HEALTH SERVICES & OUTCOMES RESEARCH 2016

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The evidence behind your decisions

FOREWORD

HSOR continued to contribute towards NHG and national strategies during the year. This was possible with (a) an alignment towards vision/mission of NHG and HSOR; (b) a clarity and unity of purpose in a multi-disciplinary team; and (c) a culture of innovation in health services research methods.

During the year, the department worked closely with clinical stakeholders and senior management to provide strong evidence on the gravity, cost and future burden of diabetes and its complications in the Central Region, in support of the Ministry of Health's 'War on Diabetes' – a mission of *providing best available evidence for decisions and translation*. Today healthcare institutions are engaging community, partners and patients at all levels to reduce the incidence rate of diabetes and its complications.

We continued to evaluate the effectiveness of our regional Population Health programmes in achieving their goals. Data, information and new knowledge are key to Population Health Management programme planning and evaluation. In 2014, we had assembled a Regional Health Database for analysis. Three years on, it has been enhanced, augmented and is a critical resource for multiple studies and application of data and decision science methodologies. It has been instrumental in defining NHG's population health segments spanning across the *living well* to *living with illness, complex care, frail* and *dying well*. The database was also enriched with mental health data completing the physical and mental spectrum of diseases. The department's growth in healthcare data and decision science capability was possible with a supportive management for deployment of new knowledge generated. Beyond the NHG, contributions included national infrastructural planning of primary care, new acute and community hospitals.

The year also marked a number of '*firsts*' for NHG: (i) started developing a population health index to measure baseline population health in Central Region, and for future evaluation; (ii) customised and deployed a productivity growth index to benchmark our healthcare institutions' productivity growth with that in developed countries; and (iii) initiated use of an activation measure among staff in NHG HQ, a key driver of health behaviour change and workplace climate.

We seek sustainability through our twin missions of *advancing knowledge and building capacity*. Towards these, four members of the team are undertaking PhD programmes; a microsimulation study of trajectories in diabetes progression has received an MOH-HSR grant; an inaugural Healthcare 'Big Data' Analytics course for informatics analysts was developed and delivered.

This report looks back at some of the contributions in 2016. Enjoy reading.

Prof Philip Choo
Group Chief Executive Officer
National Healthcare Group

HSOR@NHG

The evidence behind your decisions

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.

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PROJECTS

POPULATION HEALTH & MANAGEMENT OF DISEASES

IMPACT OF MEDICATION NON-ADHERENCE ON GLYCEMIC CONTROL AMONG NEWLY DIAGNOSED DIABETES PATIENTS

Dr Sun Yan, Dr Lin Lee-Kai, Dr Heng Bee Hoon, Dr Daniel Chew Ek Kwang, Dr Chong Phui-Nah

BACKGROUND

Adherence to pharmacotherapy is a critical aspect of medical treatment, particularly the treatment of chronic conditions such as diabetes. Despite the importance of adherence, medication non-adherence is a serious problem, with the World Health Organization noting that the average non-adherence rate is 50% among those with chronic illnesses. Medication non-adherence can have negative consequences for the patients, the provider, the physician, and the sustainability of the healthcare system.

There are two objectives of this study: the first is to study the prevalence and the associated risk factors of the medication non-adherence; the second is to examine the impact of initial medication non-adherence on glycemic control and healthcare utilisation among newly diagnosed diabetes patients in Singapore.

METHOD

This is a retrospective cohort study. Patients newly diagnosed with diabetes mellitus and with random or fasting glucose being normal in previous year in the National Healthcare Group from 2005 to 2010 were included in the study. Patients were followed up for the first two years from their first medication prescribed for measuring medication adherence; and for another three years for investigating outcomes of glycemic control, emergency department visit, and hospitalisation. Proportion of Days Covered (PDC) was calculated for each study subject as a measure of medication adherence. Medication adherence was grouped into six categories ($PDC< 20\%$, $20\% \leq PDC < 40\%$, $40\% \leq PDC < 60\%$, $60\% \leq PDC < 80\%$, $80\% \leq PDC < 100\%$, and 100%).

The primary outcome of this study is glycemic control and the secondary outcomes are hospitalisation and emergency department visit. Glycemic control was measured by the change of HbA1C, which is defined as the average HbA1c in the three years of outcome period subtracted by the HbA1c tested at or before the first medication dispense (or baseline HbA1c). Emergency department visits and hospitalisations were recorded as dichotomous variable: whether a patient had emergency department visit due to any cause in the three years outcome period, and similarly whether a patient had any hospital admission due to any cause in the same period.

The risk factors of being medication non-adherence were identified by logistic regression. The adjusted association between medication adherence and glycemic control was examined by linear regression with change in average HbA1c level as the dependent variable. The association between medication adherence and emergency department visit or hospitalisation was investigated by logistic regression.

RESULTS

Of the 2,463 study patients, 35.0% (95%CI: 33.1%-36.9%) were in the non-adherence group ($PDC<80\%$). 445 patients had PDC equal to 100%. The average age of all study patients was 57 years old (sd = 10). There were fewer males than females (40% vs. 60%) study patients. After adjusting for other covariates by logistic regression, being Indian, or patients with shorter years of hypertension or dyslipidemia, or patients with higher HbA1c level at baseline were associated with higher risk of being medication non-adherent.

Both the crude and adjusted changes of HbA1c level from baseline to outcome period are shown in Figure 1. Average HbA1c level increased for all 6 adherence groups. The biggest changes were seen in the lowest two adherence groups. After adjusting for patients' demographics,

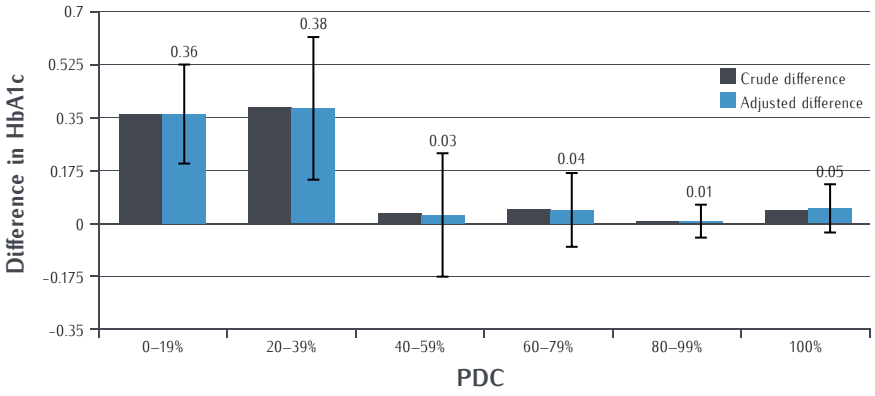
the changes of HbA1c were not statistically significant for the four higher adherence groups (PDC 40-100%). However, the two lower adherence groups had significant differences of 0.36(95% CI: 0.20-0.53) and 0.38(95% CI: 0.14-0.62) over two years respectively.

Non-adherent patients (PDC < 80%) were 73% and 75% more likely to have emergency department visits and hospitalisation compared to adherence patients (PDC ≥ 80%). Using the group of PDC=100% as reference, the lower the adherence the higher the probability of emergency department visit and hospitalisation except the lowest adherence group. After adjusting for all other covariates, all other adherence groups except that of 80%≤PDC<100% had higher risk of hospital admission or ED visit during the outcome period compared with the reference group (PDC=100%) with odds ratios significantly higher than 1 (p=0.04). (Figure 2)

CONCLUSIONS

The medication adherence in the early stage of diabetes is important for maximizing the effectiveness of pharmaceutical therapy. Health policies or interventions targeting the improvement of medication adherence among newly diagnosed diabetes patients are in need.

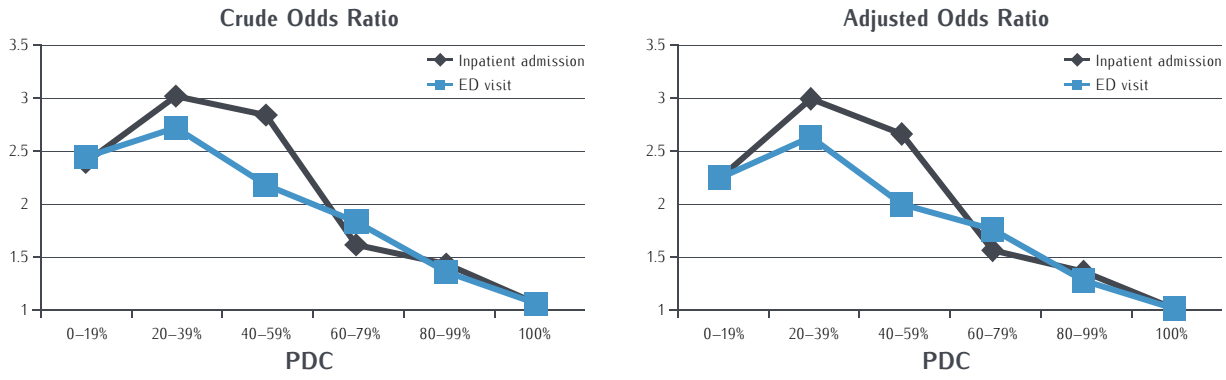
Figure 1 – Crude and adjusted HbA1c change by medication adherence group (PDC)



* By linear regression, controlling for age, age square, gender, race, and marital status.

* Error bar representing 95% confidence interval.

Figure 2 – Crude and adjusted odds ratios of hospitalisation or ED visit by medication adherence group (PDC)



*By multiple linear regression controlling for age, age square, gender, race, marital status, years in hypertension, years in dyslipidemia, and baseline HbA1c level * Reference group: PDC = 100%

RESULTS FROM THE NATIONAL HEALTHCARE GROUP STAFF ACTIVATION MEASURE

Palvinder Kaur, Alex You Xiaobin, Dr Heng Bee Hoon

BACKGROUND

Self-management is a strategy applied to address the challenges of maintaining behaviours required to manage and prevent chronic illnesses. Patient activation describes the knowledge, skills and confidence required to manage one's own health and healthcare needs. Evidence increasingly demonstrates that individuals who are highly activated are more likely to have better health outcomes, maintain healthy lifestyle behaviours and have lower healthcare utilisation and costs. The objective of this study was to investigate the relationship of activation levels with health and lifestyle characteristics of working adults.

METHODS

To assess the level of activation, the Patient Activation Measure (PAM-13) questionnaire was used. The PAM-13 and other health and lifestyle related questions were administered via an online survey to employees of the National Healthcare Group Headquarters (NHG HQ) from May to August 2016. Health and lifestyle questions included self-reported height and weight, average minutes of exercise in a week, average hours of sleep per night and interest to make a health-related behaviour change. Employees were also asked to rate their well-being on a 0 to 10 scale, with 10 being the best state possible. Body Mass Index (BMI) was computed from self-reported height and weight.

As per protocol, responses to the PAM-13 were scored and categorised into one out of four progressively higher levels of activation. The four levels of activation describe an individual's capacity of health management. Individuals in (a) Level 1 tend to be passive recipients of care, (b) Level 2 lack the knowledge and confidence to self-manage health and healthcare, (c) Level 3 have started to take action however may lack the knowledge and confidence to perform some health-related behaviour changes and (d) Level 4 have high self-management abilities but may require additional support during times of stress or health crisis. Descriptive analysis was used to describe baseline characteristics of employees stratified by levels of activation. Logistic regression was used to determine factors associated with weekly exercise of≥150 minutes.

RESULTS

Out of 1201 NHG HQ employees, 784 (65%) employees responded to the online survey. Of all respondents, 716 (91.3%) employees with valid PAM-13 scores were analysed. Proportions of staff in the four levels of activation are as follows, Level 1: 9.4%; Level 2: 16.5%; Level 3: 61% and Level 4: 13.1%. Positive correlations were observed between levels of activation and outcomes such as weekly exercise≥150 minutes, recent health behaviour change and well-being ratings. No significant correlations were seen between levels of activation and age, job band, BMI, hours of sleep per night, proportion of employees who had ≥2 days of medical leave and proportion of employees with chronic diseases. In the logistic regression model adjusting for job band, BMI, chronic diseases and departments, factors that were significantly associated with weekly exercise of ≥150 minutes were activation levels, gender and age (Table 2). Employees in Level 4 activation had 5.7 times more odds to exercising ≥150 minutes weekly as compared to referent group employees in Level 1.

CONCLUSIONS

This study suggests that the exercise is associated with activation levels. Levels of activation using the PAM-13 can potentially predict the level of support employees need to manage their health. It can also be used to evaluate the effectiveness of workplace health promotion programmes.

Table 1 – Baseline characteristics of NHG HQ staff categorised by Levels of Activation

Characteristics	Level 1 (n=66)	Level 2 (n=118)	Level 3 (n=434)	Level 4 (n=94)	P value
Age band (years) (col %)					
<30	31.3	26.3	35.7	39.4	
30-44	46.3	59.3	42.3	40.4	
45-59	20.9	11.9	18.1	18.1	
≥60	1.5	2.5	3.9	2.1	0.11
Job band (col %)					
1-2	41.8	33.1	43.7	27.7	
3A	25.4	28	29.5	34	
3B	13.4	23.7	15.3	21.3	
≥4A	19.4	15.3	11.4	17	0.05
BMI, mean (SD)	23.4 (5.2)	23.8 (5.7)	23.8 (5)	22.7 (3.3)	0.24
Proportion of employees who exercised ≥150 minutes per week (col %)	10.5	11	22.6	31.2	**<0.001**
Hours of sleep per night, mean (SD)	6.2 (1.1)	6.3 (1)	6.5 (1)	6.6 (1)	0.08
Proportion of employees who recently made a health-related behaviour change (col %)	13.5	16.1	30.2	48.1	**<0.001**
Self-rated well-being score, mean (SD)	6.1 (1.2)	6.4 (1.5)	6.9 (1.4)	7.6 (1.2)	**<0.001**
Proportion of employees with ≥2 days of medical leave per year (col %)	71.9	76.3	69.2	65.2	0.33
Proportion of employees with self-reported chronic disease (col %)	44.8	32.2	30.7	28.7	0.22

Medical Leave is a combination of sick leave and sick leave without medical certificate

Table 2 – Factors associated with exercising ≥150 minutes per week

Factors	Odds Ratio^	95% Confidence Interval
Levels of Activation		
Level 1	1	
Level 2	1.4	0.5-3.8
Level 3*	3.4	1.4-8.0
Level 4*	5.7	2.2-14.7
Gender		
Female	1	
Male*	2.3	1.4-3.8
Age Group		
30-44	1	
<30*	1.7	1.0-2.9
45-59*	2.8	1.6-5.0
≥60	1.2	0.4-4.3

^Adjusted for job band, BMI, self-reported chronic disease and departments

*significant, p<0.05

OBESITY AND CARDIOVASCULAR DISEASE RISK IN SINGAPORE — REAL WORLD EVIDENCE FROM A LARGE ADMINISTRATIVE DATABASE

Palvinder Kaur, Dr Nakul Saxena, Dr Heng Bee Hoon, Dr Zhu Zhecheng

BACKGROUND

Obesity is an established risk factor for many chronic conditions. The Singapore 2010 National Health Survey found that one in nine residents was obese (BMI ≥30kg/m^2), with 23% of the respondents at high risk of developing cardiovascular diseases (CVD). This study aims to (1) study the disease progression among patients living in central region Singapore with cardiovascular risk based on Asian BMI and (2) determine independent effects of the Asian BMI cut-offs on the risk of diabetes.

METHODS

Data for this study was taken from the Regional Health System (RHS) database. Height and weight data for patients with complete information for 7 consecutive years (2008 -2014) were included in the analysis (n=22,882).

Patients were grouped into CVD risk categories based on Asian BMI. The categories were: low risk (BMI 18.0 to 22.9 kg/m^2), moderate risk (BMI 23.0 to 27.4 kg/m^2), high risk (BMI 27.5 to 32.4 kg/m^2) and very high risk (BMI ≥32.5 kg/m^2). Initial CVD risk was defined as CVD risk based on average BMI readings in year 2008. To study the disease progression for patients with varying CVD risks, patients were segmented into six mutually exclusive disease states based on prevalence of chronic disease and their complications. The categories are as follows:

1. No known chronic disease
2. At risk of developing chronic disease (pre-diabetes or obese)
3. One chronic condition (asthma, chronic obstructive pulmonary disease (COPD), diabetes, hypertension, dyslipidemia, osteoporosis)
4. Two or more chronic conditions (at least two of the following: asthma, COPD, diabetes, hypertension, dyslipidemia, osteoporosis)
5. Chronic conditions with complications (at least one of the following: chronic kidney disease (CKD stage 3 and above), diabetes with complications, stroke, transient ischemic attack (TIA), congestive heart disease (CHD), heart failure, spine fracture and hip fracture)
6. Patients with cancer

Logistic regression analysis was used to determine the association of CVD risk categories and risk of having diabetes.

RESULTS

Disease progression of patients by initial CVD risk categories

Tables 1a-d show how patients with different initial CVD risk progressed to one of the six disease states in the following year. Among patients with low CVD risk, 45% progressed to either 'at risk' (13%), developed one chronic disease (27%), developed two or more chronic diseases (1%), were diagnosed with chronic disease with complications (3%) or developed cancer (2%) (Tables 1a-d). Comparing patients who were 'at risk' in each CVD risk category, 13%, 20%, 27% and 28% progressed to the next stages respectively (excluding developing cancer) (Table 1a-d). The risk of disease progression increased with increasing BMI. Similar trends were seen for the other disease states.

Association of CVD risk categories and diabetes
With reference to patients in the low CVD risk category, patients in the moderate, high and very high risk categories had an odds ratio of 1.78 (95% CI: 1.60 to 1.98), 2.84 (95% CI: 2.51 to 3.21) and 3.99 (95% CI: 3.30 to 4.82) for having diabetes after adjusting for age, gender and ethnicity. The risk of having diabetes increased with progressively higher CVD risk categories.

CONCLUSIONS

Public health strategies to achieve and maintain optimal BMI are critical in reducing chronic disease burden and disease progression. Such strategies are likely to have a significant impact on the prevalence of chronic diseases attributable to excess body weight.

Table 1a-d – Disease progression of patients by initial CVD risk categories within 1 year

1a) Low CVD Risk Category YEAR 0	Year + 1					
	No known chronic	At risk	One chronic condition	2+ chronic conditions	Chronic with complication	Develop cancer
No known chronic	55%	13%	27%	1%	3%	2%
At risk		87%	10%	2%	1%	1%
One chronic condition			89%	8%	2%	1%
2+ chronic conditions				92%	7%	1%
Chronic with complication					99%	1%

1b) Moderate CVD Risk Category YEAR 0	Year + 1					
	No known chronic	At risk	One chronic condition	2+ chronic conditions	Chronic with complication	Develop cancer
No known chronic						
At risk		79%	13%	5%	2%	1%
One chronic condition			86%	11%	2%	1%
2+ chronic conditions				91%	8%	1%
Chronic with complication						

1c) High CVD Risk Category YEAR 0	Year + 1					
	No known chronic	At risk	One chronic condition	2+ chronic conditions	Chronic with complication	Develop cancer
No known chronic						
At risk		73%	15%	8%	5%	0%
One chronic condition			78%	18%	4%	0%
2+ chronic conditions				88%	11%	0%
Chronic with complication					99%	1%

1d) Very High Risk Category YEAR 0	Year + 1					
	No known chronic	At risk	One chronic condition	2+ chronic conditions	Chronic with complication	Develop cancer
No known chronic						
At risk		72%	18%	6%	3%	1%
One chronic condition			84%	14%	2%	0%
2+ chronic conditions				90%	9%	1%
Chronic with complication					99%	1%

THE IMPACT OF OBESITY ON YEARS OF LIFE LOST USING STRUCTURAL EQUATION MODELLING AND HEALTHCARE BIG DATA

Alex You Xiaobin, Dr Nakul Saxena

BACKGROUND

Higher obesity is generally associated with shorter life expectancy. However, some studies with a short follow-up have shown a protective effect of obesity against mortality. The true effect of obesity towards life-expectancy is hard to understand due to the complex paradoxical mechanism: obesity increases the risk of developing chronic diseases that leads to a shortening of life expectancy; on the other hand, obesity decreases when patients suffer from chronic diseases. To understand the relationship between obesity and life expectancy, a long follow-up period is required or appropriate adjustment of the longitudinal pattern of obesity must be made. This study aims to determine the years of life lost (YLL) due to obesity in Singapore by applying Structural Equation Modelling (SEM) on multiple-source large scale healthcare administrative databases.

METHOD

In total, 41,893 patients who had attended National Healthcare Group Polyclinics (NHGP) and died during 2005-2016 (mean age at death: 73.9 years) were extracted from a Regional Health Systems database to approximate the mortality rates. Their BMI (unit: kg/m^2) histories were tracked as a measure of obesity and were categorised into four groups (<18.5, 18.5-24.9, 25-29.9, 30-34.5 and 35+ corresponding to underweight, normal, overweight, obese and severe obese respectively). To adjust for the hidden trends of BMI, a Mixed Effect Model was applied to the 6.9 million BMI records to adjust the BMI by demographic characteristics, and presence of chronic conditions, end of life factor (EoL) and individual random effect. The individual random effect takes unobserved variables (such as smoking) into account. By introducing the individual effect, the model performs well in isolating the individual effect while preserving the BMI longitudinal pattern.

With regard to each BMI record, the BMI reading was taken as the outcome variable, age at examination was taken as the random effect and the rest of the confounders were taken as the fixed effect. An EoL factor takes into account the weight loss within the last 500 days before death (approximately 18 months). An SEM was applied to study the association between the life-expectancy and the BMI adjusted by the demographic characteristics, and presence of chronic conditions as well.

RESULTS

EoL factor

The EoL weight loss is a significant trend in the mixed effect model—on the average a 2.06 BMI loss occurs to the EoL patient within 500 days approaching death. Figure 1 shows approximately 40,000 trajectories (each trajectory represents the BMI trend of a patient before death).

BMI longitudinal pattern

Since the administrative database lacks BMI records of healthy people, the mean estimation by age is biased—the BMI is high for patients who are less than 50 years. The mixed effect model adjusts this bias and achieves a lower estimation of BMI. The Mixed Effect Model shows that with adjustment, the patients' average BMI increases before 65 years, reaches the highest value of 25.3, and then constantly decreases afterwards.

BMI effects on YLL

By adjusting the BMI, the SEM shows the effect of obesity on YLL: compared to the reference group (adjusted BMI 18.5-25), the severe obese group had the highest YLL with

Figure 1 – BMI trajectories before death

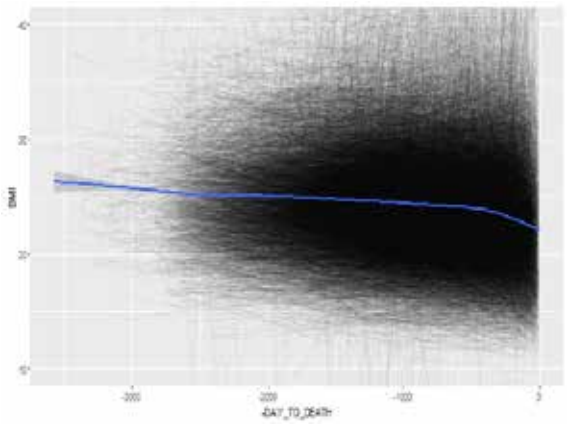
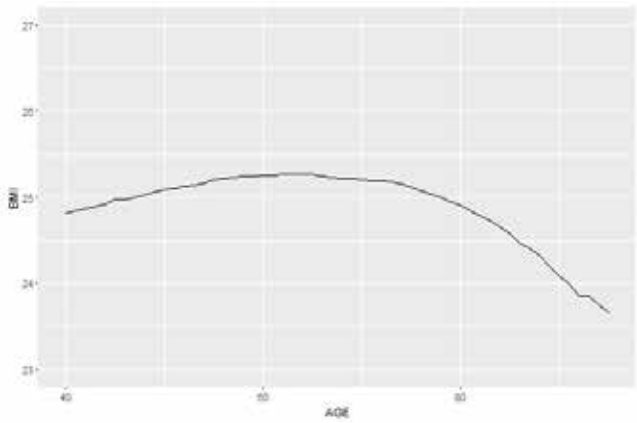


Figure 2 – BMI longitudinal pattern: BMI vs age



2.82 years (95% CI: 2.35-3.29 years); both the overweight and obese has significant impact on YLL, but less than Severe Obese. The effect of underweight is not significant. Table 2 shows the effect of BMI on LE.

Table 1 – Random effects

Random effect	Chi. square	Chi.DF	Pr(>|z|)
Individual Effect	459,025	1	0.00
Age	2,318	1	0.00

Table 2 – BMI effect on LE

Variable	Coef.	Std. Error	95% CI		Pr(>|z|)
			low	up	
Underweight (<18.5)	0.67	0.42	-0.15	1.50	0.11
Overweight (25-30)	-0.41	0.13	-0.66	-0.16	0.00
Obese (30-35)	-0.93	0.16	-1.24	-0.61	0.00
Severe obese(>=35)	-2.82	0.24	-3.29	-2.35	0.00

The significant confounding factors are listed in Table 3 as below. The effect of each variable on YLL is adjusted by the average age at death of the death cohort.

Table 3 – Confounding factors

	Coef.	Adj. Coef.	Std. Error	95% CI		Pr(>|z|)
				low	up	
(Intercept)	70.43	73.91	0.2	70.1	70.8	0.00
Gender (Female)						
Male	-2.86	-	0.1	-3.1	-2.6	0.00
Ethnicity (Chinese)						
Indian	-3.60	-	0.2	-4.0	-3.2	0.00
Malay	-4.69	-	0.2	-5.0	-4.4	0.00
Others	-3.27	-	0.3	-3.9	-2.7	0.00
MediFund	-5.44	-	0.2	-5.8	-5.1	0.00
Asthma	1.29	-2.18	0.2	0.8	1.7	0.00
Diabetes	-3.01	-6.48	0.1	-3.2	-2.8	0.00
Lipid	1.21	-2.26	0.2	0.9	1.5	0.00
Hypertension	4.43	0.96	0.2	4.1	4.7	0.00
AF	3.16	-0.31	0.1	2.9	3.4	0.00
Stroke	2.04	-1.43	0.1	1.8	2.3	0.00
CKD	4.98	1.51	0.1	4.7	5.2	0.00
CHD	0.87	-2.6	0.1	0.6	1.1	0.00

CONCLUSION

Our study confirms the association between obesity and reduction of life expectancy. The EoL weight loss is significant with a 2.06 loss during the 500 day period before death. The BMI longitudinal pattern should be well adjusted when studying the relationship between survival or life expectancy and obesity. The estimated YLL due to obesity will support the public health recommendation for adults to keep a check on their weight especially in Asia where cut off points for BMI are lower than western countries.

PROJECTION OF AGE RELATED DISABILITY BURDEN

Palvannan R.K.

BACKGROUND

To guide disability service and residential home care planning, we estimate future burden of disability. We focus on age related disability and estimate distribution of physical functional status now and in future (2030). As population level functional status data is unavailable, we model using different sources.

METHOD

We suggest 2 methods: (A) disability due to 'constant age specific rate' model, (B) disability in 'proximity to death' model.

A. Constant age specific rate model

Figure 1 – Increasing life expectancy in Singapore, but age of onset of disease is same.

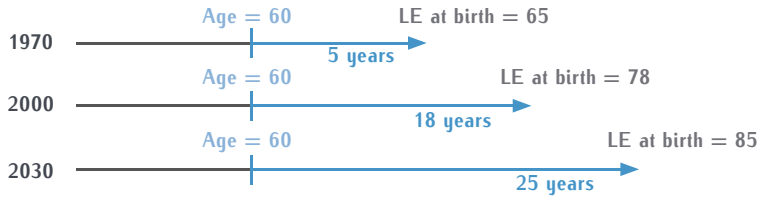


Figure 1 shows life expectancy at birth had increased due to public health interventions reducing infant mortality rate. Older population's conditional life expectancy has increased (and increasing) due to medical developments (e.g. reducing cardiovascular deaths) with a growing elderly segment. Assuming that the age of onset of a (disabling) disease is the same over different birth cohorts and time, the burden of disability is projected to increase. The National Survey of Senior Citizens report has cross sectional data of elderly and functional status. Using current, future population statistics and constant age specific rates from this survey we project the functional status distribution in 2030.

B. Proximity to death model

But studies have shown that proximity to death drives cost, and not age. So we assume that disability onset is driven by proximity to death. Gill et.al. (NEJM, 2010) longitudinal study on 'Trajectories of disability in last year of life' is a data source. It is a prospective study following a group of reasonably healthy elderly and their disability level until death. Figure 2 shows the disability trajectories among those who died (n=383). It monitored the disability level till death and ascertained their 'disability associated death' cause (i.e. advanced dementia not pneumonia) and clustered into 5 distinct trajectories (Table 1). So among those who died of cancer, 33.8% had a trajectory of 'catastrophic disabilities' during end of life, while a person who died of advanced dementia had a long period of 'persistently severe disability' (not shown in the left censored graph).

We combined this and the volume of local annual deaths to estimate the disability burden, creating a 'proximity to death' model. The annual birth (~40k) and death (~19k) shows we are not in steady state due to ageing population and immigration dynamics. Annual deaths were projected to be ~30k in 2030. The last column of Table 1 assumes distribution of 'disability associated death' locally as medically coded cause of death (e.g. pneumonia) does not help to categorise advanced dementia or frailty. Sensitivity analysis was done by changing the distribution between frailty and advanced dementia.

Figure 2 – Disability trajectories in last year of life in US study (2010)

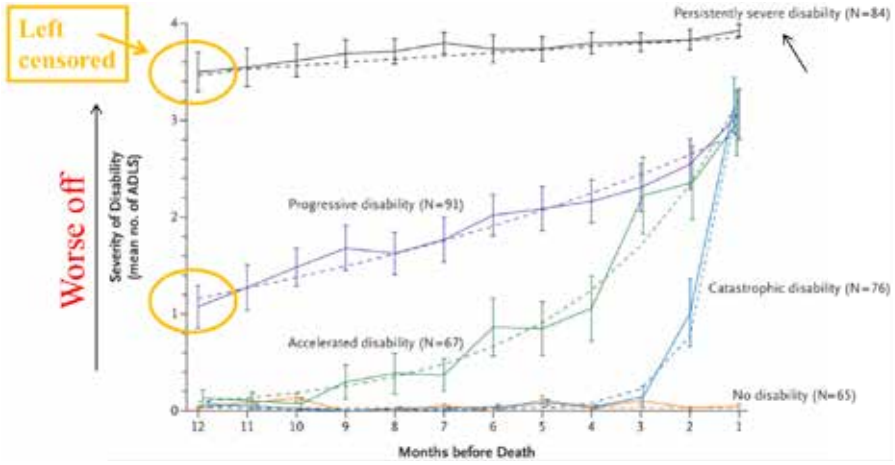


Table 1 – Association of 'Disability associated cause of death' and 'Disability trajectories'

Condition	No disability	Catastrophic disability	Accel. disability	Progressive disability	Patients	US (%)	S'pore (%)
Cancer	20.3%	33.8%	21.6%	20.3%	74	19.0%	29.7%
Organ failure	12.2%	14.6%	22.0%	32.9%	82	21.0%	26.5%
Adv dementia	1.9%	3.8%	9.4%	17.0%	53	14.0%	5.0%
Frailty	14.0%	18.7%	15.0%	27.1%	107	28.0%	24.1%
Sudden death	50.0%	30.0%	10.0%	10.0%	10	2.6%	2.9%
Other conditions	33.3%	24.6%	19.3%	19.3%	57	15.0%	11.9%
Patients	65 (17%)	76 (20%)	67 (17%)	91 (24%)	383	100%	100%

RESULTS

The current burden of disability is estimated to be 35 k (constant age specific rate model) based on the National Health Survey or between 30k to 40k (proximity to death model) based on the trajectories of disability and annual death volume of nearly 20k (Table 2). The projected burden in 2030 is 80.5k or between 45k to 60k respectively. The current prevalence of the 2 models did not differ much although they had used different sources. But the projected multiples of 2.3 and 1.5 show the difference in assumptions, methods and data.

Table 2 – Current and future estimates of disability burden

Year	Constant age specific rate model	Proximity to death model
2015	~ 35 k	~ 30 k – 40 k
2030	~ 80.5 k (2.3 times)	~ 45 k – 60 k (1.5 times)

The constant age specific rate model is conservative and assumes that a current 60 year old will have the same likelihood of a disease as a future 60 year old. In an ageing population, this projects a large burden. The proximity to death model does not factor the ageing factor explicitly and only counts the annual deaths and a constant period of disability before death, thereby assuming a postponement of onset in a background of increasing life expectancy.

CONCLUSIONS

The age related disability burden is currently estimated to about 35k and projected to increase to 45k to 80.5 k in 2030. This study highlights 2 things that are missing locally: (a) longitudinal disability studies until death (b) visibility of 'advanced dementia' or 'frailty' as leading to death.

TIME TO DIABETES RELATED COMPLICATIONS FROM NEWLY DIAGNOSED DIABETES IN SINGAPORE

Dr Nakul Saxena, Dr Ang Yee Gary

BACKGROUND

The long term sequela of diabetes mellitus (DM) can be divided into micro-vascular (small vessels) complications such as nephropathy, retinopathy and neuropathy and macro-vascular (large vessels) complications such as coronary heart disease (CHD) and stroke. This study aims to determine the cumulative incidence of DM complications (renal, skin/peripheral vascular disease, coronary heart disease and stroke) after newly diagnosed DM and to compare the cumulative incidence of DM complications by age at onset and Asian BMI categories.

METHODS

Patients with newly diagnosed diabetes mellitus (DM) from 1 Jan 2005 to 31 December 2014 in 3 tertiary hospitals and 9 primary care clinics (n = 33,334) were included for analysis. All patients were free of DM as determined by HbA1c levels one year before.

Complications were grouped into the above categories based on the Chronic Disease Management Database (CDMD) dictionary classifications. Patients were followed up to the development of the complication, death or were alive as on 31/12/2014 (end of follow up). Competing risk regression was used to determine the risk of developing the complication. To determine the effect of BMI on development of complications, patients were stratified into low risk (<23 kg/m^2), moderate risk (23-27.4 kg/m^2) and high risk (≥ 27.5 kg/m^2) BMI. Life tables were generated to determine the cumulative incidence of each complication.

RESULTS

Table 1 shows the development of diabetes complications by age at onset of diabetes. The 1, 5 and 10 year disease free survival for all five complications were lowest for the ≥ 65 years category patients compared to patients <40 years and 40-64 years (Table 2). Competing risk regression for patients segregated by BMI categories showed that patients with higher BMI had a higher risk of developing renal complications (Figure 1).

CONCLUSION

Cumulative incidence of diabetes related complications was significantly higher for patients with a late age at onset. Later age at onset of diabetes was significantly associated with diabetes related complications independent of HbA1c, ethnicity, gender and co-morbidities. Mean time (conditional) to a diabetes complication was not too high for the <40 years group compared to the ≥ 65 years group. Longer follow up is needed to determine the true median time to event for each complication.

Our study had the following limitations:
Short follow up time. The prevalence of DM complications might have been higher in the younger population if we had longer follow up time.

Date of onset of diabetes was taken as the start date from our administrative database. It could be that the older patients had diabetes at a younger age but was not captured in the database resulting in a higher incidence of complications in the older age patients.

Table 1 – Increasing life expectancy in Singapore, but age of onset of disease is same.

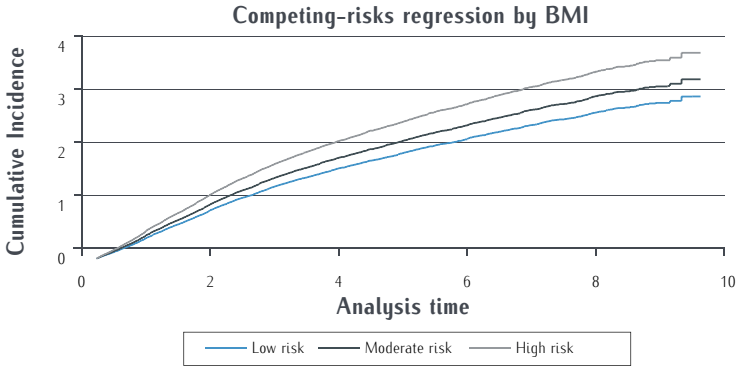
Diabetes complications by age at onset

Complication	All Age groups N (%)°	Age <40 years N (%)°	Age 40-64 years N(%)°	Age ≥ 65 years N(%)°
Renal	5,630 (20.9%)	139 (2.5%)	2,889 (51.3%)	2,602 (46.2%)
Skin/PVD/Vascular	3,817 (12.7%)	105 (2.8%)	2,021 (52.9%)	1,691 (44.3%)
CHD	2,087 (8.0%)	42 (2.0%)	1,001 (48.0%)	1,044 (50.0%)
Stroke	1,018 (3.5%)	17 (1.7%)	372 (36.5%)	629 (61.8%)

Table 2 – Cumulative incidence of DM complications

	Cumulative incidence			
Time	**Renal**	**Skin/PVD/Vascular**	**CHD**	**Stroke**
1 year	5.8% (5.5% to 6.1%)	2.8% (2.6% to 3.0%)	2.4% (2.2% to 2.6%)	1.5% (1.4% to 1.7%)
5 years	29.7% (29.1% to 30.4%)	19.4% (18.8% to 19.9%)	14.3% (13.8% to 14.9%)	9.8% (9.3% to 10.2%)
10 years	44.9% (43.2% to 46.7%)	37.9% (36.5% to 39.5%)	27.0% (25.3% to 28.7%)	20.3% (18.6% to 23.2%)
Median follow up time	3.61 years	4.10 years	4.02 years	4.13 years

Figure 1 – Competing risk regression for renal complications stratified by initial BMI



PROJECTS

ORGANISATION & DELIVERY OF SERVICES

EFFECTIVENESS OF THE VIRTUAL HOSPITAL PROGRAMME FOR FREQUENT ADMITTERS

Dr Joseph Antonio D Molina, Ge Lixia, Dr Yap Chun Wei, Dr John Arputhan Abisheganaden, Dr Tan Kok Leong, Dr Heng Bee Hoon

BACKGROUND

In 2011, 15% of all patients admitted to Tan Tock Seng Hospital were hospitalised 3 or more times in the past 12 months. Of those who survived through 2012, 14% had 3 or more admissions in the following year.

Frequent admissions often result from a combination of medical and non-medical factors such as having multiple chronic illnesses, low patient activation, the lack of social support, social isolation, economic, as well as other psycho-social issues. A large proportion of admissions is therefore avoidable, leading to the unnecessary consumption of health resources and may contribute to a shortage of beds for patients who actually require hospitalisation. In response to this, Tan Tock Seng Hospital (TTSH) launched the Virtual Hospital (VH) Programme in 2013.

The VH Programme

Understanding that frequent admissions result from a wide range of factors, and that the services provided must match the right patient, TTSH patients with 3 or more admissions were grouped into: (1) True Frequent Admitters (FA) – patients whose admissions were mainly avoidable; (2) Transient Admitters (Transients) – patients whose frequent admissions were expected to be temporary and mainly surgery-related, and; (3) End Of Life (EOL) – patients admitted for terminal conditions. Of these 3 groups, the VH Programme was designed to address the needs of the True FAs.

The VH Programme aimed to reduce unnecessary hospital admissions amongst True FA patients and ensured that care was right-sited through the sustainable use of clinical manpower; alignment and coordination of roles between doctors, nurses, care coordinators, health managers, social workers and allied health professionals; collaboration with community partners, and; incorporation of a follow-up plan after the patient has been discharged from hospital. Services included health, home, medication and functional assessments; health monitoring and treatment; behavioural counselling; medication and appointment reconciliation; functional rehabilitation, and; discharge planning. Aside from multi-disciplinary case discussions, the programme involved home visits as well as outbound telephone calls. Care bundles were tailored to specific chronic diseases and consisted of activities and services delivered at recommended timings during the patient's participation in the programme. After a follow-up assessment approximately 4-6 months from enrolment, stable patients were either jointly managed or handed over to primary care for follow-up.

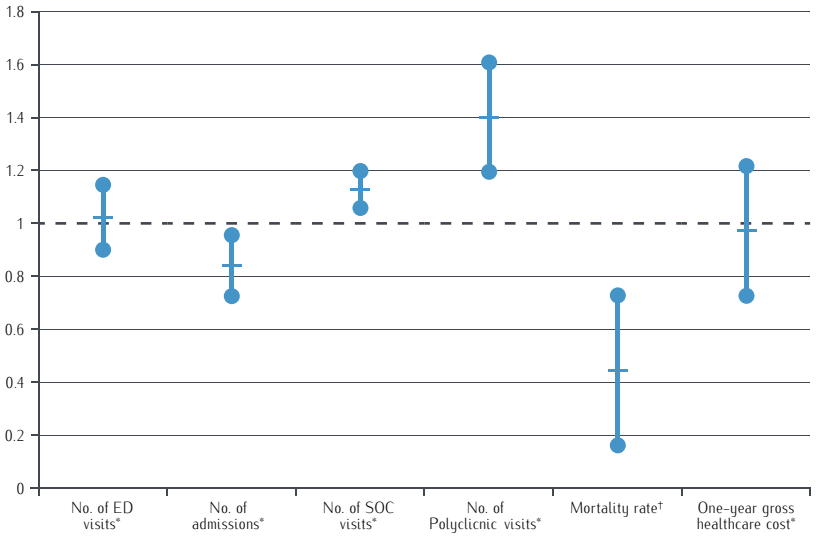
METHODS

The VH programme was evaluated by comparing 92 True FA patients enrolled in the programme with another 257 True FA patients who were similarly eligible but not enrolled. Both groups were followed up for 12 months, and compared in terms of the number of hospital admissions; total number of days they stayed in hospital; risk of death; number of emergency department (ED) visits; number of specialist outpatient clinic (SOC) visits; number of Polyclinic visits, and; total cost incurred for all health services availed for the year.

RESULTS

Results revealed that those enrolled in VH had 17% fewer admissions in the following year than those not enrolled (Figure 1). Although there was no significant difference in the number of days they stayed in hospital over one year, VH patients had a 65% lower risk of death than those not enrolled in the following year. VH patients had 13% more SOC visits, and 39% more Polyclinic visits than those not enrolled. There was no difference in the number of ED visits, or in the 1-year total cost of health services for the two groups.

Figure 1 – Adjusted effect measures of enrolment in the VH program and selected healthcare utilisation outcomes



*Incidence rate ratio †Odds ratio

CONCLUSION

These findings suggest that it is possible to reduce unnecessary hospitalisations and the risk of death of former frequent admitters while right-siting their care to the ambulatory setting and keeping the cost incurred for health services stable.

EFFECTIVENESS OF THE INTEGRATED HIP FRACTURE CARE PROGRAM

Dr Joseph Antonio D. Molina, Dr William Chan, Dr Rani Ramason, Dr Heng Bee Hoon

BACKGROUND

About 2,300 patients were admitted for hip fracture in Singapore in 2007 and 2008, of which 728 and 628 cases in these respective years were admitted at TTSH. (Source: MOH).

In light of the increasing burden of hip fractures in the country, as well as the need to optimise the care for these patients, a Workgroup for Integrated Care of Hip Fractures was formed in April 2010 to review the existing care processes and design an integrated care pathway. The Integrated Hip Fracture Care Pathway (IHFCP) aimed to achieve seamless integration of care from admission and treatment to rehabilitation and post-discharge community services, optimise patients' clinical outcomes, facilitate timely access to health services, reduce unnecessary utilizations and reduce mortality.

METHODS

Patients 60 years and older admitted to TTSH with acute fragility hip fracture, with neck of femur, intertrochanteric or subtrochantric fracture were managed on the Hip Fracture Clinical Pathway.

The IHFCP evaluation utilised a descriptive design, with outcomes analysed separately for each of the 5 years of program implementation from October 2011 to September 2016. Evaluation comprised 20 indicators and outcomes including health service utilisation, quality metrics, mortality, functional and other physical performance parameters, and quality of life, assessed over one year of follow-up. As full implementation of the IHFCP took place from the second year, first year results were treated as baseline.

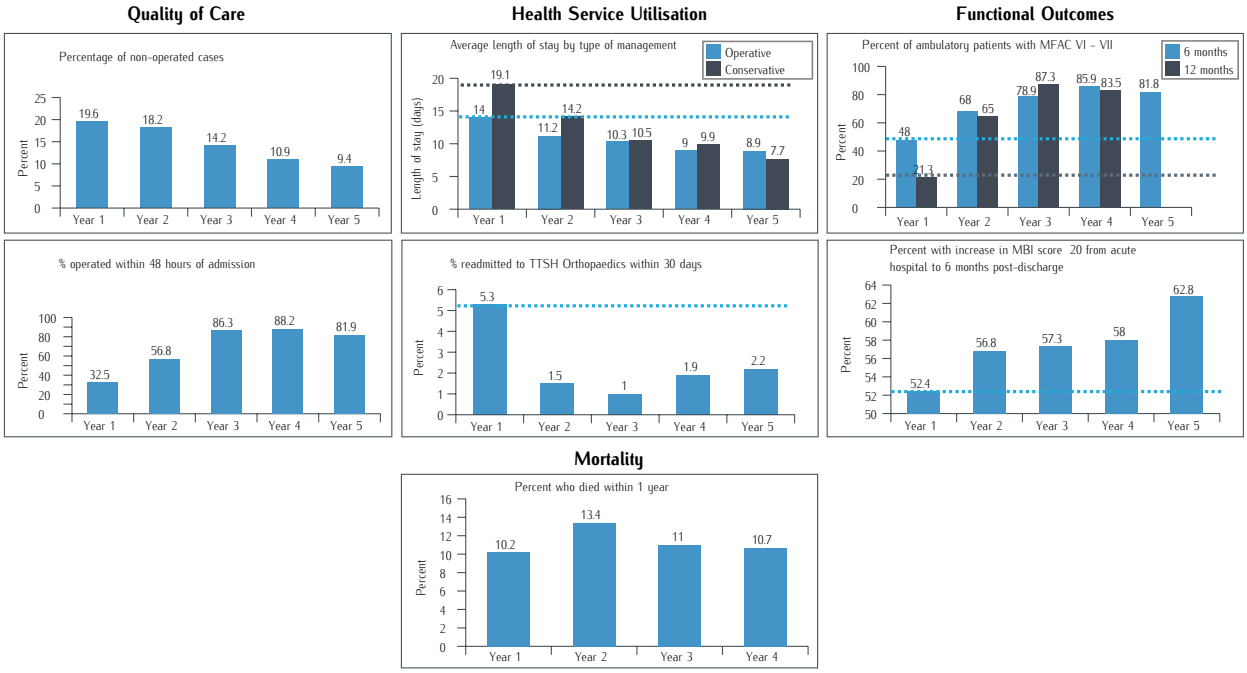
RESULTS

There were 557 and 2142 patients during baseline and the full 4 years of follow-up, respectively. The average age of hip fracture patients ranged from 79 to 82 years across the five years, with more females, and more than 85% of patients of Chinese ethnicity.

Improvements in years 2 to 5 over baseline were observed for 12 out of 20 process and outcome measures (Figure 1); these include: Assessment by ICM within 1 working day; Surgeries performed within 48 hours of admission; Percentage of non-operated cases; Initiation of therapy by post-operative day 1; Transfer to inpatient rehabilitation by post-operative day 6; Proportion of patients who failed nutritional screening who were assessed by a dietician; Proportion with functional outcome assessment at pre-morbid, 6 and 12 months; Average length of stay at acute hospital; Average length of stay at inpatient rehabilitation; 30-day readmission rate; Proportion with Modified Barthel Index (MBI) score of 20+, and; Modified Functional Assessment Classification (MFAC) of VI to VII at 6 and 12 months.

Improvements over baseline were observed for 3 of the 4 post-baseline years for the following: Admission to Orthopaedic ward within 4 hours of arrival at the ED; Proportion of patients referred for day rehabilitation; Proportion who completed the individualised program at the day rehabilitation centre, and; Proportion with Timed-up-and-go $\leq$30 seconds at discharge from inpatient rehabilitation.

Figure 1 – Changes From Baseline to Year 5 for Selected Outcomes



Results were less favourable post-baseline for (1) the proportion of patients who had a bone health assessment within 3 months of presentation at the ED, and (2) 1-year all-cause mortality. Challenges in identifying those eligible for bone mineral density (BMD) screening led to the low number of patients during the first year and likely falsely elevated percentage screened. Introduction of Denosumab in year 2 resulted in an increase in the absolute numbers of eligible patients, and in the number screened within 3 months. Hence, while the proportion screened was higher in year 1, the total number screened was higher in years 2 to 5 (Table 1). With regard to mortality, there was a transient increase from year 1 to 2, with a trend toward baseline in subsequent years (Figure 1).

Table 1 – No. (%) of patients by timing of BMD

Timing	Frequency (%)				
	Year 1*	Year 2	Year 3	Year 4	Year 5
Within 3 months of ED presentation	142 (98.6)	371 (96.1)	470 (96.1)	503 (94.9)	265 (94.6)
> 3 months from ED presentation	2 (1.4)	15 (3.9)	19 (3.9)	27 (5.1)	15 (5.4)
Total number of eligible patients on the Hip Fracture Clinical Pathway	144 (100.0)	386 (100.0)	489 (100.0)	530 (100.0)	280 (100.0)

*For Year 1, 9 patients have missing data

Less than 0.5% had wound infection or pressure ulcer and less than 1.5% developed venous thromboembolism. The incidence of urinary tract infection, was lower in the last 2 years than at baseline.

As for quality of life, the proportion whose level of anxiety/depression improved or was unchanged increased in years 2 to 4. Compared to baseline, the proportion whose pain/discomfort improved or remained the same was higher in years 2 and 3 but lower in years 4 and 5. For the domains of mobility, self-care and usual activities, the proportion with unchanged or improved quality of life was lower at years 2 to 5 than baseline.

CONCLUSIONS

Favourable findings have helped transform the payment structure into a bundle payment model for the Integrated Hip Fracture Care Program.

EFFECTIVENESS OF DIABETES FOOT SCREENING IN PRIMARY CARE IN PREVENTING LOWER EXTREMITY AMPUTATIONS IN SINGAPORE

Dr Gary Ang Yee, Dr Yap Chun Wei, Dr Nakul Saxena

BACKGROUND

The prevalence of diabetes mellitus in Singapore has increased from 8.2% in 2004 to 11.3% in 2010 and is projected to reach 15% in 2050. The risk of lower extremity amputations (LEA) in diabetes patients is 20 times higher than non-diabetes patients. It is estimated that 1,500 LEA are performed in diabetes patients in Singapore annually. The average direct medical cost is estimated to be SGD 5,100 for minor LEA and SGD 9,600 for major LEA. All these highlight the importance of preventing LEA in diabetes patients.

Clinical practice guidelines recommend that all individuals with diabetes mellitus should receive an annual foot examination to identify high-risk foot conditions. Despite this recommendation, there is little evidence in literature to show that this is effective in preventing LEA in diabetes patients. This study aims to evaluate the effectiveness of diabetes foot screening in primary care in preventing LEA and to identify risk factors for LEA.

METHODS

This is a retrospective cohort study of diabetes patients living in the central region who visited the National Healthcare Group Polyclinics for the first time from 1 January 2008 to 31 December 2012. The intervention of interest was foot screening performed at least once during 2 years of follow up and the outcome of interest was LEA (major and /or minor) performed during 2 years of follow up. Logistic regression was done to identify factors associated with LEA.

RESULTS

Table 1 shows the baseline characteristics. Among those who underwent foot screening, there were 4 (0.02%) major amputations and 19 (0.12%) minor amputations compared with 51 (0.52%) major amputations and 68 (0.69%) minor amputations among those who did not ($p<0.001$). Table 2 shows the risk factors for LEA.

CONCLUSION

The lack of diabetes foot screening has been found to be associated with a higher risk of having LEA. Higher HbA1c and longer duration of diabetes were also associated with higher risk of having LEA. Further research is needed to find out whether improving diabetes foot screening will lead to reduction in LEA.

Table 1 – Baseline characteristics

	Foot screening done		P value
	Yes (n=16,382)	No (n=9,791)	
Age, mean (SD)	66.7 (12.0)	68.2 (14.5)	<0.001
Gender, n (%) Male	8,229 (50.7)	5,092 (52.1)	0.035
Ethnicity, n (%) Chinese Malay Indian Others	 12,659 (77.3) 1,318 (8.1) 1,956 (13.2) 781 (3.0)	 7,073 (72.2) 892 (9.1) 1,494 (15.3) 332 (3.4)	 <0.001
Medifund user, n (%)	1,360 (8.3)	1,393 (14.2)	<0.001
Duration of diabetes, mean (SD)	1.5 (3.9)	2.7 (4.0)	<0.001
HbA1c, mean (SD)	7.9 (2.1)	7.7 (2.1)	0.008
BMI Categories, n (%) Risk of nutritional deficiency diseases and osteoporosis (<18.5) Low risk (18.5-22.9) Moderate risk (23.0-27.4) High risk (>=27.5) Unknown	 198 (1.2) 2,040 (12.5) 4,883 (29.8) 4,364 (26.6) 4,897 (29.9)	 164 (1.7) 1,130 (11.5) 2,086 (21.3) 1,693 (17.3) 4,718 (48.2)	 <0.001
Comorbid conditions, n (%) Chronic kidney disease Hip fracture	 2,030 (12.4) 81 (0.5)	 2,011 (20.5) 117 (1.2)	 <0.001 <0.001

Table 2 – Risk factors for LEA

No diabetes foot screening	Odds Ratio (95% CI)
	9.1 (4.7-17.5)
BMI Categories, n (%) High Risk (>=27.5) Risk of nutritional deficiency diseases and osteoporosis (<18.5) Low risk (18.5-22.9) Moderate risk (23.0-27.4) Unknown	 Reference 9.9 (1.8-53.9) 3.0 (0.74-12.4) 4.8 (1.4-16.7) 3.8 (1.1-12.9)
Hip fracture	5.0 (1.1-23.0)
Medifund user	2.8 (1.5-5.2)
Chronic kidney disease	2.0 (1.0-4.0)
HbA1c	1.4 (1.3-1.5)
Duration of diabetes	1.05 (1.00-1.09)

IDENTIFICATION OF RISK FACTORS FOR ED VISITS AND ADMISSIONS DUE TO HYPOGLYCAEMIA

Dr Yap Chun Wei, Dr Heng Bee Hoon

BACKGROUND

ED visits or admissions due to hypoglycaemia are potentially avoidable if diabetes is well-controlled. Hence, it is important to identify patients with poor diabetes control who are at risk of ED visit or admissions within a year so that appropriate interventions could be given. This project aims to identify the risk factors for ED visits and admissions due to hypoglycaemia.

METHODS

This is a retrospective cohort study using information extracted from administrative databases. Singaporean or permanent residents living in Central region who are of age 20 and above, and regularly visited Ang Mo Kio polyclinic, Hougang polyclinic, Toa Payoh polyclinic or TTSH specialist outpatient clinics for diabetes consultations between 2006 and 2014 were included in the study. Patients were followed up until death or 31 December 2015, whichever is earlier.

All patients were followed up yearly, starting from their date of recruitment into the study. Thus each patient may have more than one follow-up period. For patients without a hypoglycaemia episode requiring ED visit or admission during a follow-up period, the most recent value of baseline variables, except HbA1c, were taken, up till 12 months before start of follow-up period. For HbA1c, the nearest value from 6 months before to 1 month after start of follow-up was used as baseline. For patients with hypoglycaemia episode requiring ED visit or admission during a follow-up period, the most recent value of baseline variables, except HbA1c, were taken, up till 12 months before the hypoglycaemia episode. For HbA1c, the nearest value from 6 months before to 1 month after hypoglycaemia episode was used as baseline. Values were treated as unknown if no values were found within the baseline period.

A total of 27 variables related to patient demographics, comorbidities, previous hypoglycaemia episodes, drugs dispensed and dosage changes were considered. Multivariate logistic regression, with adjustment for repeated observations on individuals, was used to identify risk factors for ED visits and admissions due to hypoglycaemia.

RESULTS

There were 67,373 patients included in this study, with a total of 389,521 follow-up periods. Among these, 3,266 (0.8%) follow-up periods had an ED visit or admission due to hypoglycaemia. The model identified history of hypoglycaemia episodes, lower baseline HbA1c, younger and older age, female gender, Malays and Indians, low BMI, hypertension, coronary heart disease, chronic obstructive pulmonary disease, chronic kidney disease stage 3 to 5, dementia, stroke, non-renal microvascular complications and macrovascular complications, use of insulins, metformin, sulfonylureas, acarbose, thiazolidinediones, meglitinides, and recent drug or dosage changes as significant risk factors (Table 1).

CONCLUSION

The identified risk factors could help clinicians to identify high-risk patients and provide appropriate interventions to prevent future ED visits and admissions due to hypoglycaemia.

Table 1 – Significant risk factors.

Predictors	Odds Ratio (95% CI)	p value
Patient history and laboratory values		
Previous hypoglycaemia		
0	**Reference**	
1	1.64 (1.31 - 2.04)	<0.001
2	4.12 (1.98 - 8.57)	<0.001
≥3	23.16 (6.35 - 84.46)	<0.001
HbA1c		
<5.0	2.63 (1.86 - 3.70)	<0.001
5.0 – 5.9	2.40 (2.10 - 2.74)	<0.001
6.0 – 6.4	1.37 (1.21 - 1.55)	<0.001
6.5 – 6.9	**Reference**	
7.0 – 8.5	0.58 (0.52 - 0.65)	<0.001
>8.5	0.36 (0.31 - 0.42)	<0.001
Unknown	0.12 (0.10 - 0.15)	<0.001
Patient characteristics		
Age		
20 – 29	3.19 (1.35 - 7.51)	0.008
30 – 39	1.83 (1.22 - 2.73)	0.003
40 – 49	1.26 (0.98 - 1.62)	0.078
50 – 59	**Reference**	
60 – 69	1.16 (1.01 - 1.32)	0.032
70 – 79	1.26 (1.10 - 1.44)	0.001
80 – 84	1.19 (1.01 - 1.41)	0.043
≥85	0.84 (0.69 - 1.03)	0.095
Female	1.16 (1.07 - 1.26)	0.001
Race		
Chinese	**Reference**	
Malay	1.22 (1.06 - 1.41)	0.007
Indian	1.24 (1.10 - 1.41)	0.001
Others	1.30 (0.97 - 1.75)	0.082
BMI		
<18.5	1.70 (1.42 - 2.03)	<0.001
18.5 – 22.9	**Reference**	
23.0 – 27.4	0.62 (0.56 - 0.69)	<0.001
27.5 – 29.9	0.52 (0.45 - 0.60)	<0.001
≥30	0.44 (0.38 - 0.52)	<0.001
Unknown	1.33 (1.16 - 1.52)	<0.001
Comorbidities		
Hypertension	2.74 (2.25 - 3.33)	<0.001
Coronary heart disease	1.23 (1.13 - 1.34)	<0.001
COPD	1.33 (1.05 - 1.67)	0.016
CKD stage 3 to 5	2.47 (2.25 - 2.72)	<0.001
Dementia	1.95 (1.67 - 2.27)	<0.001
Stroke (exclude TIA)	1.21 (1.09 - 1.34)	<0.001
Microvascular (non-renal) complications	1.72 (1.58 - 1.88)	<0.001
Macrovascular complications	1.43 (1.27 - 1.61)	<0.001
Medications		
Insulin	3.65 (3.26 - 4.09)	<0.001
Metformin	0.83 (0.76 - 0.91)	<0.001
Sulfonylurea	1.44 (1.32 - 1.57)	<0.001
Acarbose	1.70 (1.44 - 1.99)	<0.001
Thiazolidinedione	1.92 (1.13 - 3.24)	0.015
Meglitinide	2.85 (1.27 - 6.40)	0.011
Drug/dose change		
Drug change	1.51 (1.32 - 1.72)	<0.001
Dose increase only	1.37 (1.20 - 1.58)	<0.001
Dose decrease only	1.28 (1.12 - 1.47)	<0.001
Dose increase and decrease	1.45 (1.20 - 1.75)	<0.001
No change	**Reference**	
Unknown	2.33 (2.08 - 2.60)	<0.001

FACTORS ASSOCIATED WITH HIGHER CAREGIVER BURDEN AMONG FAMILY CAREGIVERS OF ELDERLY CANCER PATIENTS: A SYSTEMATIC REVIEW

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BACKGROUND

Caring for elderly cancer patients may result in multi-dimensional caregiver burden on family caregivers. Recognition of the factors associated with higher caregiver burden is important for targeting interventions at family caregivers most in need and reducing adverse health outcomes related to caregiver burden. The aim of this study was to identify factors associated with higher caregiver burden among family caregivers of elderly cancer patients.

METHODS

Search strategy

A systematic search of 7 electronic databases (CINAHL, Scopus, PsycINFO, Cochrane Central Register of Controlled Trials, Web of Science, Medline and PubMed) was conducted from database inception to October 2014. The reference list of all identified studies was searched for any additional studies.

Eligibility criteria

Original observational studies published in English language and with assessment of associations between at least one independent variable and caregiver burden among family caregivers of elderly cancer patients were selected. A study was excluded if: 1. results were not presented separately for family caregivers of cancer patients; 2. patients' age information was not available or patients' mean/median age was younger than 65 years; 3. the study shared the same sample with another major study that was included in the review; 4. caregiver burden was an independent variable instead of an outcome.

Quality Assessment

The methodological quality of the included studies was independently assessed by two reviewers using a modified criteria checklist and rated as high, moderate or low quality (Table 1).

Table 1 – Criteria for Assessment of Quality Level of Studies and Best-evidence Synthesis

Item	Level	Subject Selection
Quality level of studies	**High**	Multivariate analysis performed and had a quality score≥7
	Moderate	Multivariate analysis performed and had a quality score<7, or no multivariate analysis performed but had a quality score>5
	Low	No multivariate analysis performed but had a quality score≤5
Level of evidence	**Strong**	Minimum of 3 high quality studies with generally consistent findings
	Moderate	Minimum of 2 moderate quality studies with generally consistent findings
	Limited	Minimum of 1 low quality study with generally consistent findings
	Conflicting	Converse findings in >25% of the studies
	None	No studies could be found

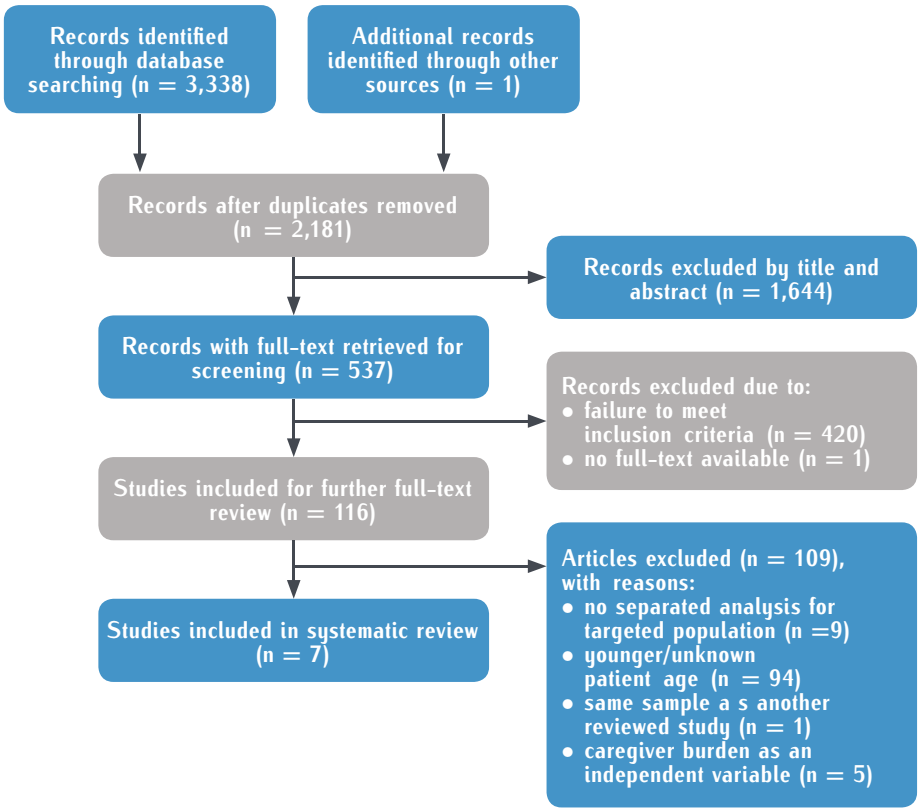
Data extraction and synthesis

Relevant data including study design, sample size, caregivers' socio-demographics, patients' socio-demographics and disease characteristics was extracted using a pre-developed data extraction form. Best-evidence synthesis model (Table 1) was employed.

RESULTS

The search yielded a total of 3,339 articles. After tile and abstract screening and full-text assessment, 7 studies were finally included in the review (Figure 1).

Figure 1 – Flow Diagram of Study Selection Procedure



Study Characteristics

These 7 studies involved 1,233 (range 30 to 618) eligible family caregivers who were predominantly females (75.3%) and spouses (65.9%). They provided primary care to cancer patients during or post cancer treatment in 5 studies and during hospice or in-patient palliative care in 2 studies.

Factors Associated with Higher Caregiver Burden

Twenty-two factors were identified to be associated with higher caregiver burden: caregiver characteristics (11 factors), patient characteristics (7 factors), caregiving situation (2 factors) and resources (2 factors). Younger age, solid tumours and assistance with patient's activities of daily living were the 3 associated factors classified as moderate evidence. Contradictory findings on association between relationship with patient and higher caregiver burden: siblings experienced higher caregiver burden in a high-quality study while spouses and children did in a moderate-quality study. The other 18 factors were limited evidence which were only supported by one study respectively.

DISCUSSION & CONCLUSIONS

The evaluation of current evidence identified three moderate-evidence factors associated with higher caregiver burden: younger caregivers, solid tumours and assistance with patient's activities of daily living. The findings of this review might provide evidence in identifying family caregivers at high-risk of higher caregiver burden.

WHAT WORKS BEST FOR WHOM? – TARGETED INTERVENTIONS FOR FREQUENT ADMITTERS

Dr Joseph Antonio D. Molina, Ge Lixia, Dr Yap Chun Wei, A/P John Arputhan Abisheganaden, Dr Tan Kok Leong, Dr Heng Bee Hoon

BACKGROUND

A large proportion of patients admitted to hospital consist of "frequent admitters." In Tan Tock Seng Hospital (TTSH), 15% of all patients admitted in 2011 were hospitalised 3 or more times in the previous 12 months. Patients with frequent admissions are a heterogeneous group whose admissions are attributable to varying degrees of medical, social and behavioural factors. Among frequent admitters (FA), 3 subgroups stand out. The first group, the "Transient" admitters are those whose excess admissions are temporary as they are mainly post-surgery related and underlying factors leading to admissions are expected to abate in due course. The second group consists of End of Life (EOL) patients who have undergone prognostication due to a terminal condition and for whom death within 6 month is not unexpected. The third group, the "True" FA comprises those whose hospitalisations are brought about by chronic medical conditions often confounded by non-clinical factors such as social isolation, financial constraints, low level of activation, and inadequate care arrangement.

Given the differences in underlying conditions and challenges faced by the 3 groups, there is a need to customise the intervention according to their specific needs. Of these three groups, admissions of True FA are largely preventable and, with the right combination of support from the hospital and community, are most amenable to intervention. In 2012 TTSH launched the Virtual Hospital (VH) Program for True FA. The program aimed to reduce unnecessary hospital admissions and ensure that care was right-sited; align and coordinate roles between doctors, nurses, care coordinators, health managers, social workers and allied health professionals; facilitate collaboration with community partners, and; provide the patient with a follow-up plan after discharge from hospital. To effectively plan the intervention including the resources needed, it was necessary to assess the distribution of FA patients according to the 3 subgroups, as well as to estimate the cost of health services for each subgroup, before and after their index admission.

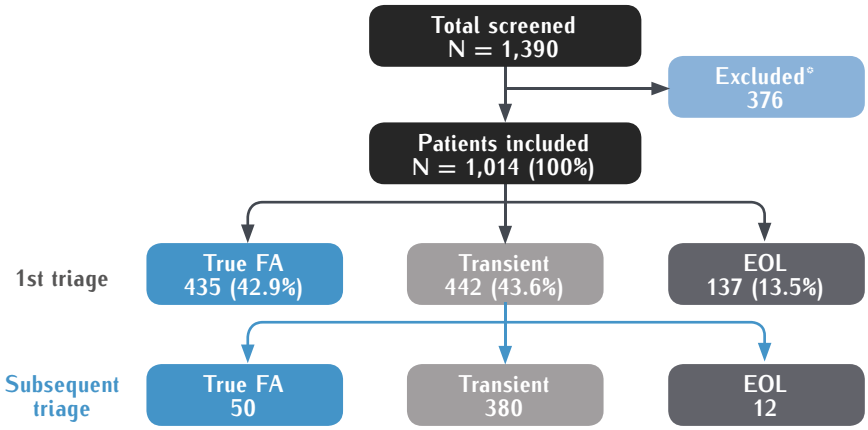
METHODS

A daily list of patients admitted in 2014 who had been hospitalised 3 or more times in the past 12 months was extracted. Four clinically-trained assessors working in pairs reviewed the electronic medical records of these patients to classify them into True FA, Transients and EOL as of the patient's index admission date, using the stratification criteria developed by the VH team. The stratification criteria consist of a checklist of 9 main items identifying patients admitted for cancer, surgical or end-organ related conditions. The assessors conducted the stratification exercise independently. Each pair then compared the results of their assessment for each individual patient. Disagreements in patient classification were escalated to two other members of the study team for final determination. Aside from classifying the patients, data on health service utilisation 12 months before and after the index admission was extracted. These included inpatient episodes; Emergency Department (ED), Specialist Outpatient Clinic (SOC) and Polyclinic visits; and day surgeries. In addition, costs incurred for each service level was extracted for the 12 month period before and after the index admission.

RESULTS

A total of 1,390 patient records/admissions were screened, 1,014 of whom were included in the stratification exercise. As of the index admission, 42.9% were classified as True FA (Figure 1).

Figure 1 – Results of FA Patient Stratification



Exclusion criteria: Foreigner; Died during index admission, institutionalised, ADL-dependant or bed-bound, Receiving active cancer treatment, HIV patients

Of the 3 groups, the True FA had the smallest reduction in the average number of hospitalisations after the index admission. In addition, while True FA incurred the lowest average overall gross cost before the index admission, average overall gross cost one year after the index admission was the highest among the 3 groups (Table 1).

Table 1 – Average Number of Healthcare Visits and Cost of Health Services, Before and After Index Admission

Average Number of Visits (1 Year Before and After Index Admission)							
Institution		True FA (n=435)		Transient (n=442)		End of Life (n=137)	
		No. or Cost	Change (%)	No. or Cost	Change (%)	No. or Cost	Change (%)
NHGP	Before	3.77	-20.9	3.15	-19.7	2.58	-72.8
	After	2.98		2.53		0.70	
SOC	Before	15.26	+4.0	14.49	+3.9	20.64	-46.9
	After	15.86		15.06		10.96	
Day Surgery	Before	0.28	+3.3	0.32	-5.6	0.34	-56.5
	After	0.29		0.30		0.15	
ED	Before	6.51	-19.5	6.11	-27.4	4.80	-44.9
	After	5.24		4.44		2.64	
Inpatient	Before	5.52	-21.5	4.95	-30.5	5.28	-47.9
	After	4.43		3.44		2.75	
Average Gross Cost ($, 1 Year Before and After Index Admission)							
NHGP	Before	293.24	-27.3	244.30	-24.5	234.88	-79.7
	After	213.14		184.47		47.56	
SOC	Before	2,314.75	+4.3	2,522.10	+2.6	5,831.31	-53.7
	After	2,414.95		2,588.55		2,702.43	
Day Surgery	Before	329.75	-3.8	474.65	-14.0	409.72	-51.9
	After	317.20		408.14		197.22	
ED	Before	1,769.86	-17.8	1,566.65	-28.9	1,247.61	-42.4
	After	1,454.42		1,114.61		719.10	
Inpatient	Before	26,915.47	-7.1	29,291.64	-27.3	36,599.28	-48.5
	After	24,977.13		21,307.48		18,854.64	
All Cost	Before	31,623.07	-7.0	34,099.34	-24.9	44,322.79	-49.2
	After	29,396.85		25,603.25		22,520.94	

CONCLUSION

Results suggest that True FA comprise a large proportion of all frequent admitters. The size of this group reflects the potential impact that health programs and services may have on health service utilisation and cost outcomes. This stratification exercise has demonstrated that as a whole, patients with frequent admissions have widely varying needs, reinforcing the need for targeted interventions. As demonstrated by changes between pre- and post-health service utilisation and cost, in the absence of effective interventions, True FA may contribute to an increase in the overall cost to the institution.

TREND IN HbA1c LEVELS AMONG PRIMARY CARE DIABETES PATIENTS ADMITTED TO TAN TOCK SENG HOSPITAL IN 2013

Dr Gary Ang Yee, Teow Kiok Liang

BACKGROUND

Improved glycemic control reduces the risk of microvascular complications in patients with diabetes mellitus. Despite this, not all diabetes patients can reach their target HbA1c levels. Hospital admissions have been proposed as an opportunity to improve glycemic control due to the intense daily exposure to clinical care teams. However, the impact of long term glycemic control after discharge is largely unknown. This study aims to assess the effect of hospital admission on glycemic control in patients with Diabetes Mellitus up to 1 year after discharge. We also looked at whether the effect is different between medical and surgical admissions.

METHODS

This is a retrospective cohort study of patients with diabetes mellitus that were admitted to Tan Tock Seng Hospital (TTSH) from 1 January 2013 to 31 December 2013. HbA1c levels at baseline, 6 months and 12 months after discharge were extracted along with demographics data. Paired t-test was done to assess the difference between HbA1c levels at baseline and 12 months after discharge.

RESULTS

We identified 2,682 patients with diabetes mellitus that were admitted to TTSH. 1,759 (65.6%) were admitted to medical disciplines while the rest were admitted into surgical disciplines. Baseline characteristics are shown in table 1. The medical patients were older (mean age 71.1 years) compared to surgical patients (mean age 70.0 years) and had higher baseline HbA1c levels (7.61% vs 7.39%) but comparable in terms of gender and ethnicity. Table 2 and Figure 1 shows the trend in glycemic control over 1 year. There were statistically significant differences in HbA1c levels for both medical patients and surgical patients at baseline and 6 months after discharge. For medical patients, the difference was still statistically significant after 12 months but not for surgical patients.

CONCLUSION

Glycaemic control is better in both medical and surgical patients 6 months after discharge but only better in medical patients 12 months after discharge. More research is needed to explore whether hospital admissions are an opportunity to improve glycaemic control especially in the long term.

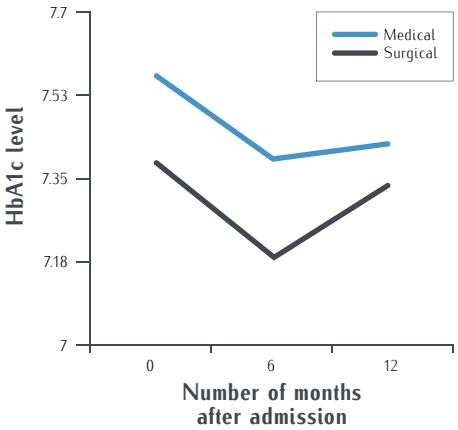
Table 1 – Baseline characteristics

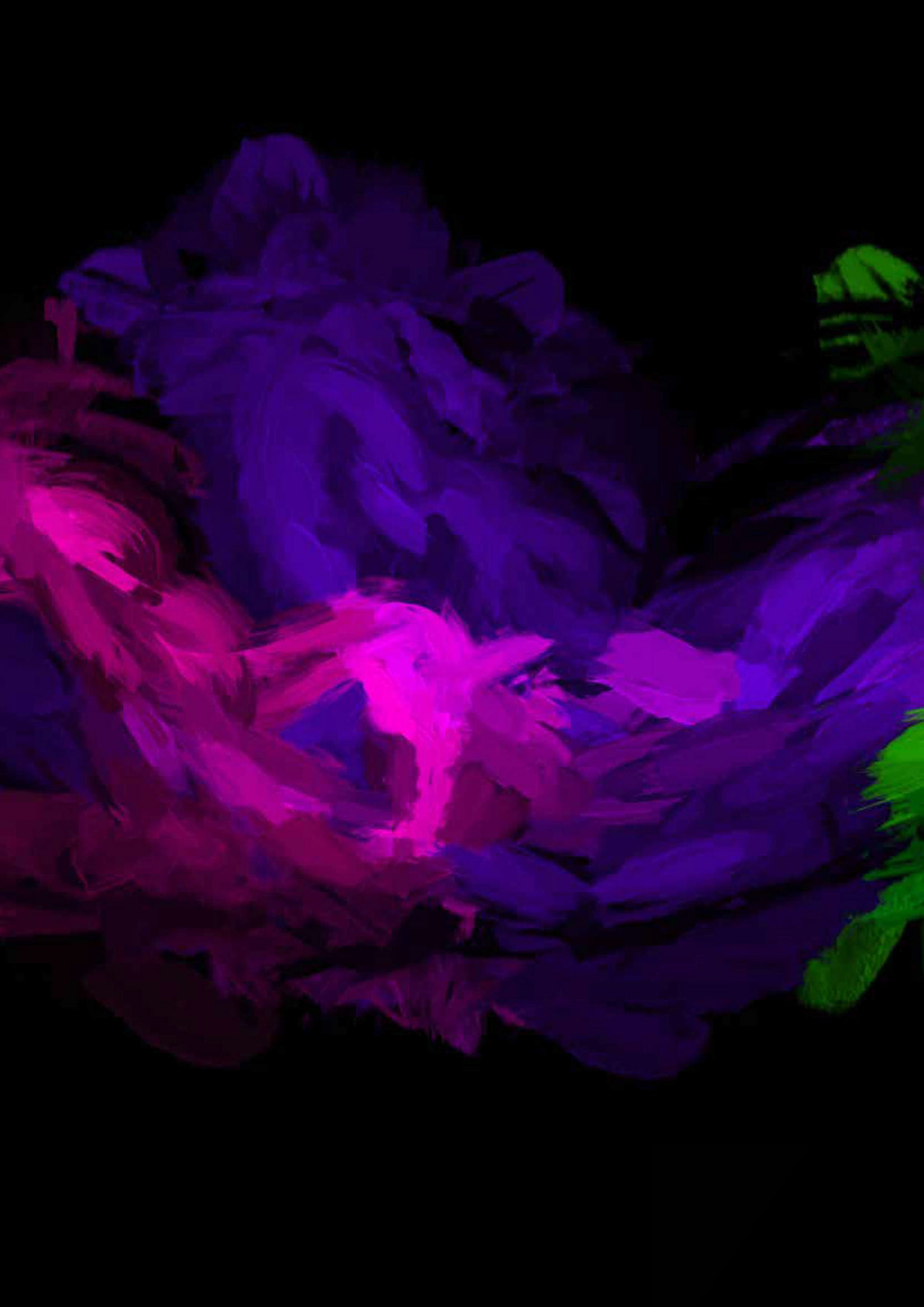
	Medical	Surgical	P value
	(n=1,759)	(n=923)	
Age, mean (SD)	71.1 (11.3)	70.0 (11.1)	0.0247
Gender			
Male (%)	814 (46.3)	462 (50.1)	0.063
Ethnicity			
Chinese (%)	1,309 (74.4)	720 (78.0)	0.18
Malay (%)	136 (7.7)	67 (7.3)	
Indian (%)	227 (12.9)	101 (10.9)	
Others (%)	87 (5.0)	35 (3.8)	
Baseline HbA1c, mean (SD)	7.61 (1.60)	7.39 (1.34)	0.0003

Table 2 – HbA1c trend over time

Admission type	HbA1c, mean (SD)				
	Baseline	6 months	P value	12 months	P value
Medical	7.61 (1.60)	7.40 (1.42)	<0.001	7.44 (1.46)	<0.001
Surgical	7.39 (1.34)	7.16 (1.26)	<0.001	7.34 (1.36)	0.2243

Figure 1 – HbA1c trend over time





PROJECTS

HEALTH & WELFARE ECONOMICS

PRIMARY CARE DEMENTIA CLINIC REDUCES SOCIETAL COST OF DEMENTIA: A COST-UTILITY ANALYSIS

Kelvin Teo Wee Sheng, Tan Woan Shin, Charis Ng Wei Ling, Dr Pradeep Paul George, Dr Nakul Saxena, Dr Cindy Yeo[1,2], Dr Noorhazlina N Ali[2,3], Dr Chew Aik Phon[2,3], Karen Tan Ai Wen[3], Dr Low Kang Yih[4], Dr Karen Ng[4], Dr Colin Tan[4], Dr Chong Mei Sian[2,3]

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BACKGROUND

The prevalence of dementia in Singapore is expected to increase with an ageing population. With the inclusion of dementia into the Chronic Disease Management Program, more primary care consultations are expected in the polyclinic. A Primary Care Dementia Clinic (PCDC) was set up in Ang Mo Kio Polyclinic to manage stable patients. The objective of this study was to evaluate the cost-utility of dementia care at PCDC compared with specialists' care at the Memory Clinic (MC) and standard care at Other Polyclinics (Others).

METHODS

This was a quasi-experimental study using dementia patients who were not managed at PCDC as controls. Stable dementia patients with a Clinical Dementia Rating of 1.0 to 3.0 were recruited for the programme. Costs were measured from the societal viewpoint, including both direct and indirect costs. To establish cost-utility, EQ-5D was used to calculate Quality Adjusted Life Years (QALYs). Cost and utility were measured at 6-month and 1-year. Both the generalised linear and linear regression models were used to analyse costs and health benefits respectively. The incremental cost-effectiveness ratio was calculated by dividing the difference in costs by the difference in QALYs.

RESULTS

263 dementia patients were recruited for this study. PCDC saw 99 patients while MC and other polyclinics saw 101 and 63 patients respectively. The highest cost driver among dementia patients was the indirect cost, contributing 47.7% to 60.9% of annual societal cost. Cost savings were observed in the direct medical and indirect costs (Figure 1). Multivariate analysis of cost, after adjusting for baseline data showed no differences in societal cost between MC vs PCDC or PCDC vs other polyclinics. However, at 12 months, the adjusted indirect cost for PCDC was 12% lower than that of MC and this was statistically significant (Table 1). Direct medical costs were also lower for PCDC compared to other polyclinics at 6 months and this was statistically significant.

Ordinary Least Square (OLS) regression to determine the mean incremental QALY, after adjusting for baseline data showed that at 12 months QALY for PCDC group was 0.07 higher than the MC group. Result was statistically significant. (Mean incremental QALY was -0.07 (95%CI: -0.12 to -0.018). There were no other differences in QALY for any other comparison after adjusting for baseline variables.

CONCLUSION

Our analysis shows no societal cost difference between MC, PCDC and other polyclinics. However, at 12 months, QALYs for the PCDC group were higher than the other groups. Patients attending PCDC had lower direct medical costs compared to other polyclinic patients at 6 months. Given these findings, setting up PCDCs in other polyclinics across Singapore could facilitate in providing good quality and cost effective integrated care thereby reducing the burden on dementia care specialists at the hospitals.

Figure 1 – Societal cost distribution at 6-month and 12-month

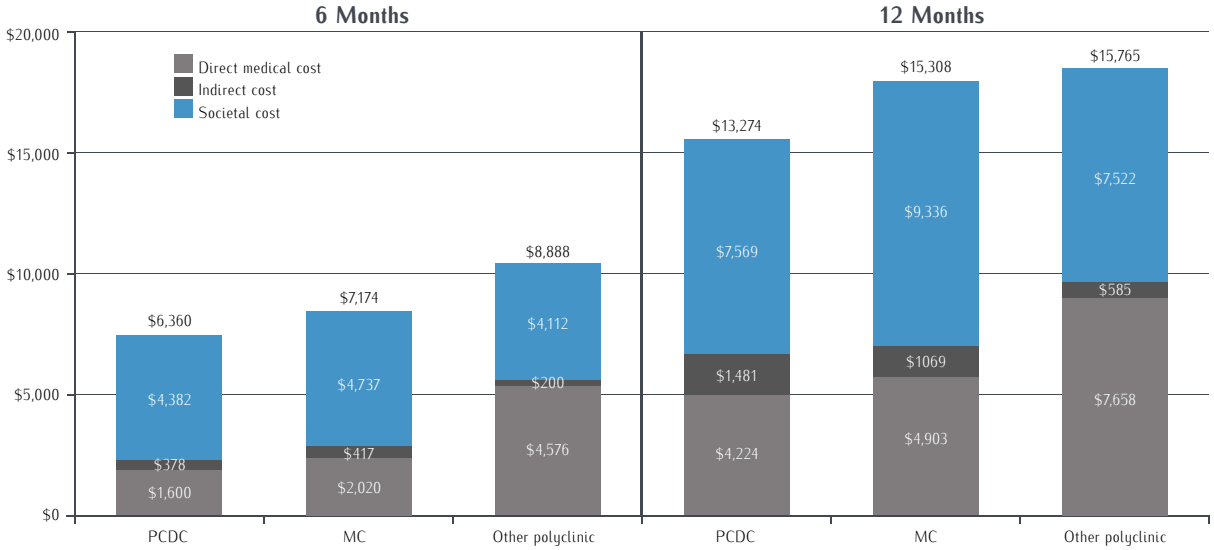

Table 1 – Multivariate analysis of cost at 6 month and 12 month follow up

Multivariate analysis of cost: Primary Care Dementia Clinic (PCDC) vs Memory Clinic (MC)				
Comparison	**Time**	**Rate ratio (CI)**	**Mean adjusted PCDC cost**	**Mean adjusted MC cost**
Direct medical cost	6-month	1.08 (0.89, 1.31)	$ 1,926 ($1,688 to $2,164)	$1,652 ($1,452 to $1,853)
	12-month	1.16 (0.87 to 1.54)	$ 4,897 ($4,249 to $5,545)	$4,512 ($3,820 to $5,204)
Indirect cost	6-month	0.92 (0.82 to 1.06)	$ 4,321 ($4,030 to $4,613)	$4,738 ($4,428 to $5,048)
	12-month	0.88 (0.78 to 0.99)*	$ 7,437 ($6,822 to $8,052)	$8,938 ($8,222 to $9,654)
Societal cost	6-month	0.97 (0.85, 1.10)	$ 6,467 ($6,138 to $6,795)	$6,885 ($6,532 to $7,237)
	12-month	0.98 (0.85, 1.13)	$ 13,446 ($12,617 to $14,275)	$14,284 ($13,298 to $15270)
Multivariate analysis of cost: Primary Care Dementia Clinic (PCDC) vs Other polyclinics				
Comparison	**Time**	**Rate ratio (CI)**	**Mean adjusted PCDC cost**	**Mean adjusted other polyclinic cost**
Direct medical cost	6-month	0.68 (0.34 to 0.98)*	$1,916 ($1,550 to $2,282)	$3,805 ($2,947 to $4,662)
	12-month	0.98 (0.47 to 2.05)	$4,639 ($4,063 to $5,215)	$6174 ($5,302 to $7046)
Indirect cost	6-month	1.08 (0.78 to 1.48)	$4,279 ($3,941 to $4618)	$3,727 ($3,320 to $4,135)
	12-month	1.03 (0.76 to 1.39)	$7,325 ($6,716 to $7,935)	$6,707 ($5,955 to $7,459)
Societal cost	6-month	0.89 (0.62, 1.28)	$6,426 ($5,921 to $7,132)	$7,716 ($7,066 to $8,365)
	12-month	0.99 (0.77 to 1.51)	$13,536 ($12,541 to $14,531)	$13,537 ($12,385 to $14,689)

* indicates significant difference at P =0.05
All models adjusted for baseline age, gender, marital status, comorbidities, agitation/aggression, Barthel score and CDR Global rating.

RETURN ON INVESTMENT OF BLENDED ADVANCE CARDIAC LIFE SUPPORT TRAINING COMPARED TO FACE-TO-FACE TRAINING IN SINGAPORE

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BACKGROUND

Internet adoption and computer usage at work and home in the past decade have provided opportunities for innovation in Advanced Cardiac Life Support (ACLS) training. With pressure on budgets across health care systems, there is a need for more cost-effective solutions. In the last decade, traditional ACLS training has evolved from passive to active learning technologies. The primary objective of this study is to compare the cost, cost-savings, return on investment of blended ACLS (B-ACLS) with a face-to-face ACLS (F-ACLS) in Singapore.

METHODS

B-ACLS and F-ACLS courses are offered in two training institutes in Singapore. Direct and indirect costs of training were obtained from one of the training provider. Major costs included hardware, software, maintenance, installation, training, and opportunity costs of forfeited income. Benefits of training include total savings if blended ACLS was used instead of F-ACLS and a reduction in travel cost.

RESULTS

The estimated annual cost to conduct B-ACLS and F-ACLS were S$60,017 and S$107,462 respectively. Discounted total cost of training over the life of the course (5 years) was S$138,781 for B-ACLS and S$400,138 for F-ACLS. Opportunity cost account for 53% and 21% of the costs among the F-ACLS and B-ACLS respectively. B-ACLS yielded a 162% return on the money invested; i.e., B-ACLS yielded $1.62 for every dollar spent. There would be 56% savings over the life of the course if B-ACLS was used instead of F-ACLS.

Table 1 – Course and cost characteristics for BACLS and ACLS training.

	BACLS	FACLS
Course characteristics		
Course duration (days)	0.5	1.5
Life expectancy of course (years)	5	5
Total number of learners per class	3	5
Number of classes per year	15	14
Total learners trained per year	45	70
Cost characteristics		
Fixed costs (annually)		
Programmer cost	$9,801.44	$3,833.28
Facility /hosting costs	$4,760.00	$9,520.00
Server set-up and maintenance cost	$3,000.00	-
Production costs*	$25,287.00	$23,000.00
Revision cost	$1,904.42	$5,366.66
Variable costs (annually)		
Instructor costs	$1,525.53	$5,125.49
Learners opportunity cost	$12,614.36	$57,117.02
Travel cost	$900	$2,800
Reading material costs	$225	$700
Total cost in SGD	$60,017.77	$107,462.45
Total cost of training over life of course in SGD	$138,781.33	$400,138.45

*Includes purchase of hardware, software,simulator equipment and internal labour cost, discount rate of 4% was used to compute cost of training over life of course (5 years).

Table 2 – Cost-saving and return on investment.

Savings & Return on investment (ROI)	
Total savings over life of course (SGD)	$225,299.40
Average savings per month (SGD)	$3,754.99
% savings over life of course	56%
ROI (total savings/total cost)	162%
Months to break even	36.96

CONCLUSION

The B-ACLS course provides significant cost savings to the provider and a positive return on investment. B-ACLS should be more widely adopted as the preferred mode of ACLS training, As a start, GPs looking for reaccreditation of the ACLS training should be encouraged to take B-ACLS instead of F-ACLS.

ECONOMIC FEASIBILITY OF PREVENTIVE PROGRAMS FOR PATIENTS AT-RISK OF CHRONIC DISEASE – A COST BENEFIT ANALYSIS APPROACH

Dr Meng Fanwen, Alex You Xiaobin, Palvannan R. K.

BACKGROUND

Patients who are at risk of a chronic disease may develop the irreversible chronic condition and subsequently complications. The morbidity and cost of the disease concerns patients, society and policy makers. Well intended programs are proposed to reduce the incidences or postpone the onset of chronic disease compared with current care models e.g. in a Diabetes Prevention Program, patients with pre-diabetes are educated, formed into peer groups, urged and given exercise programs. Policy makers would like to know the economic feasibility of a proposed intervention program that aims to reduce the incidences of the disease for patients who are at risk.

METHODS

Cost-benefit analysis was applied to assess program feasibility. The study period consists of two time periods, i.e., program implementation period and program effective period. From the start of effective period, patients will progress to the disease with a reduced incidence rate until end of the effective period. The benefits from the intervention were calculated as the total cost-savings due to the reduced disease progression during the study period. The costs of the intervention were a sum of a fixed program setup cost plus program operating cost. The disease incidence rate and cost factors were estimated based on the empirical data from the RHS database. Effective period and incidence reduction rate (IRR) are basically unknown prior to the program. A continuous time Markov model was developed to simulate the dynamic process of program implementation, disease progression and program effectiveness. This model is used to analyse the tradeoff between the effective period and IRR (incidence reduction rate for cost breakeven) during the study period. Based on the model, we can conduct what-if analysis to show the result when the assumed cost and benefit inputs are changed. Finally, an analytic web application is developed in R and Shiny.

RESULTS

By applying second-order Taylor expansion, we derived an analytical estimation of IRR in the case of no setup cost with a relatively short implementation period.

$$IRR = \frac{2}{\text{Incidence Rate} \times \frac{\text{Annual disease cost}}{\text{Program Cost}} \times \text{Effective period}^2}$$

In the above formula, 4 input parameters are relevant to IRR, i.e., disease cost, program cost, incidence rate without intervention and effective period. To reduce the dimensionality and facilitate decision-making, we can use the ratio of disease cost to program cost in analysis. So in this case, three input factors are needed to estimate IRR. The formula shows that the effective period would make a larger effect on incidence reduction than the factors such as disease incidence rate or the cost ratio. A sample data point is shown in Table 1. With an estimated yearly incidence rate of 8%, annual disease cost $2,400 and program cost of $140, we derived incidence reduction rate of 16.3% if effective period was assumed to be

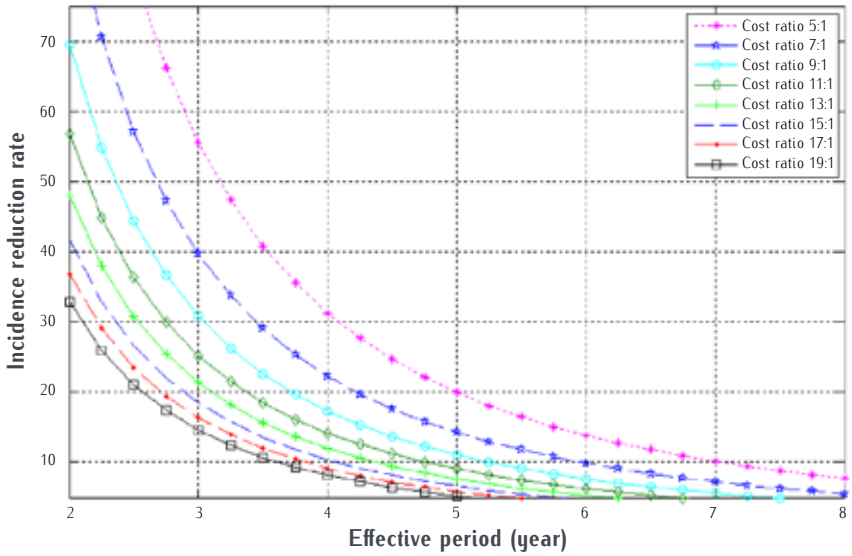
3 years, resulting in that incidence rate would reduce to 6.8% from the baseline incidence rate of 8%. Since 16.3% appears an achievable reduction target according to the reference, we suggest that the program is feasible for implementation.

Table 1 – An illustrative example

Description	Values
Disease cost ($/year per person)	2,400
Program cost ($/person)	140
Baseline incidence rate* (%)	8
Disease cost: Program cost ratio	17:1
Assumed effective period of study (year)	3
Incidence reduction rate to breakeven (%)	16.3
Reduced incidence rate (%)	6.8

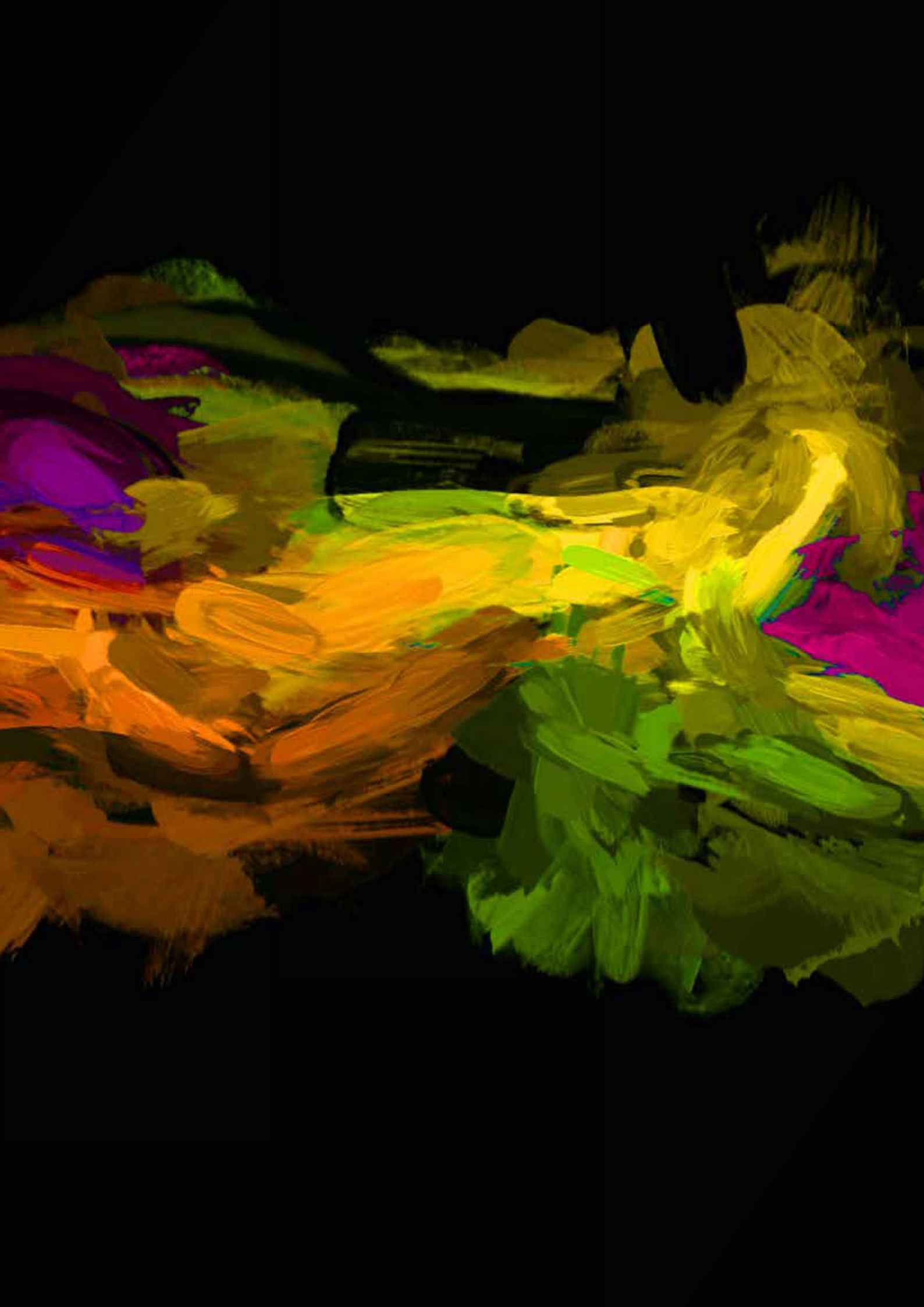
We analysed trade-offs between effective period and IRR using various cost ratios ranging from 5:1 to 19:1, as illustrated in Figure 1. For each cost ratio scenario, the curve represented the corresponding pairs of effective period and IRR for cost break-even. Decision makers may choose appropriate the appropriate operating curve for their context

Figure 1 – The trade-off between effective period and IRR with different cost ratios (incidence rate = 8%/year)



CONCLUSION

In this study, we developed a decision model and an analytic application to assess the economic feasibility of a program intervention using cost benefit analysis and continuous time Markov model. An analytical formula was obtained concerning two factors of interest, i.e., effective period and incidence reduction rate. This would facilitate decision makers to quickly assess the feasibility of an intervention.



PROJECTS

RESEARCH DESIGN & METHODOLOGIES

VIRTUAL REALITY ENVIRONMENTS FOR HEALTHCARE PROFESSIONAL EDUCATION – META ANALYSES

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BACKGROUND

Virtual reality environments (VRE) are a form of electronic learning (eLearning) which digitally replicate the real world and allow users to immerse themselves in their training, and learn through experience. We reviewed whether VRE based interventions help improve knowledge of healthcare professionals (HCPs) compared to other interventions, such as traditional learning approaches.

METHODS

A systematic review was conducted in accordance with the Cochrane Database of Systematic Reviews guidelines. Studies with sufficient homogeneity were pooled for meta-analysis. We searched the following databases: MEDLINE, EMBASE, the Cochrane Central Register of Controlled Trials (CENTRAL), PsychINFO, Educational Resource Information Centre (ERIC) (Ovid), Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Web of Science Core Collection. Databases were searched from January 1990 to August 2016. For all included studies, we searched reference lists. We also searched the lists of references of other relevant systematic reviews that were identified whilst running our electronic searches. Additionally we searched through trial registries (clinicaltrial.gov, and WHO ICTRP) for ongoing studies. VRE interventions were classified as 3D VRE on a computer screen, computer generated 3D models, 3D virtual reality room and head mounted displays.

RESULTS

A total of 31 studies assessed knowledge gain post intervention. Eighteen studies reported that the intervention was significantly better than the control group in terms of knowledge gain, two studies reported that the control group is better and 11 studies reported no significant difference in knowledge gain between intervention and control.

We were able to perform three meta-analyses of sufficiently homogenous studies. The first meta-analysis of two studies showed that virtual clinic/patients probably improved knowledge gain post-intervention compared to traditional learning (lectures) for pre-registration healthcare professionals (Standardised Mean Difference (SMD) 0.68 (95%CI: 0.42 to 0.94); I2 =0%; moderate quality evidence) (Table 1). The second meta-analysis of two studies showed

that computer generated 3D models probably improved knowledge gain post-intervention compared to 2D images (computer based) for pre-registration healthcare professionals (SMD 1.54 (95%CI: 1.23 to 1.85); I2 =0%;moderate quality evidence) (Table 2). Both studies used different tools to assess outcomes. The third meta-analysis of 8 studies showed that a 3D VRE on a computer may provide little or no difference in knowledge gain post-intervention compared to 2D images (paper or computer based) for pre-registration and post-registration healthcare professionals (SMD 0.10 (95%CI: -0.06 to 0.26); I2 =0%; low quality evidence).

CONCLUSION

Based on the results of the meta-analyses conducted in this review, it seems that virtual clinics/patients, probably improved knowledge in the short term for pre-registration healthcare professionals compared to traditional learning. Conversely, 3D VRE models probably do not improve short-term knowledge gain compared to either traditional learning or computer-based learning using 2D images.

Table 1 – Virtual clinics/patients vs traditional learning for pre-registration HCP knowledge gain

Study	VRE			Control			Weight	Standardised mean difference
	Mean	SD	Total	Mean	SD	Total		
LeFlore 2012	83.9	15	46	75	12	47	33.20%	0.65 [0.23, 1.07]
Succar 2013	16	1.8	95	14.6	2.2	93	66.80%	0.69 [0.40, 0.99]
Total (95% CI)			141			140	100.00%	0.68 [0.44, 0.92]
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.03$, df = 1 (P = 0.87); $I^2 = 0\%$								
Test for overall effect: Z = 5.54 (P < 0.00001)								

Table 2 – 3D model vs 2D images (computer-based) for pre-registration HCP knowledge gain (3D- vs 2D-based questionnaire)

Study	VRE			Control			Weight	Standardised mean difference
	Mean	SD	Total	Mean	SD	Total		
Beermann 2010	7.2	1.7	51	4.7	1.7	57	51.90%	1.46 [1.03, 1.89]
Muller-Stich 2013	8.1	1.6	52	5.4	1.7	53	48.10%	1.62 [1.18, 2.07]
Total (95% CI)			103			110	100.00%	1.54 [1.23, 1.85]
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.27$, df = 1 (P = 0.60); $I^2 = 0\%$								
Test for overall effect: Z = 9.81 (P < 0.00001)								

A NOVEL WAY TO VISUALISE AND ANALYSE CHRONIC DISEASE PATHWAY OF NEWLY DIAGNOSED DIABETES PATIENTS USING CHRONIC DISEASE REGISTRY

Teow Kiok Liang, Dr Gary Ang, Palvannan R K, Dr Nakul Saxena, Dr Yap Chun Wei, Dr Zhu Zhecheng

BACKGROUND

Large administrative data can complement clinical knowledge and provide insights to local patients' disease trajectory. Three healthcare clusters share the Chronic Disease Management System (CDMS) that provides rich information on patients' chronic conditions. In this study, we present a novel way to map the complex chronic disease trajectory of newly diagnosed Type II Diabetes patients.

METHODS

We used CDMS to identify retrospectively a cohort of patients who developed diabetes from 2007 to 2010, and had negative lab tests one year prior. We extracted their other diseases till 2015.

We divided the patients into 2 groups. Group 1 were patients without other diseases (excluding hypertension and hyperlipidaemia) prior to having diabetes and Group 2 who had conditions prior to diabetes. Process Mining (PM) was used to visualise the disease pathways.

RESULTS

There were a total of 13,549 patients (7,123 in Group 1) and 2,604 trajectories. The top trajectory (37%) was patients with only Diabetes. The next trajectory (4%) was patients who developed CKD3A.

The subsequent complications (%, median duration) from Group 1 included CKD3A (14%, 3.7yr), CKD4 (1.9%, 4.5yr), Anemia (12%, 2.8yr), CHD (7.0%, 2.8yr) and Stroke (3.5%, 2.8yr). The PM map also identified significant flows between Anemia and CKD3A.

For Group 2, the pre-existing or concurrent conditions included CKD3A (39%), CHD (31%) and Stroke (20%).

DISCUSSION & CONCLUSIONS

While there are limitations, this Process Mining study went beyond simple pairwise disease association and explored highly complex longitudinal disease sequences. Further work includes studying other cohorts and clustering of the trajectories to identify key segments for population management.

Notation: Number in node represents number of cases; number in arc represent number of instances and median duration in year. Only key flows are shown

Figure 1 – Group 1: Population with newly diagnosed diabetes in 2007 and without prior complications.

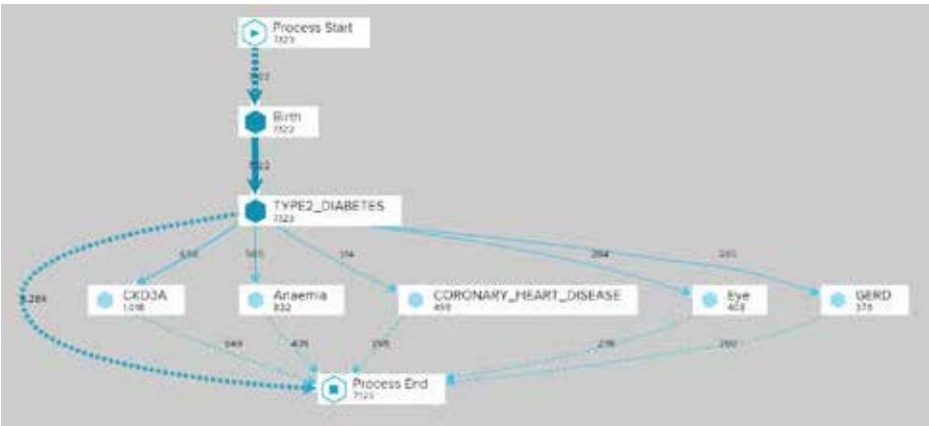
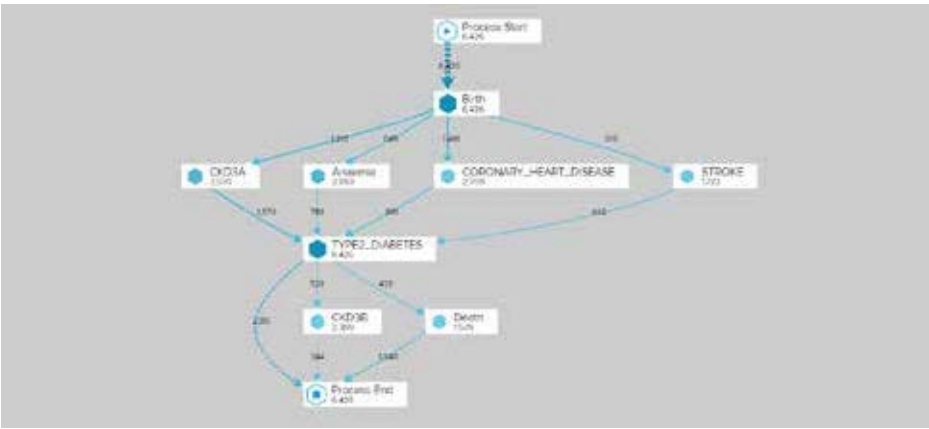


Figure 2 – Group 2: Population with newly diagnosed diabetes in 2007 and with prior complications.



DEVELOPING WEB APPLICATIONS FOR HEALTHCARE BIG DATA ANALYTICS WITH R AND SHINY PACKAGE

Alex You Xiaobin, Palvannan R K, Dr Meng Fanwen

INTRODUCTION

As machine learning methods are being applied on large scale data, interactive visualization becomes an indispensable technique to communicate complex model results and for better understanding. To build a web visualization software application requires effort and capability in the graphical design of web pages and setting up of server infrastructure. The Shiny package in R programming language provides a one-stop solution for backend data processing, interactive visualization design and web application deployment.

Shiny is a visualization package for developing dashboard and web applications. It is written in R language, and it balances customization and ease of use. Compared to other visualization packages, Shiny has: 1) advanced backend data processing function in a high level language, 2) well-designed aesthetics, 3) APIs to integrate other visualization packages, 4) a standard architecture for rapid deployment. A data analyst without a computer science background can develop and deploy a sophisticated interactive visualization application with R and Shiny. This article will cover the basic introduction of Shiny development and deployment.

SHINY ARCHITECTURE

UI & Server

Shiny has a concise architecture with two parts: ui.R and server.R.
The ui.R defines the user interface (UI) of the application. Developers can choose different types of input and output controls of the interactive visualization application. Input controls can be selection, slider, and free text. Output controls can be dynamic/static graph, table and free text. Pre-designed layouts and themes can be found in the package.

The server.R is the key component that defines the function of the application. It includes R functions that take input from ui.R, processes the data at the backend, and renders the result for viewing. The R Core for calculation allows developers using other data science libraries in R for advanced computing.

Appearance

The Shiny package provides different pre-designed layouts for choice. The basic layout divides the UI into header, sidebar and the main body. On the basic layout, the developer can apply the shinydashboard package for better aesthetics and advanced control customization. Other than the basic layout, developers can switch to flexdashboard for writing interactive technical reports.

API to other interactive visualization packages

The Shiny package has a wide range of choices to develop visualization content, since it is written in R language. Within R, developers can choose among popular visualization packages, such as lattice, ggplot2 and rgl. Nowadays, in CRAN (The Comprehensive R Archive Network), interactive visualization packages such as plotly, rcharts and googlevis are available. Different types of visualization output can be rendered to the UI according to the needs.

SHINY DEPLOYMENT

Shiny applications can be deployed to a web server for open access. The Shiny architecture has a secure-by-design feature that protects the data and source code from viewers' access. There are two ways to deploy a Shiny application: the Shiny server and shinyapps.io.

Shiny Server
Developers are able to set up and run a Shiny server locally to host its applications. The advantage of running a local server is that developers can build a live link between the local data source and the web application. Shiny server can be run on Unix OS. Currently, Rstudio is maintaining two versions of server packages: the open source version, the Shiny server and the commercial version, the Shiny server pro.

Shinyapps.io
Compared to setting up own Shiny server locally, it is relatively easier to deploy applications in shinyapps.io. The shinyapps.io allows developers to upload the applications to the cloud without the tedious effort in setting up a server. Besides, developers can manage all uploaded applications through the shinyapps.io dashboard.

APPLICATIONS OF SHINY IN NHG

Program feasibility analysis
In a study of program feasibility analysis, Shiny is used to develop a calculator with visualization. The calculator needs to take inputs of different program scenarios, conduct scientific calculation at the backend, and render dynamic charts as output. The R core fulfils the needs of logic and scientific calculation efficiently. So we can package an algorithm or a model for end user. See Figure 1 for screen snapshots.

Diabetes life table
Patient survival is a dynamic process. To present the survival of diabetes with all gender and age combination in a concise and intuitive way, Shiny allows viewer to key in variables and slice-and-dice the data. The dynamic pattern of survival is obvious when viewer changes the inputs. At the backend, it utilises the data processing functions in R, which simplifies the data preparation step. See Figure 2.

Figure 1 – Program feasibility analysis

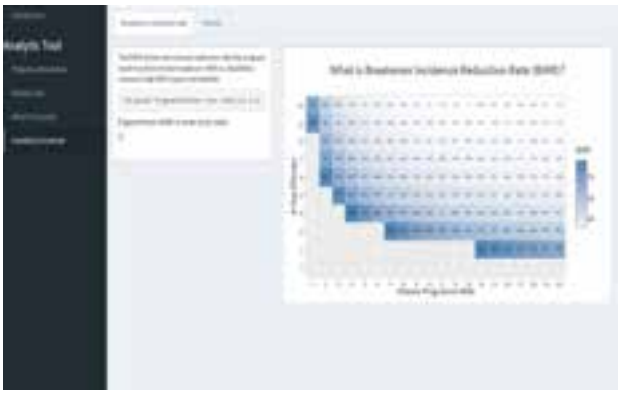
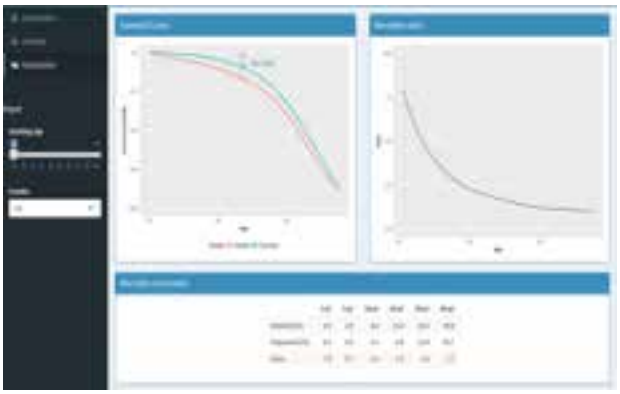


Figure 2 – Diabetes life table



CONCLUSION

Shiny is a package that integrates and standardises web application development. It assists data scientists in translating research results into visualizations and applications, and makes the development process more efficient. Policy makers and clinicians will also benefit from the customised applications for end use. The Shiny apps can provide cost effective and user-friendly solutions.

PUBLICATIONS

Original Articles

1. ***Zhu ZC***, ***Heng BH***, ***Teow KL***. Interactive data visualisation to understand data better: Case studies in healthcare system. International Journal of Knowledge Discovery in Bioinformatics 2014; 4 (2): 1-10.

2. ***Meng FW***, ***Teow KL***, *Ooi CK*, *Soh CKK*, *Tay SY*. Shift capacity planning for nursing staff in emergency department using mixed integer programming. Pacific Journal of Optimization 2016, 12(3): 635-648.

3. ***Meng FW***, ***Teow KL***, *Ooi CK*, ***Heng BH***, *Tay SY*. Minimization of the coefficient of variation for patient waiting system governed by a generic maximum waiting time policy. Journal of Industrial and Management Optimization 2017; DOI:10.3934/jimo.2017017.

4. ***Tan WS***, *Lee A*, *Yang SY*, *Chan S*, *Wu HY*, ***Ng CWL***, ***Heng BH***. Integrating palliative care across settings: A retrospective cohort study of a hospice home care programme for cancer patients. Palliative Medicine Feb 2016 [DOI: 10.1177/0269216315622126]

5. ***Ng CWL***, *Cheong SK*, *Govinda Raj A*, ***Teo WSK***, *Leong IYO*. End-of-life care preferences of nursing home residents: Results of a cross-sectional study. Palliative Medicine 2016, 9(30): 843-853.

6. ***Zhu ZC***. Application of geographical information system and interactive data visualization in healthcare decision making. International Journal of Big Data and Analytics in Healthcare 2016; 1(1): 49-58.

7. ***Saxena N***, ***George PP***, ***Heng BH***, *Lim TH*, *Yong SO*. Burden of Wet Age Related Macular Degeneration and its economic implications in Singapore in the year 2030. Ophthalmic Epidemiology 2016; 23(4): 232-237.

8. ***Ang YG***, ***Heng BH***, *Liew AST*, *Chong PN*. Annual all-cause mortality rate for patients with diabetic kidney disease in Singapore. Journal of Clinical & Translational Endocrinology 2016; 4: 1-6.

9. ***Ang YG***, ***Yap CW***, ***Saxena N***, ***Lin LK***, ***Heng BH***. Diabetes-related lower extremity amputations in Singapore. Proceedings of Singapore Healthcare: 1-5. DOI: 10.1177/2010105816663521.

10. ***Ge L***, *Mordiffi SZ*. Factors associated with higher caregiver burden among family caregivers of elderly cancer patients: a systematic review. Cancer Nursing. DOI: 10.1097/NCC.0000000000000445

Protocol

11. ***Saxena N***, *Kyaw BM*, *Vseteckova J*, *Dev P*, ***George PP***, ***Lim KTK***, *Kononowicz AA*, *Masiello I*, *Car LT*, *Konstantina C*, *Zary N*, *Car J*. Virtual reality environments for healthcare professional education (Protocol). Cochrane Database of Systematic Reviews 2016, Issue 2. Art. No.: CD012090. DOI: 10.1002/14651858.CD012090.

12. ***George PP***, *Toon E*, *Hadadgar A*, *Jirwe M*, ***Saxena N***, ***Lim KTK***, *Semwal M*, *Tudor Car L*, *Zary N*, *Lockwood C*, *Car J*. Online- and local area network (LAN)-based eLearning for medical doctors education (protocol). Cochrane Database of Systematic Reviews 2016, Issue 3. Art. No.: CD012108. DOI: 10.1002/14651858.CD012108.

AWARDS & GRANTS

Conference Presentation Awards

Singapore Health & Biomedical Congress 2016, Singapore
September 2016

BEST POSTER AWARD – BRONZE (Nursing)
Ge Lixia
Factors associated with higher caregiver burden among family caregivers of elderly cancer patients: a systematic review

Research Grants

MOH HSR NIG Grant

Understand the complex network of pre-diabetes, diabetes and complications: disease progression and trajectory modelling using big retrospective data sources

Dr Zhu Zhecheng *(Principle Investigator)*
Teow Kiok Liang *(Co-Investigator)*
Dr Gary Ang Yee *(Co-Investigator)*
Li Ruijie *(Co-Investigator)*
Dr Heng Bee Hoon *(Co-Investigator)*
Dr Lee Eng Sing *(Co-Investigator)*
Prof Federico Girosi *(Collaborator)*

Amount: $194,000

TRAINING & EDUCATION

15th Healthcare Operations Research Appreciation Course

January 2016
Speakers: ***Dr Meng Fanwen***
Dr Zhu Zhecheng
Palvannan RK
Teow Kiok Liang

Operations Research (OR) techniques are useful to determine the best course of action of a decision problem under limited resources. The science is in the maths and algorithms for addressing decision problems. It's an art as success in all the phases that precede and succeed the solution of a mathematical model, depends largely on the creativity and personal abilities of the decision maker. The 2-day course introduced OR concepts with healthcare applications. The focus was on building intuition around theory, walking through illustrative examples and demonstrating insights from results that will support and inform decision making.

Operational Research (a module in Introduction to Health Services Research, Masters of Clinical Investigation) for SSHSPH's MPH students and YLLSoM's MCI

January 2016
Speaker: ***Teow Kiok Liang***

Operations Research (OR) techniques are useful to determine the best course of action of a decision problem under limited resources. This introduction module focuses on process variability on resource requirements and waiting time. It gives the participants the theory and application of queueing theory in healthcare.

Healthcare Operations Research Appreciation Course for NUH

April 2016
Speakers: ***Teow Kiok Liang***

Operations Research (OR) techniques are useful to determine the best course of action of a decision problem under limited resources. This is the second run of 1-day workshop for NUH participants for the period 2015-2016.

1st and 2nd Using Big Data for Better Healthcare Course

May and Nov 2016
Speakers: ***Alex You***
Dr Joseph Molina
Dr Sun Yan
Dr Yap Chun Wei
Dr Zhu Zhecheng

This two-day short course introduces participants with basic concepts and methodology of using big data for better decision making in healthcare. The course focuses on practical issues on how to ask so-what healthcare questions; study design; data analytics, results presentation and implications for better healthcare. Case studies are also covered to illustrate the concepts and analytical methods. Guided hands-on sessions are provided to help participants apply techniques learned on solving practical problems.

CONFERENCE PRESENTATIONS

MAY — **International Society for Pharmacoeconomics and Outcomes Research (ISPOR) 21st Annual International Meeting, Washington D.C., USA**

1. **Ang YG**, **Heng BH**
   All-cause mortality of diabetes patients after lower extremity amputations

2. **Meng FW**, **Sun Y**, Leow KS Melvin
   Optimal treatment strategies in prevention of stroke and coronary heart disease among type 2 diabetes patients using Markov Decision Process

3. **Saxena N**, **George PP**, **Heng BH**, Lim TH, Yong SO
   Burden of wet age related macular degeneration in Singapore in the year 2030

JUNE — **2nd International Health Congress, London, UK**

4. **Yap CW**, **Heng BH**, Chong PN
   Estimating the risk of future emergency department (ED) visit due to asthma exacerbation during a doctor consult in a primary care setting

5. **GE L**, Mordiffi SZ
   Associated factors of subjective burden in family caregivers of elderly cancer patients: a systematic review

JULY — **Operational Research Applied to Health Services 2016 Conference, Pamplona, Spain**

6. **Teow KL**, Tan KB, Phua HP
   Applying gravity model to estimate demand of public hospital beds in Singapore

SEPTEMBER — **International Society for Pharmacoeconomics and Outcomes Research (ISPOR) 7th Asia-Pacific Conference, Singapore**

7. **Ang YG**, **Teow KL**, Tan KB, Phua HP
   Trend in HbA1C levels among primary care diabetes patients admitted to a tertiary hospital in Singapore in 2013

8. **Saxena N**, **Ang YG**
   Time to diabetes related complications from newly diagnosed diabetes in Singapore

Singapore Health & Biomedical Congress 2016, Singapore

9. **Teow KL**, **Ang YG**, **Palvannan RK**, **Saxena N**, **Yap CW**, **Zhu ZC**
A novel way to visualise and analyse chronic disease pathway of newly diagnosed diabetes patients using chronic disease registry

10. **George PP**, Zhabenko O, **Saxena N**, **Heng BH**, Car LT, Zary N, Lockwood C, Car J
Online and local area network (LAN)-based eLearning interventions for medical doctors' education – A systematic review diagnosed diabetes in Singapore

11. **GE L**, **Molina JDM**, Abisheganaden JA, Tan KL, **Heng BH**
Evaluation of the Virtual Hospital Programme at Tan Tock Seng Hospital

12. **GE L**, Mordiffi SZ
Factors associated with higher caregiver burden among family caregivers of elderly cancer patients: a systematic review

2nd Singapore International Public Health Conference & 11th Singapore Public Health & Occupational Medicine Conference

13. **Saxena N**, **Ang YG**
Time to diabetes complications for patients with newly diagnosed diabetes mellitus in Singapore

14. **Ang YG**, **Lin LK**, **Yap CW**, **Saxena N**
Effectiveness of diabetes foot screening in primary care in preventing lower extremity amputations

12th European Evaluation Society Biennial Conference, Maastricht, the Netherlands

15. **Molina JDM**, Ismail NH, **Heng BH**, Leong IYO
Effectiveness of a community-based falls prevention program for the elderly

DECEMBER **Australian Statistical Conference 2016 (in conjunction with Australasian Data Mining Conference & OZCOTS), Canberra, Australian**

16. **You XB**, **Saxena N**
The impact of obesity on years of life lost using structural equation modelling and healthcare big data

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. **Lim Teck Kiat Kenneth**
BCom (Hons Class 1)
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8. **Dr Meng Fanwen**
MSc (Operations Research), PhD (Operations Research)
Operations Research Specialist

9. **Michelle Jessica Pereira**
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MPhty (Sports Physiotherapy)
Senior Research Analyst

10. **Dr Nakul Saxena**
BPharm, PhD (Epidemiology)
Senior Research Analyst

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

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

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

14. **Reuben Ong**
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Research Assistant

15. **Dr Sun Yan**
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18. **Dr Yap Chun Wei**
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19. **You Xiaobin Alex**
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Statistician (Data Science)

20. **Dr Zhu Zhecheng**
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