuben Ong
Montreal Cognitive Assessment: Regression based normative data of an Asian Population

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Singapore Health & Biomedical Congress 2017

Oral Presentation Award (Education Research) - Silver

Nakul Saxena
Virtual Reality Environments for Health Professional Education: A systematic review

HSOR TRAINING COURSES

17th Healthcare Operations Research Appreciation Course

February 2017

Speakers:

Dr Zhu Zhecheng
Dr Meng Fanwen
Palvannan R.K
Teow Kiok Liang

The 2-day course will introduce Operations Research concepts with healthcare applications. It will focus on building intuition around theory, walk through illustrative examples and show insights from results that will support and inform decision making. Case studies will show applications of OR techniques as well as the process of problem solving during the engagement with the decision maker.

Healthcare Analytics Foundation Course

May & November 2017

Speakers:

Alex You Xiaobin
Dr Joseph D. Molina
Dr Yap Chun Wei
Dr Sun Yan

This course is designed for administrators, nurses or allied healthcare professionals who have interest in using healthcare data for assisting decision making as well as improving healthcare delivery or patient care.

Big Data Analytics for better healthcare

May & November 2017

Speakers:

Alex You Xiaobin
Dr Joseph D. Molina
Dr Yap Chun Wei
Dr Sun Yan
Dr Zhu Zhecheng

This course is designed for active clinicians or allied healthcare professionals who have interest in or are involved in using big data for improving healthcare delivery or health outcomes; for better patient management or healthcare decision support.

Introduction to Health Services Research

August 2017

Speakers:

Teow Kiok Liang
Dr Yap Chun Wei
Dr Sun Yan
Dr Pradeep Paul George
Michelle Jessica Pereira
Dr Joseph D. Molina

This one-day course will provide an overview of the basic concepts, rationale, general and discipline-specific methods used in carrying out health services research. It will include practical exercises, case studies and examples of real-world HSR projects. The course is designed to cover a broad range of topics at an introductory level. The main objective is to familiarize participants with a repertoire of methods that are often encountered in the conduct of health services re-search. It is hoped that students can use the lessons and material gleaned from this course as a springboard to explore these and other methods in depth for their own efforts in applied research. Essentially an appreciation course, it may also serve as a preparatory module for those interested in attending other more in-depth courses on specific HSR topics.

CONFERENCE PRESENTATIONS

JULY 2017 — **51st Singapore-Malaysia Congress of Medicine & 12th Singapore Public Health and Occupational Medicine 2017, Singapore**

1. **Ang YG,** Yap CW, You XB
   Lifetime costs of Type 2 Diabetes Mellittus in Singapore

2. **Kaur P,** Saxena N, Heng BH, Zhu ZC
   Obesity and chronic disease progression amongst patients with varying cardiovascular risks

3 **Kaur P,** Saxena N, Heng BH, Zhu ZC
   Are you empowered to take care of your health?

Asia Pacific Hospice Care Conference, Singapore

4. **Tan WS - Invited speaker**
   Building the Evidence for Care: Demystifying Economic Evaluation in Palliative Care Studies

5. **Tan WS - Invited speaker**
   Palliative Care in the Community: Integrated Palliative Care - Working as a Community

AUG 2017 — **Operations Research Applied to Health Services 2017, Bath, UK**

6. **Palvannan RK**
   Segmentation of primary care patients by annual cost

OCT 2017 — **Singapore Health & Biomedical Congress 2017, Singapore**

7. **Tan WS - Invited speaker**
   Population Health Plenary Session 4 "Economics of Integrating Palliative Care

8. **Yap CW - Invited speaker**
Population Health Plenary Session 4
"What is the current health and social status of our Central Region population? – results from population health index study"

9. **Ang YG,** Yap CW
The effects of continuity of care in primary care on hypoglyacemic episodes requiring emergency department visit or hospital admission

10. **Ge L,** Yap CW, Ong RJ, Heng BH
Social isolation, loneliness and their relationships with depressive symptoms: a population-based study

11. **Ge L,** Yap CW, Ong RJ, Heng BH
Assessing frailty using health survey data and its association with health-related quality of life among older adults in Singapore

12. **Kaur P,** Lim YH, Heng BH
A Preliminary Assessment of the Psychometric Properties of the Patient Activation Measure amongst Working Adults in Singapore

14. **Ong RJ,** Ge L, Yap CW, Heng BH
Montreal Cognitive Assessment: Regression based normative data of an Asian Population

15. **Saxena N,** Kyaw BM, Vseteckova J, Nikolaou CK, Posadzki P, George PP, Divakar U, Masiello I, Kononowicz AA, Zary N, Car LT
Virtual reality environments for health professional education: A systematic review

OCT 2017 — 17th Alzheimer's Australia Biennial National Dementia Conference, Melbourne, Australia

16. **Ong RJ,** Ge L, Yap CW, Heng BH
Montreal Cognitive Assessment: Regression based normative data of an Asian Population

OCT 2017 — Society for Medical Decision Making (SMDM) Annual Meeting, Pittsburg, USA

17. **You XB,** Ang YG, Yap CW
NHG-Disease Trajectory Finder (DTF) and its application for diabetes patients

THE TEAM

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

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

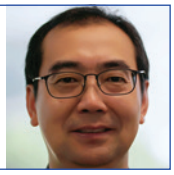
3. **Dr Ang Yee Gary**
MBBS, MPH, Dip (Family Med), GDMH,
Dip (Family Practice Dermatology)
Associate Consultant

4. **Ge Lixia**
BMed (Nursing), MSc (Physiology)
Research Analyst

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

6. **Li Ruijie**
MSc (Occupational Therapy)
Principal Research Analyst

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



8. **Michelle Jessica Pereira**
BPhty (Hons Class 1), MPhty
(Sports Physiotherapy)
Senior Research Analyst

9. **Dr Nakul Saxena**
BPharm, PhD (Epidemiology)
Principal Research Analyst

10. **Palvannan R. K.**
BEng, MEng (Industrial Engineering)
Operations Research Specialist

11. **Palvinder Kaur**
BSc (Biomedical), MSc (Public Health)
Senior Research Analyst

12. **Dr Pradeep Paul George Gunapal**
BSMS, MSc (Epidemiology)
Principal Research Analyst

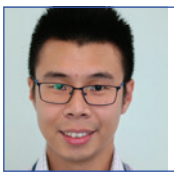
13. **Reuben Ong**
BA (Psychology) (Magna Cum Laude)
Research Analyst

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

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

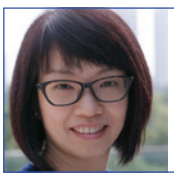
16. **Teow Kiok Liang**
BEng (Electrical Engineering), MSc
(Industrial & Systems Engineering)
Operations Research Specialist

17. **Dr Yap Chun Wei**
BSc (Hons) (Pharm), PhD
Principal Research Analyst
(Data Science)



18. **You Xiaobin Alex**
BEcon (Statistics), MSc (Statistics)
Statistician (Data Science)

19. **Dr Zhu Zhecheng**
MSc (Information Engineering), PhD
(Industrial & Systems Engineering)
Operations Research Specialist



20. **Tan Hwee Ling Jasmine**
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