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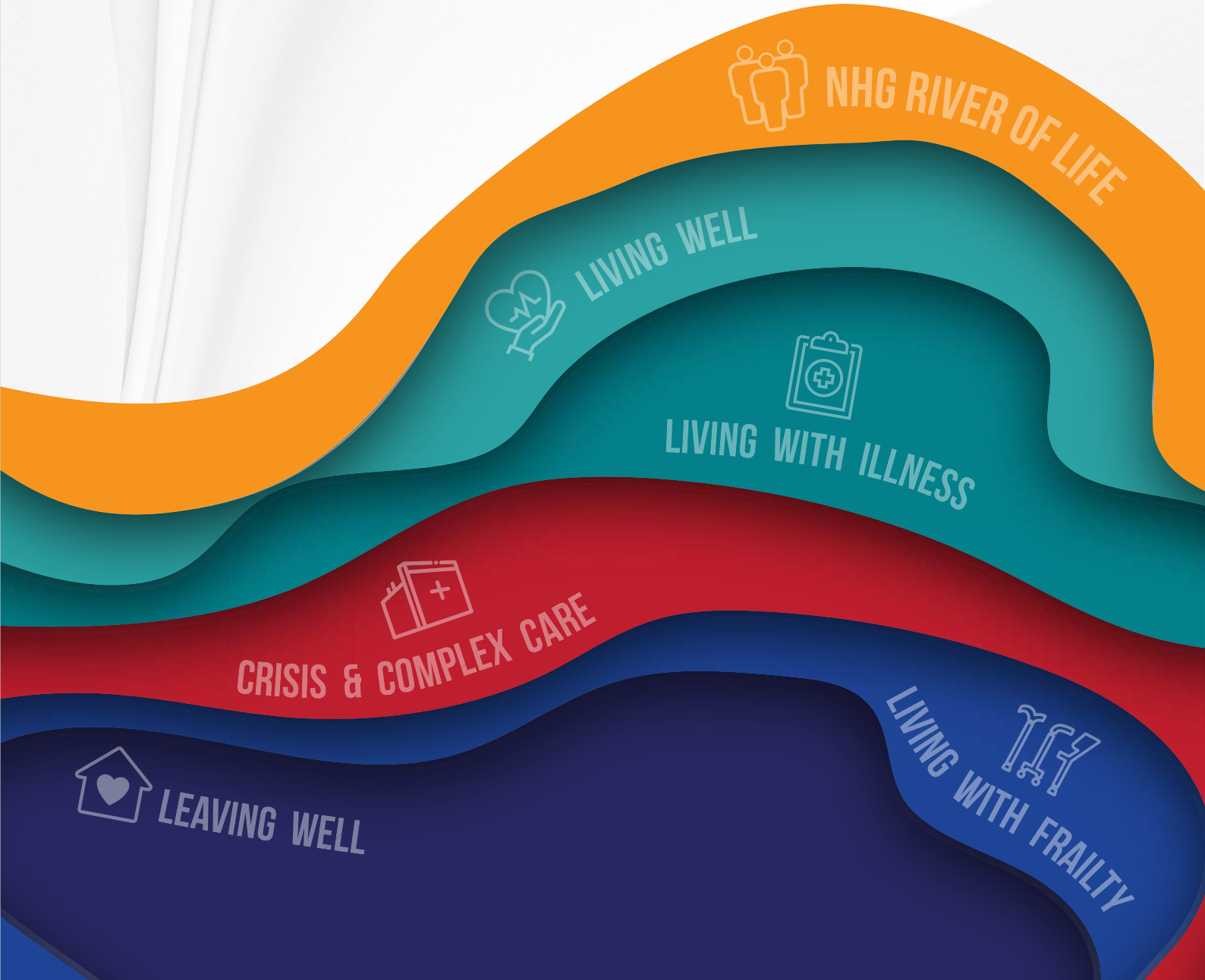
HEALTH SERVICES & OUTCOMES RESEARCH

ANNUAL REPORT 2019



FOREWORD

The **River of Life** is National Healthcare Group (NHG)'s segmentation of our population based on health needs. It broadens our perspective yet focuses our action. We are responsible for our population's health across a progressive spectrum of need from Living Well to Leaving Well, and accountable to deliver preventive and curative clinical care cost-effectively. As the framework crystallises within the NHG, HSOR's work in 2019 was aligned along these directions. The goal remains: to provide the best available evidence to senior management and clinicians for decision making; a mission made possible with the collaborations with and ownership of projects by stakeholders.

In a **Population Health Registry** of our central regional population, every patient is placed in one of the River of Life (RoL) segments, and their progression through various RoL segments is tracked longitudinally. In addition, a multi-phased longitudinal population-based survey had resulted in a summated **Population Health Index** (PHI), which defines an individual's state of health, based on multiple dimensions of health. Further qualitative inquiry to understand what makes an individual weather a health crisis, used a multi-dimensional approach to measure health resilience of our population.

This annual report highlights work that uncovered new or useful knowledge that impacts policy. As a health system, **predicting future healthcare utilization cost** is critical in population health management, yet individual patient cost prediction is challenging due to uncertainty in utilization, patient heterogeneity, cost variation and unobservable factors. Several quantitative models were tested for performance; and has resulted in a baseline reference for future prediction models. Singapore's demographic and epidemiological shifts, and workforce contraction have many older adults delaying retirement and working till older, majority of whom have chronic diseases. Beyond medical expenses, **health-related productivity loss** (HRPL) from chronic diseases translates to about 12% in productivity reductions from an employer's perspective. Policymakers, employers and clinicians need to bear HRPL in mind for cost-effective chronic disease management among working older adults.

Other abstracts covered programme evaluation and measurements, evidence synthesis, scoping reviews, cost-effectiveness analyses, prediction models, simulation and risk stratification tools to inform decisions and policy. We hope you find them interesting and useful.

PROFESSOR PHILIP CHOO
Group Chief Executive Officer
National Healthcare Group

OUR VISION

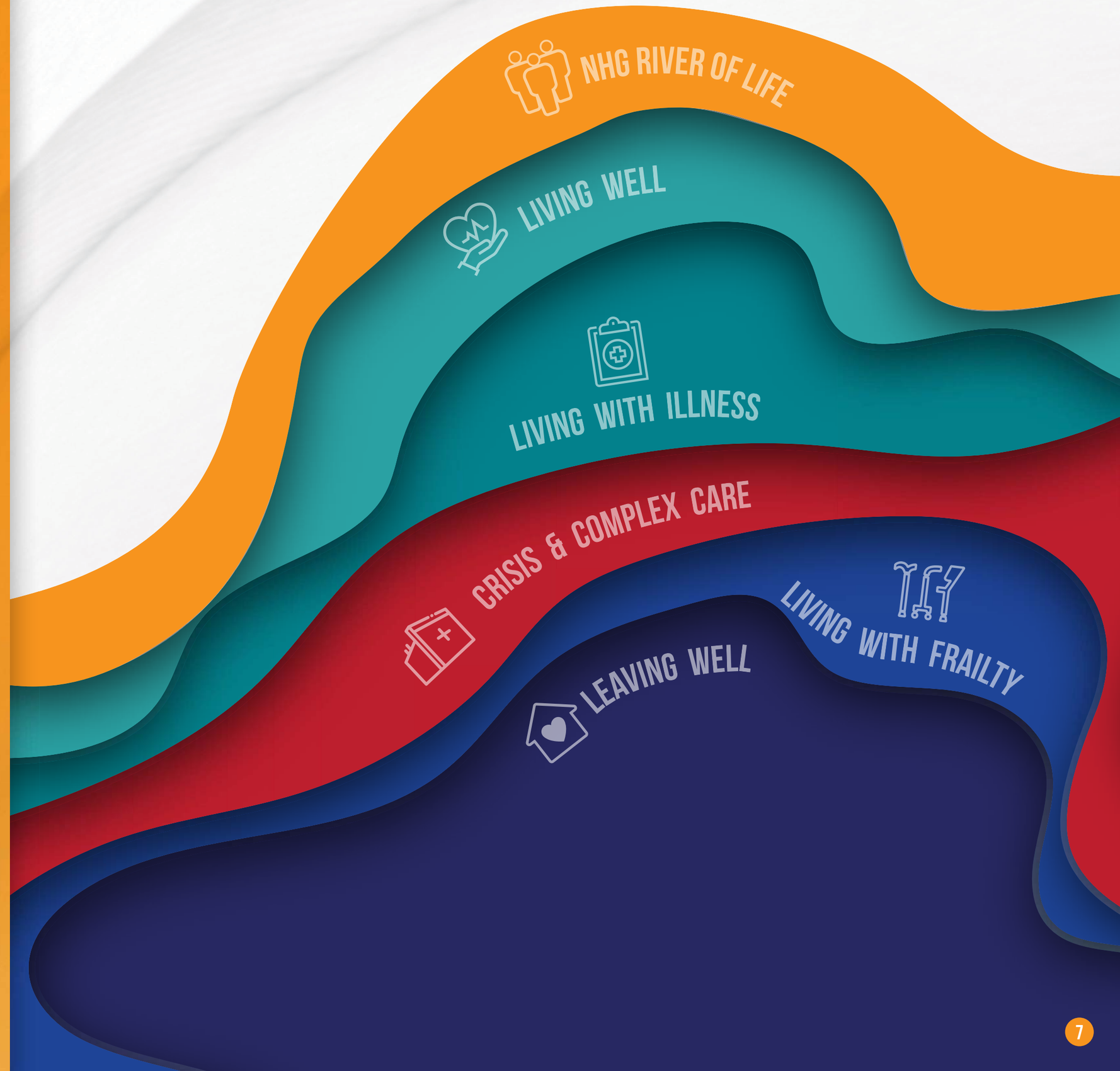
To add years of healthy life to the people of Singapore through excellence in Health Services Research.

OUR MISSION

To improve the quality of healthcare by providing best available evidence for decision making and knowledge translation; and build capacity and advance knowledge in Health Services Research.

CONTENTS

NHG RIVER OF LIFE



CREATING A RIVER OF LIFE REGISTRY: IDENTIFYING POPULATION SEGMENTS FOR POPULATION HEALTH MANAGEMENT

Dr Yap Chun Wei

HIGHLIGHTS

- **A registry for NHG population segments has been built and can be used to track outcomes for each segment.**

Introduction

The NHG River of Life (RoL) framework aims to help our population live well, at every stage of life, from Living Well, Living with Illness, Living with Frailty to Leaving Well. To facilitate care and tracking of outcomes for each population segment, it is important to be able to assign each person to a particular population segment. This article describes a registry for these population segments and outlines the definition for each population segment.

Methods

The RoL registry tracks the progression of a person through the various population segments longitudinally. At birth, a person is assumed to be in the Living Well segment. The registry records the date of progression to another segment. Progression is assumed to be unidirectional, that is a person can only progress from Living Well to Living with Illness, then to Living with Frailty and finally to Leaving Well. While a person could skip certain population segments, reverting to earlier population segments is not allowed (e.g. from Living with Illness to Living Well is not allowed). The criteria for each population segment is listed below. For each segment, the date of progression is the date in which the respective criteria is met.

Living with Illness (any of following):

- Diagnosed with any of the 20 Singapore Ministry of Health Chronic Disease Management Programme conditions (anxiety, asthma, bipolar disorder, benign prostate hyperplasia, chronic obstructive pulmonary disease, dementia, depression, diabetes, dyslipidaemia, epilepsy, hypertension, ischaemic heart disease, nephrosis/nephritis, osteoarthritis, osteoporosis, Parkinson, psoriasis, rheumatoid arthritis, schizophrenia, stroke).
- Diagnosed with cancer, heart failure and/or chronic kidney disease Stage 3A to 5.
- Diagnosed with mild, moderate or severe frailty using the electronic frailty index.

Living with Frailty (all of the following must be met):

- Age 65 and above.
- Diagnosed with mild, moderate or severe frailty using the electronic frailty index.
- History of Medifund use or public assistance requirement, CHAS Blue status, or rental flat housing.

Leaving Well (any of the following):

- Discharge to Hospice from specialist outpatient clinics, emergency department, day surgery or inpatient episodes.
- Referral to palliative care, identified using administrative service codes.
- Referral to palliative care, identified using TTSH palliative medicine referral list.
- Non-accidental deaths, identified using causes of death that are in Agency for Healthcare Research and Quality chronic conditions indicator list.

The date of progression to Leaving Well in the case of non-accidental deaths without prior discharge to hospice or referral to palliative care, is defined as 1 year before date of death.

Results

As of 1 January 2018, the number and percentage of Singaporeans/Permanent Residents living in NHG regions known to NHG in Living Well, Living with Illness, Living with Frailty and Leaving Well are 962,242 (68.1%), 410,696 (29.1%), 32,553 (2.3%) and 6,610 (0.5%), respectively. The total healthcare utilization of these population segments in 2018 are $275.9M (18.2%), $887.3M (58.5%), $240.7M (15.9%) and $113.5M (7.5%), respectively. After 1 year, the progression of this population is shown in Table 1.

Table 1. Population segment progression of Singaporean/Permanent Residents living in NHG regions in 1 year

		2019				
		Living Well	Living with Illness	Living with Frailty	Leaving Well	Died
2018	Living Well	924,005 (96.16%)	35,781 (3.72%)	278 (0.03%)	291 (0.03%)	500 (0.05%)
	Living with Illness	N.A.	398,770 (97.10%)	9,238 (2.25%)	1,131 (0.28%)	1,557 (0.38%)
	Living with Frailty	N.A.	N.A.	31,194 (95.83%)	515 (1.58%)	844 (2.59%)
	Leaving Well	N.A.	N.A.	N.A.	718 (10.86%)	5,892 (89.14%)

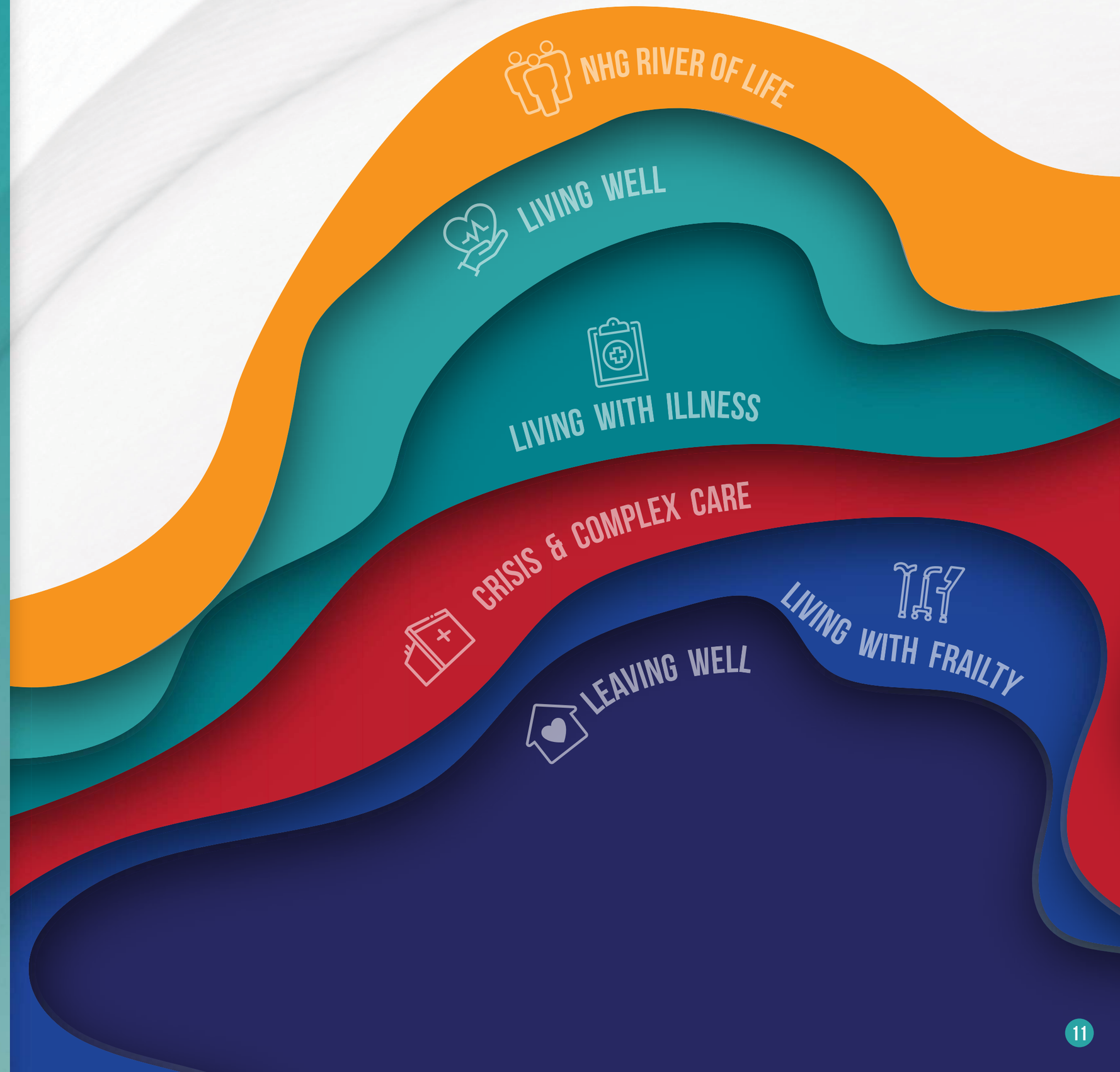
*Percentages shown are row percentages.

Conclusion

A population registry with clearly outlined definitions for each population segment has been built and can be used to track each segment's outcomes for population health management.

LIVING WELL

A focus on healthy individuals and population health management



DEVELOPMENT OF A NOMOGRAM FOR PREDICTING 1-YEAR INCIDENCE RISK OF HYPERTENSION

Reuben Ong, Dr Pradeep Paul George, Dr Heng Bee Hoon

HIGHLIGHTS

- **A nomogram was generated for the 1-year risk of hypertension diagnosis based on survival analysis hazard ratios.**
- **The degree of each risk factor's contribution to the increased risk of hypertension diagnosis is clearly delineated.**

Introduction

Administrative databases carry a wealth of information over time at the individual level. This allows us to conduct survival analysis and study the impact of risk factors on being diagnosed with diseases. However, despite multiple studies done on prevalent diseases like hyperlipidaemia, diabetes mellitus and hypertension, information is not made readily accessible for convenient use by frontline clinicians. Our study not only studies the risks of being diagnosed with hypertension but also provides quick reference charts for easy clinical use.

Methods

A total of 7491 individuals who attended a community health screening and self-reported to be free of chronic disease without prior diagnosis in administrative databases were retroactively followed up for a year from their first screening date. Demographic and clinical measurements (blood pressure, height, weight, blood panel) data of these individuals was used to build a Cox survival regression model for the 1-year risk of being diagnosed with hypertension. A nomogram was then compiled from the Cox survival hazard ratios. Besides a corporeal tool, an online browser-based web application was also implemented.

Results

We developed a nomogram to ascertain an individual's risk of being diagnosed with hypertension in the following year (Figure 1). Upon screening, an individual's data-point on each risk factor scale corresponds to a score, and the total of all the risk factor scores is associated with the probability of that individual developing hypertension in the coming year. The web application interface included a graphical depiction of the probability of disease over the follow up period (Figure 2).

Conclusion

Nomograms can be utilised in the clinical setting to inform patients of their current risks and the degree to which they can lower their risks by making lifestyle changes that would minimise their risk factors. The same procedure can be applied for other diseases or groups of diseases of interest to produce nomograms for quick reference use.

Figure 1. Nomogram for 1 year hypertension risk

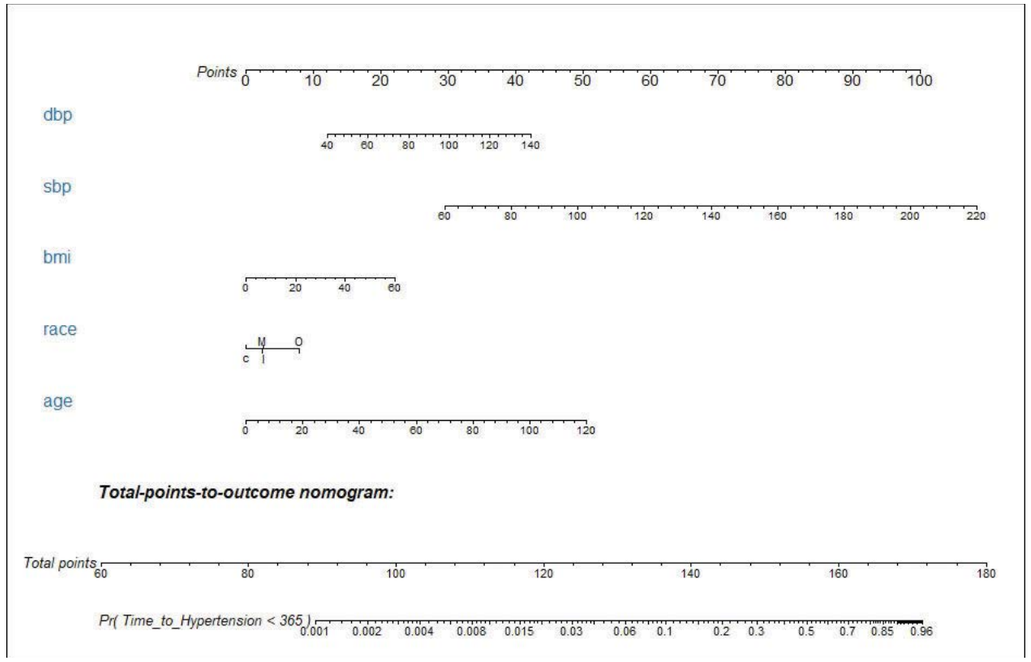
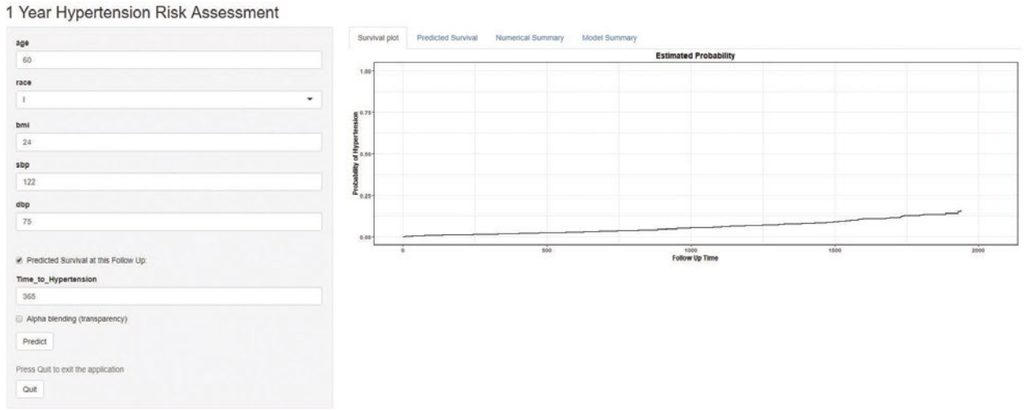


Figure 2. Web based application for nomogram



ANTHROPOMETRIC PREDICTORS OF INCIDENT DIABETES, HYPERTENSION AND HYPERLIPIDAEMIA AMONG HEALTH SCREENING PARTICIPANTS IN SINGAPORE

Dr Pradeep Paul George, Reuben Ong, Dr Heng Bee Hoon

HIGHLIGHTS

- **All five anthropometric measures are equally good at predicting incident diabetes.**
- **Body Mass Index and waist circumference outperformed other anthropometric measures for predicting hypertension and hyperlipidaemia.**

Introduction

Obesity is a well-established risk factor for many chronic diseases. Studies suggest anthropometric measurements that describe central fat distribution are superior in predicting chronic diseases compared to measurements of general adiposity. However, this issue remains controversial. The early identification of at-risk individuals, prior to the onset of disease, is important in planning health screening frequency and interventions to prevent chronic diseases. The aim of this study was to assess the ability of anthropometric measurements to identify people at risk of developing hyperlipidaemia, diabetes or hypertension; and estimate their predictive accuracies.

Methods

Anthropometric measures of adiposity comprising of body mass index (BMI), waist circumference (WC), estimated body fat percentage (BF %), weight adjusted waist index (WWI) and waist to height ratio (WHeiR) were collected through a community health screening program in a tertiary hospital. The ability of these measures to predict risk of diabetes, hypertension, hyperlipidaemia and any combination were assessed by Cox proportional hazards analysis, adjusting for demographics and biomarker levels. The models were then evaluated using ROC curve analysis.

Results

A total of 7,491 people were included in the analysis (Table 1). Across disease models (Table 2), the anthropometric measures performed best in predicting incident diabetes with Area Under the Curve (AUC) values ranging between 0.844 (WC) and 0.846 (BF%); followed by predicting incident hypertension with AUCs ranging between 0.789 (BF%) to 0.798 (WC); and lastly in predicting incident hyperlipidaemia (AUCs: 0.706 (BF%) – 0.730 (BMI, WC, WHeiR). The AUCs for predicting incidence of any of the 3 chronic conditions are 0.762 for BMI, 0.762 for WC, 0.754 for estimated body fat, 0.759 for WWI, and 0.761 for WHeiR.

There were no statistically significant differences in AUCs between BMI, WC, and WHeiR for any of the disease models tested (hyperlipidemia, diabetes, hypertension, any of the 3 diseases). BF% and WWI had significantly lower AUC than other anthropometric measures for predicting incident hyperlipidaemia or any of the 3 diseases. BF% also performed worse in predicting incident hypertension. However, BF% had the lowest Akaike Information Criterion (AIC) values across the disease models, showing a better goodness of fit of the model to the data used to derive it (internal validity).

Conclusion

All five anthropometric measures are equally good at predicting incident diabetes, however, BMI and WC outperformed the other measures when it comes to predicting hypertension and hyperlipidaemia.

Table 1. Sample Demographics

Variables	Categories	Overall 7,491 (100%)	DM 70 (0.9%)	HTN 338 (4.5%)	HLP 242 (3.2%)	Any disease 526 (7.0%)
Age	Mean ± SD	52.9 (9.3)	58.0 (9.5)	59.8 (10.1)	58.9 (10.1)	59.1 (10.0)
Gender	Males	2135 (28.5%)	23 (32.9%)	128 (37.9%)	102 (42.1%)	200 (38.0%)
Race	Chinese	6464 (86.3%)	53 (75.7%)	277 (82.0%)	194 (80.2%)	427 (81.2%)
	Malays	462 (6.2%)	8 (11.4%)	36 (20.7%)	19 (7.9%)	51 (9.7%)
	Indians	345 (4.6%)	6 (8.6%)	14 (4.1%)	18 (7.4%)	29 (5.5%)
	Others	220 (2.9%)	3 (4.3%)	11 (3.3%)	11 (4.5%)	19 (3.6%)
BMI	Mean ± SD	22.8 (3.8)	25.8 (4.7)	24.1 (4.5)	24.3 (4.5)	24.2 (4.5)
WC	Mean ± SD	80.8 (10.1)	88.4 (11.3)	85.5 (10.7)	86.1 (10.5)	85.6 (10.6)
BF%	Mean ± SD	39.4 (6.7)	43.5 (6.9)	42.6 (7.0)	43.1 (7.0)	42.5 (7.0)
WWI	Mean ± SD	10.6 (0.7)	10.9 (0.7)	10.9 (0.7)	10.9 (0.7)	10.9 (0.7)
WHeiR	Mean ± SD	50.4 (6.1)	55.5 (7.3)	53.5 (6.7)	53.6 (6.7)	53.4 (6.7)

*DM: Diabetes; HTN: Hypertension; HLP: Hyperlipidemia

Table 2. Model comparison of continuous anthropometric measures

	AUC				AIC			
Measure	DM	HTN	HLP	Any disease	DM	HTN	HLP	Any disease
BMI	0.845	0.795	0.730	0.762	909.8	4560.5	3580.6	7954.8
WC	0.844	0.798	0.730	0.762	912.5	4555.0	3579.4	7947.9
BF%	0.846	0.789[a]	0.706[a]	0.754[a]	868.5	4407.6	3433.5	7627.6
WWI	0.846	0.795	0.722	0.759	914.2	4559.6	3584.7	7956.3
WHeiR	0.845	0.797	0.730	0.761	911.2	4555.1	3576.7	7947.9

*DM: Diabetes; HTN: Hypertension; HLP: Hyperlipidemia
[a] AUC of Estimated body fat percentage is significantly different from other measures within the same outcome model

A LITERATURE REVIEW ON EXISTING RESILIENCE ASSESSMENT TOOLS

Chieh Pann Pei, Eric Chua Siang Seng, Ge Lixia, Dr Yip Wan Fen, Dr Tan Woan Shin

HIGHLIGHTS

- **A multi-dimensional approach should be adopted for measuring health resilience.**
- **Six potential dimensions were identified from existing resilience tools, which are attitudes, characteristics, coping and adaptation, external supports, resources, trust and commitment.**

Introduction

Various community-based programmes have been initiated in Singapore to promote health and wellness of the community, aiming to strengthen community health resilience. However, measuring community resilience is challenging. While there are several resilience tools available, none of the existing resilience tools measure health-centric resilience from an individual's perspective. Therefore, a lack of assessment method makes it difficult to measure how effective community-focused policy and projects are. Hence, the aim of this literature review was to examine the multi-dimensional concept of resilience as defined by existing resilience tools. Findings from this literature review can guide the development of a health-centric resilience tool.

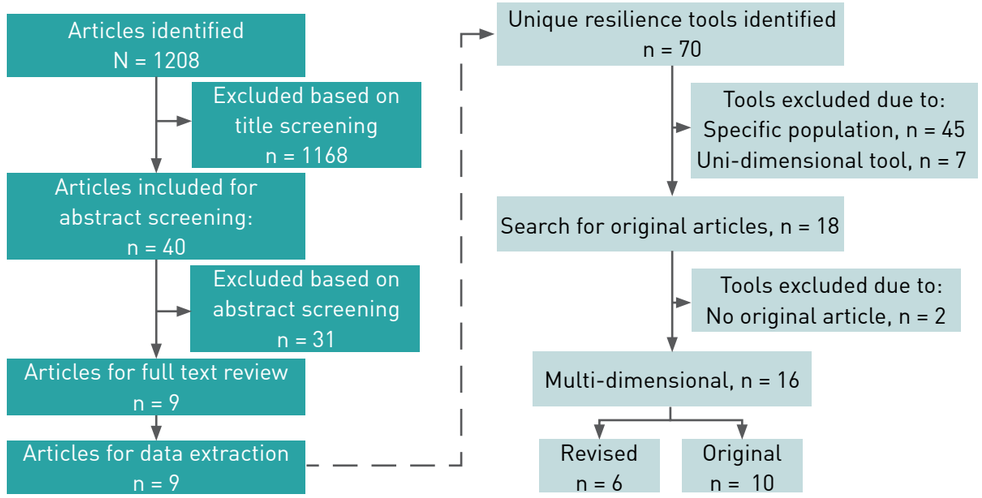
Methods

A PubMed search on reviews and systematic reviews was conducted on October 2019 using key words of 'resilience', 'tool', 'scale', 'technique', 'instrument', 'index', 'measur*' and 'assess*'. Only review articles which involved human subjects and published in English over the past ten years were included. Titles and abstracts of the identified articles were screened, and full text were further assessed if necessary. Resilience tools reviewed in the final articles were identified and their relevant articles reviewed were retrieved. Relevant data (e.g. Author, year, study population, name, dimensions and items of the tool, purpose of the tool) were extracted from the retrieved articles using a pre-developed data extraction form. Only multi-dimensional resilience tools developed for the general population were included in this review. Resilience tools that are uni-dimensional, developed explicitly for adolescents, caregivers, specific diseases and vulnerable populations, or only measures overlapping concepts (coherence, transcendence, coping, life purpose) but not resilience per se were excluded.

Results

The search yielded a total of 1,208 articles. After screening, 9 articles remained for full text review and data extraction. A total of 70 unique resilience tools were identified. Of these, 52 were excluded based on our above exclusion criteria. A manual search for the original articles of the remaining 18 tools was subsequently conducted but we were unable to retrieve two tools from the original articles. Finally, 16 multi-dimensional tools (including 6 revised tools) were retained for data extraction (Figure 1).

Fig 1. Flow Diagram of Article Selection and Tool Identification



A total of 59 questionnaire items falling under six domains were collated from the 16 multi-dimensional tools (Table 1). These questionnaire items were then segregated into respective dimensions based on their similarity and the authors' descriptions of the individual indicators (Figure 2).

Table 1. Dimensions and number of questionnaire items

Dimensions	Questionnaire items
Characteristics	18
Coping & Adapt	15
Attitude	12
External supports	10
Resources	2
Trust and commitment	2
Total	59

Fig 2. The 6 Dimensions covered by Resilience Tools

Conclusion

Resilience is a multi-dimensional construct. From our review, a total of six potential dimensions were identified from existing resilience tools. This information can be used as a reference guide during the development of a health-centric resilience tool.

AGE DIFFERENCES IN THE RELATIONSHIPS BETWEEN INDICATORS OF SOCIOECONOMIC STATUS AND SOCIAL ISOLATION

Ge Lixia, Dr Tan Woan Shin, Dr Yap Chun Wei, Dr Heng Bee Hoon

HIGHLIGHTS

- **Each socioeconomic indicator studied showed a clear gradient with social isolation and significant age disparities were found in those relationships.**

Introduction

Socioeconomic status (SES) is a crucial determinant of health. However, little is known whether the associations between different indicators of SES and social isolation vary across ages. This study examined the associations between individual SES indicators and social isolation across age groups: young (21-44), middle-aged (45-64), and older adults (≥65).

Methods

Cross-sectional data of 1,930 representative community-dwelling adults was obtained from the Population Health Index (PHI) survey conducted in the Central Region of Singapore. The 6-item Lubben Social Network Scale was used to identify social isolation using the cut-off score of ≤12. Five SES indicators were measured: education level, employment status, personal income in SGD, flat type and self-perceived monetary sufficiency. Separate logistic regressions were conducted to examine the association between each SES indicator and social isolation (Model 1 adjusted for demographics, Model 2 adjusted for demographics and the other four SES indicators) in each of the three age groups.

Results

Substantial differences in the proportion of isolated individuals were observed across the three age groups where 13.8%, 27.5% and 45.4% were socially isolated among those aged 21-44 years, 45-64 years and 65 years and above, respectively.

Each SES indicator showed a clear gradient with social isolation. Modelling results (Table 1) showed that education level, personal income, and self-perceived monetary sufficiency were associated with social isolation in young adults; education level, employment status, personal income, flat type and self-perceived monetary sufficiency were associated with social isolation in middle-aged adults; and flat type and self-perceived monetary sufficiency were associated with social isolation in older adults.

Conclusions

The influence of individual SES indicators on social isolation varied across age groups. Therefore different SES indicators and specific interventions are needed to address social isolation for different age groups.

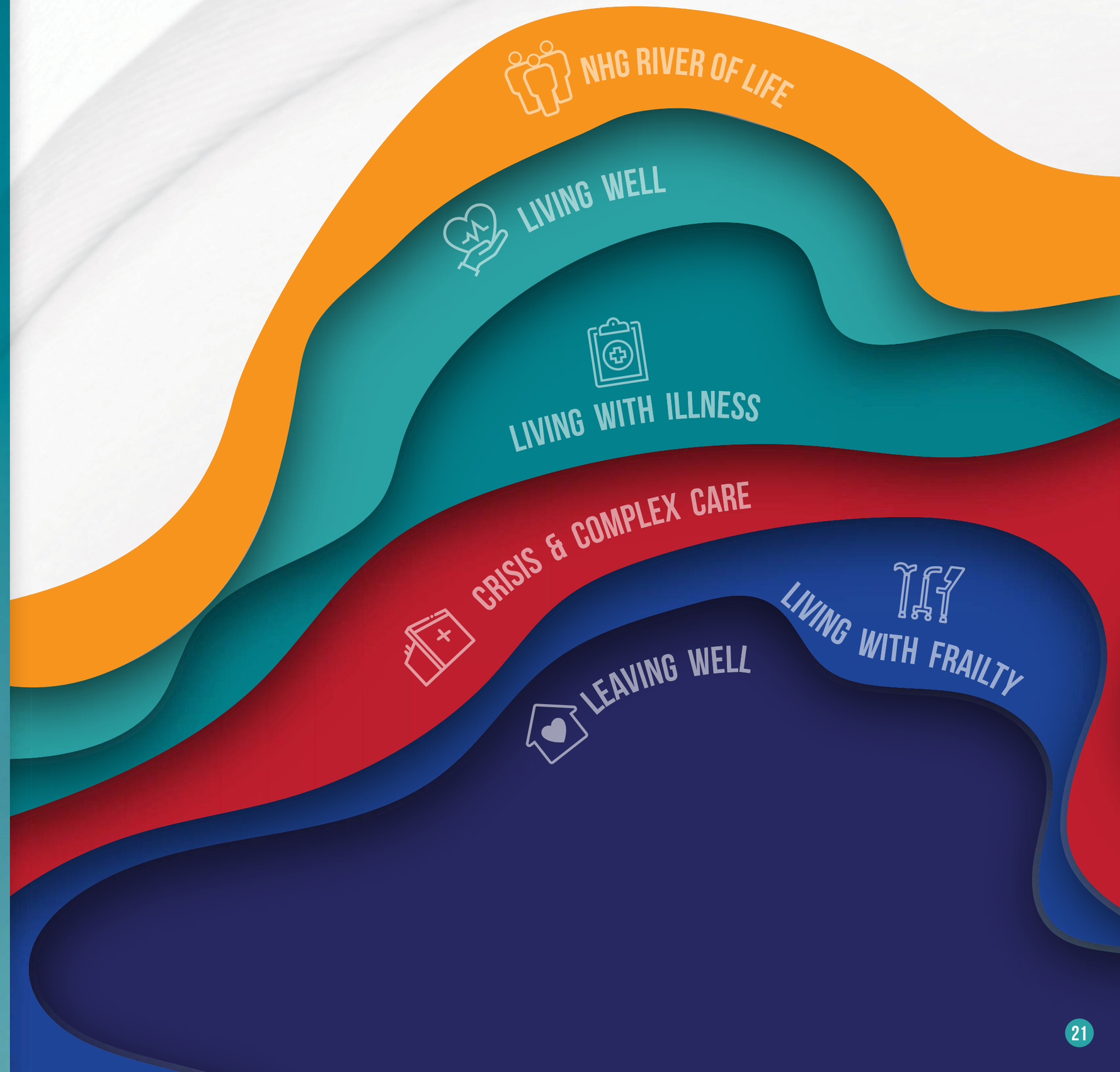
Table 1. Average marginal effects (AMEs)% and model fit for social isolation across ages

Socioeconomic variables	Young adults (n=657)		Middle-aged (n=776)		Older adults (n=497)	
	AME%	OR	AME%	OR	AME%	OR
Education level (Ref: High)						
Model 1+	R^2 change =8.0%*		R^2 change =8.4%		R^2 change =2.3%	
Middle	**17.8**	**3.7**	**12.2**	**2.2**	5.3	1.3
Low	**29.4**	**6.5**	**32.1**	**5.6**	18.8	2.3
Model 2++	R^2 change =1.6%**		R^2 change =0.6%		R^2 change =0.4%	
Middle	**10.3**	**2.4**	4.5	1.3	-2.7	0.9
Low	11.1	2.5	**11.3**	**2.0**	4.0	1.2
Employment status (Ref: Employed)						
Model 1	R^2 change =1.0%		R^2 change =3.6%		R^2 change =0.6%	
Inactive	4.52	1.4	-0.7	1.0	-6.2	0.8
Unemployed	**14.4**	**2.6**	**36.7**	**5.1**	5.5	1.3
Model 2	R^2 change = -0.2%		R^2 change =1.7%		R^2 change =0.3%	
Inactive	-3.7	0.7	-4.5	0.8	-6.0	0.8
Unemployed	1.2	1.1	**21.9**	**3.2**	-5.2	0.8
Personal income (Ref: ≥5,001)						
Model 1	R^2 change =11.2%		R^2 change =11.9%		R^2 change =0.3%	
1,501-5,000	**7.7**	**3.0**	**12.6**	**3.1**	12.2	1.8
≤1,500	**24.8**	**9.5**	**32.6**	**8.6**	16.4	2.1
Model 2	R^2 change =3.5%		R^2 change =1.7%		R^2 change =0.1%	
1,501-5,000	4.9	1.9	8.6	1.9	6.5	1.4
≤1,500	**18.7**	**5.4**	**16.3**	**3.0**	5.5	1.3
Flat type (Ref: 5-room&above)						
Model 1	R^2 change =3.9%		R^2 change =10.0%		R^2 change =5.8%	
3-/4-room	**7.4**	**2.1**	**14.1**	**2.4**	10.7	1.6
1-/2-room	**17.9**	**4.1**	**51.9**	**12.5**	**38.9**	**5.6**
Model 2	R^2 change =0.6%		R^2 change =1.7%		R^2 change =2.3%	
3-/4-room	3.3	1.4	6.8	1.6	6.3	1.3
1-/2-room	-0.8	0.9	**29.4**	**4.8**	**26.7**	**3.4**
Self-perceived monetary insufficiency (Ref: No)						
Model 1	R^2 change =5.5%		R^2 change =7.4%		R^2 change =9.0%	
Yes	**21.7**	**4.0**	**32.7**	**4.5**	**35.8**	**5.0**
Model 2	R^2 change =1.5%		R^2 change =2.4%		R^2 change =6.7%	
Yes	**11.4**	**2.4**	**18.7**	**2.7**	**31.8**	**4.3**

Results in bold: p<0.05
+ Model 1 adjusted for age groups, gender, ethnicity, marital status and living arrangement.
+ + Model 2 adjusted for variables in Model 1 + other four non-outcome SES indicators
* McKelvey & Zavoina's pseudo-R2 change compared to the basic model without that specific indicator of SES
** McKelvey & Zavoina's pseudo-R2 change to model 2 attributed to that specific indicator of SES

LIVING WITH ILLNESS

A focus on patients with specified diseases who do not require hospitalisation or complex medical care



PREDICTING 1-YEAR HEALTHCARE COST OF PRIMARY CARE PATIENTS

Palvannan R.K., David Kok Hwa Chieh[1]
[1] National Healthcare Group Polyclinics

HIGHLIGHTS

- **Historical usage is a significant predictor of future healthcare utilization cost.**
- **Quantitative prediction models have better accuracy than simpler intuitive ones, but have a large relative error of 90% and classification accuracy of only 47%.**
- **2-step regressions are insightful in predicting those with utilization (AUC=0.87), while decision tree models are robust to outliers and discontinuous cost distribution.**

Introduction

Individual patient cost prediction is challenging due to the uncertainty in utilization, patient heterogeneity, cost variation and unobservable factors. Literature shows that recent past cost strongly predicts short-term cost, and additional clinical information may help to identify high-cost patients. Our study aimed to predict 1-year cost of primary care patients and compare the performance of several modeling approaches.

Methods

Resident patients ≥ 21 years of age who visited Ang Mo Kio Polyclinic (AMKP) at least once for acute/chronic illness between 2014 – 2016 were first studied. Their utilization cost data at hospitals/polyclinics in 2017 was extracted and fitted to predictive models with a 70/30 split for internal validation. Then, the fitted coefficients were used to predict 2018 cost of AMKP resident patients during 2015 – 2017 using different models (Table 1). Table 2 is a description of the patients used for prediction (2015 – 2017).

Results

Patients' mean cost in 2017 and 2018 were similar (Table 2). By including utilization across 3 years, the cost trend was smoothened. Large 2018 cost variability challenges prediction and can be attributed to those without utilization in 2018 (27%), and the variability among those with utilization (Figure 1). Table 3 shows the results of the predictive models used. Mean error (ME) is zero, as there is no bias. Mean Absolute Percentage Error (MAPE) is a relative error of regression models. Classification shows the percentage of patients whom a pre-determined cost category classified accurately. Intuitive models, though appealing due to the simplicity of using a few predictors, do not out-perform quantitative models. However, regression models have a large relative error of 90% compared to international studies that showed 70% error for a population under health plans and cost distribution for a different population. Using a classification model (47% accuracy) may be better, as long as cost categories are chosen sensibly.

The 2-step regression consisted of a binary classifier and continuous regression model. The classifier model had high AUC (0.87) in delineating patients who do and do not utilize healthcare in 2018, but its overall performance was reduced by a poorly fitted continuous model. The decision tree using classification and regression algorithms was robust to outliers and the discontinuous cost distribution gave similar accuracies. The different models highlighted different significant factors, but common variables were age, previous years' cost, cost trend, usage (emergency, in- and, outpatient), disease indices, disease (kidney and diabetic) status.

Conclusion

This study is a baseline reference for future prediction modeling exercises that may benefit from richer clinical data and better algorithms.

Table 1. Description of predictive models

Approach	Model	Description
Intuitive (Stratification)	Mean cost	Mean cost
	Mean cost of stratified groups	Patients are stratified into a) 3 groups: healthy, chronic, with complications b) socioeconomic groups c) age groups
	Cost categories transition matrix	2017 categories used to predict 2018 categories
Regression (Statistical & Machine Learning)	2-step regression	Combining 1) a binary model that predicts if a patient uses in 2018 and 2) a conditional regression of 2018 cost if patient utilizes
	Decision Tree	Using decision trees to segment 2018 cost
Classification	Decision Tree	Using decision trees to segment 2018 cost into categories

Table 2. Baseline data of patients

Variables	Value/ Description
Patients	138,827
Age	52 (mean)
Gender	Male = 46.5%
Ethnicity (CMIO)	80%, 8%, 7.8%, 4%
Lower socioeconomic status	8.1%
Smoking status	Last known
Chronic conditions	13 from CDMS
Acute conditions	Grouped ICD conditions
Disease index	CCI, DCSI, eFI
Utilization history	NHGP, ED, SOC, IP
2017 cost (mean, median, 99th percentile)	$2043, 411, 30 687
2018 cost (mean, median, 99th percentile)	$2130, 381, 33 600

Figure 1. Cost distribution in 2018

Table 3. Results of prediction models

Approach	Model	Regression metrics (Target)					Classification (Target)
		ME ($0)	MAE ($0)	MAPE (0%)	RMSE ($0)	R^2 (100%)	Hit ratio (100%)
Intuitive	Mean cost	$0	$1838	120%	$3513	-	18%
	Disease stratified	$0	$1598	107%	$3272	13%	20%
	Cost on cost	$0	$1473	98%	$3211	16%	24%
Regression	2-step regression	$0	$1428	90%	$3176	21%	23%
	Decision Tree	$0	$1413	90%	$3118	24%	22%
Classification	Decision Tree	-	-	-	-	-	47%

THE ECONOMIC BURDEN OF COMMON CHRONIC DISEASES AMONG WORKING OLDER ADULTS

Dr Michelle Jessica Pereira, Dr Yap Chun Wei, Dr Heng Bee Hoon

HIGHLIGHTS

- **Health-related productivity loss can be a source of economic burden associated with common chronic diseases among working older adults.**

Introduction

Many are delaying retirement and working till older when they are more likely to have chronic diseases. This study estimated the potentially overlooked, economic burden of health-related productivity loss (HRPL) associated with common chronic diseases among working older adults.

Methods

This was a cross-sectional study using population health survey data, collected from Singapore residents living in the National Healthcare Group catchment area. Respondents aged above 60 years or older and employed were included in this study.

Available data pertinent to this study included the Work Productivity and Activity Impairment (WPAI) questionnaire, self-reported prevalence of common chronic diseases (diabetes [D], hypertension [H] and dyslipidemia [L]), demographics and employment information. The WPAI measures HRPL, the extent of health-related absenteeism and presenteeism (at-work performance). The analysis followed a human capital approach to valuate HRPL, which was then fitted with an adjusted generalised linear model, with subsequent post-hoc estimation.

Results

Data from 559 working older adult respondents (44.2% females) was analysed (Table 1). 356 (63.7%) were employed fulltime. Most (89.7%) earned less than the median monthly income in Singapore (Ministry of Manpower November 2019 data=$4, 437; Figure 1).

Table 1. Characteristics of respondents by working status

	Full-time (n=356)	Part-time (n=203)
Age (mean, SD) *	64.9 (4.5)	66.3 (5.0)
Female (count, percent) *	130 (35.6)	117 (57.6)
Chinese ethnicity (count, percent)	284 (79.8)	178 (87.7)
Lives alone (count, percent) *	65 (18.3)	56 (27.6)
Housing type (count, percent)		
Public	340 (95.5)	196 (96.6)
Private	16 (4.5)	7 (3.4)
Chronic diseases (count, percent)		
0	161 (45.2)	81 (39.9)
1	91 (25.6)	55 (27.1)
2	66 (18.5)	46 (22.7)
3	38 (10.7)	21 (10.3)

*Between-group differences detected (p<0.05)

Amongst those with at least one chronic disease (n=317), 53.9% had concomitant conditions (Figure 2).

Figure 1. Distribution of self-reported monthly income of study participants.

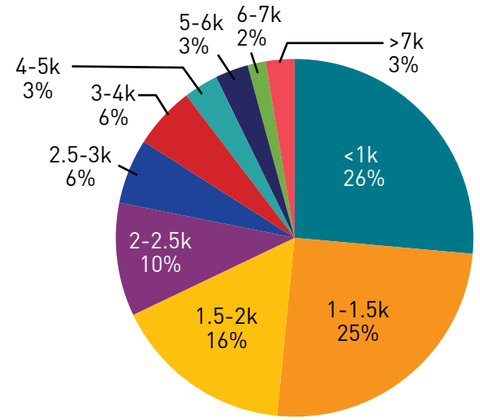
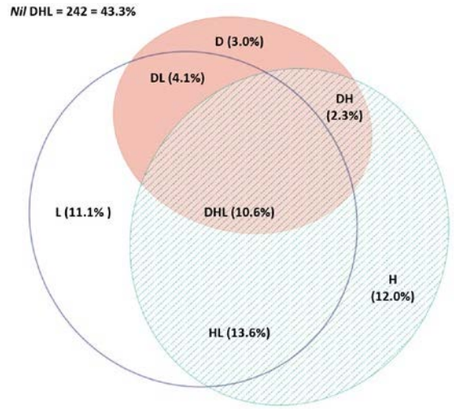


Figure 2. Venn diagram of study participants' comorbidity status



Few reported absenteeism (4.1%), but 23.4% reported some level of presenteeism. Mean productivity impairment was 17.9% (maximum 100; SD=33.6). The magnitude of monetised HRPL for those with chronic disease/s is potentially 1.7 times more (Table 2), compared to healthy peers (p<0.05). This could translate to approximately 12% in productivity reductions from an employer's perspective.

Table 2. Results of main model

	IRR	S. E.	p-value	95% C. I.
Lives alone	1.1	0.3	0.67	0.7 – 1.8
Part-time employment	0.4	0.1	<0.01*	0.2 – 0.6
Health status	(Reference: Healthy – Nil chronic disease)			
1 chronic disease	1.7	0.5	0.04*	1.0 – 2.9
2+ chronic diseases	1.7	0.4	0.04*	1.0 – 2.8

IRR: Incident rate ratio, SE: Standard error, CI: Confidence interval. *p<0.05.
^Generalised linear model (Gamma family, log link) adjusted for age, gender and race.

Conclusions

Beyond medical expenses, HRPL is also a source of economic burden associated with common chronic diseases among working older adults. HRPL in this group needs urgent attention from societies facing rapid population ageing and workforce contraction. Policymakers, employers and clinicians alike need to bear HRPL in mind for cost-effective chronic disease management among working older adults.

SIMULATING THE IMPACT OF A DIABETES PREVENTION PROGRAM

Dr Zhu Zhecheng

HIGHLIGHTS

- **Through microsimulation, the impact of a diabetes prevention program is expected to reduce disease prevalence and overall healthcare costs.**

Introduction

Diabetes and related complications are big challenges to the sustainability of any healthcare system. Policy makers are keen to know whether diabetes prevention programs can be cost effective or even cost saving. In this microsimulation study, we modelled long-term disease progression of chronic diseases centered around diabetes and evaluated the impact of a diabetes prevention program on reducing disease prevalence and overall healthcare costs.

Methods

A microsimulation model was constructed in three steps: first, a synthetic Singapore population was constructed as a starting cohort. Second, Markov Chain Monte Carlo process was applied to model the process of aging and disease progression at the individual level. Third, the impact of a diabetes prevention program was simulated by considering the delay of diabetes onset and related complications. Outcomes such as disease prevalence, direct and indirect medical costs, and disability adjusted life years (DALY) were measured to quantify cost savings or cost effectiveness.

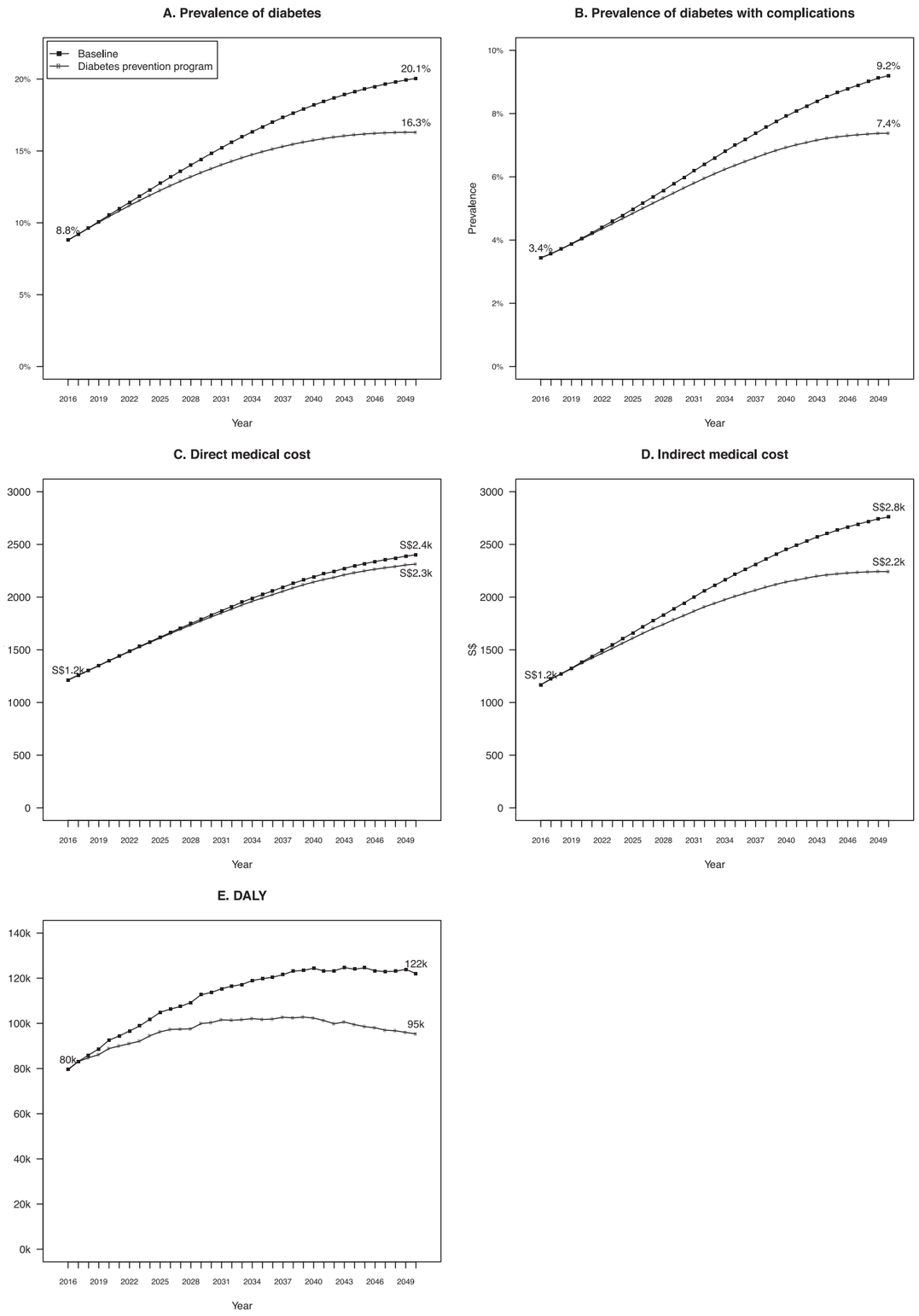
Results

Figure 1 illustrates the microsimulation results. It shows that by intervening with a diabetes prevention program, diabetes prevalence is expected to drop from 20.1% in 2016 to 16.3% in 2050 and the prevalence of diabetes with complications is expected to drop from 9.2% to 7.4% in the same timeframe. Direct medical costs are expected to reduce from S$2.4k to S$2.3k per person per year. Indirect medical costs are expected to reduce from S$2.8k to S$2.2k per person per year. DALYs are expected to lessen from 112k to 95k per year.

Conclusion

Diabetes prevention programs are highly likely to be cost effective or even cost saving if the costs of the interventional programmes are well-controlled.

Figure 1. Simulation results of microsimulation



RISK OF ATRIAL FIBRILLATION AMONG PATIENTS WITH DIABETES, HYPERTENSION OR DYSLIPIDAEMIA

Dr Aidan Lyanzhiang Tan, Palvannan R. K.

HIGHLIGHTS

- **Conditions of diabetes, hypertension and dyslipidaemia increase the risk of atrial fibrillation.**

Introduction

Atrial fibrillation (AF) is the most common dysrhythmia internationally, with predicted increase in prevalence in the future. Prevention of AF or control of the condition is necessary to avoid high-burden complications such as stroke or congestive heart failure. Risk factors for AF include advanced age, and other avoidable conditions such as hypertension, thyroid disease and ischaemic heart disease. Diabetes, in particular, increases the risk of stroke among patients with AF and has also been postulated to be a risk factor for the development of AF. We conducted this study to describe the association between diabetes (D), hypertension (H) and dyslipidaemia (L) and AF.

Methods

A retrospective cohort study was conducted for NHG patients (≥18 years as of end 2012) without pre-existing AF, living within the Central or Northern zone. Data was analysed using a Cox proportional hazards regression model, adjusting for patient demographics and comorbidity. Patient comorbidity and DHL status was defined at baseline.

Of interest was the effect of DHL on the development of AF from 2013 to 2018, presented as incidence rate ratios (IRR). IRRs were calculated as the ratio between the incidence rate of AF among those with diabetes or the condition of interest, and the incidence rate of AF among those without DHL (background incidence rate).

Results

We included 1,189,102 patients (49% male). Mean baseline age was 47 (SD19) years. Chinese ethnicity made up 76%, with 11% Malay, 8.2% Indian and 5.6% others. Majority did not have any DHL conditions (80%). Approximately 1% (13,537) of patients developed AF during the 5-year follow-up. The overall AF incidence rate was 1.9 per 1000 person-years.

The IRR for diabetes was 5.9 (95%CI 5.7–6.1), dyslipidaemia 7.5 (95%CI 7.3–7.8) and hypertension 10.9 (95%CI 10.5–11.3). The IRRs showed an inverse association with age, where IRRs were higher for those younger (<40 years) compared to the older age group (≥75 years), as shown in Figure 1.

The multivariate Cox regression model in Figure 2 showed an increasing hazard ratio with increasing age. Males also had a higher risk relative to females (HR 1.31, 95%CI 1.27–1.36). Of the three DHL conditions, hypertension had the strongest effect on AF risk (HR 1.84, 95%CI 1.75–1.94), similar to that of pre-existing heart failure (HR 1.99, 95%CI 1.84–2.15).

Conclusion

Aside from increasing the risk of ischaemic heart disease and stroke, DHL conditions also increased the risk of AF. Hypertension had the strongest effect relative to diabetes and dyslipidaemia. Upstream control of risk factors (DHL) can potentially help to reduce the development of AF and its subsequent complications.

Figure 1. Simulation results of microsimulation

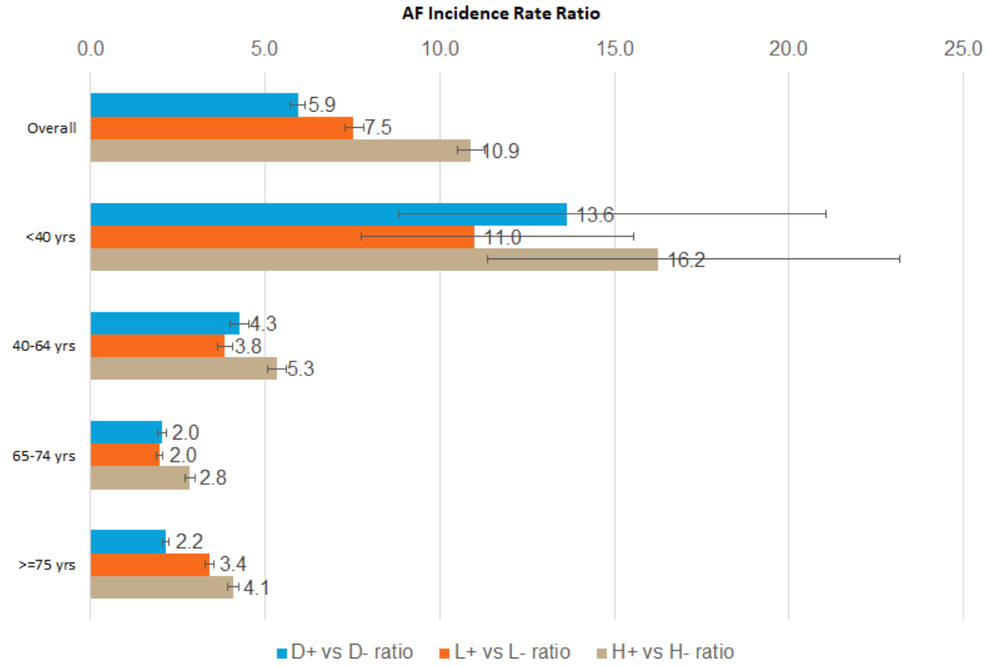
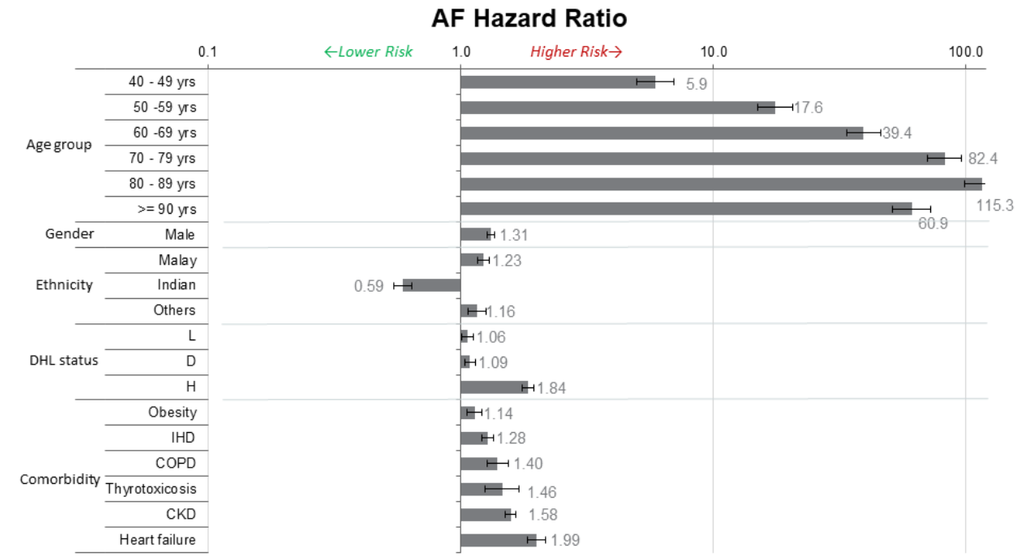


Figure 2. Effect of factors on the development of atrial fibrillation



MEDICATION RECOMMENDATIONS FOR DIABETIC PATIENTS USING CONTRAST-SPECIFIC PROPENSITY SCORES

Dr Meng Fanwen, Dr Han Shasha[1], Dr Joel Goh[1], Dr Melvin Leow[2], Dr Donald Rubin[3]

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HIGHLIGHTS

- **We investigated multiple treatment effects on cholesterol control in type 2 diabetic patients using contrast-specific propensity scoring derived from observational data.**
- **Four subclasses were derived regarding key covariates based on propensity scores with medication options.**

Introduction

In principle, clinicians make evidence-based treatment decisions, relying on clinical guidelines when available. However, this approach is not without problems, mainly because clinical guidelines may not be sufficiently contextualised for specific clinical practices. Clinical guidelines are often broad, and current guidelines for dyslipidaemia in Singapore are based on the US treatment experience, even though the US clinical trial populations may be quite different to the Singapore patient cohort. As a result, locally based clinicians may not be able to regularly rely on guidelines, but instead, use their own experience and judgment often to treat patients. An alternative would be to analyse local observational data that are statistically representative of the target patient population, to provide contextual evidence on treatment effects. Hence, this study seeks to examine treatment effects on cholesterol control of type 2 diabetes (T2DM) patients in Singapore, using contrast-specific propensity scoring.

Methods

We analysed a cohort of T2DM patients extracted from the Chronic Disease Management System (CDMS), who made at least one visit to public healthcare providers from January 2008 to December 2015. A unit observation was defined as a patient-visit during which both total cholesterol (TC) and high-density lipoprotein (HDL) were measured. The primary outcome metric was the patient's lipid ratio (LR), which is a risk factor of cardiovascular complications. For a given patient-visit, we computed the change between the patient's LR at that visit from their first visit. This change reflects how much an individual patient improved in response to treatment and may be considered more reflective of the physician's decision-making.

We then implemented an approach using contrast-specific propensity scoring to estimate causal effects of multiple treatments by considering three different possible treatment options: fibrates, statins, and no medication[1]. We clustered patients into subclasses, where each subclass would contain observed units with similar propensity scores.

Results

A total of 61,709 patients (53.94% females) were analysed, accounting for 578,434 patient-visits. Mean age at diagnosis with diabetes was 55.78 years. We analysed the means and standard deviations of factors under consideration. Table 1 shows descriptive statistics of demographics, key risk factors, and medication conditions.

Table 1. Descriptive statistics of study data from study patients and patient-visits

Demographics	**Percent females (%)**	53.94 (0.20)
	Percent Chinese (%)	69.94(0.18)
	Percent smokers (%)	4.48(0.08)
	Average age at diagnosis (years)	55.78(12.18)
	Average age at visit (years)	61.49(11.30)
Laboratory measures	**HbA1c (%)**	7.58(1.50)
	LDL (mmol/L)	2.76(0.87)
	LR	3.95(1.29)
Physical exam measures	**SBP (mmHg)**	131.96(34.44)
	DBP (mmHg)	73.78(10.13)
	BMI (kg/m^2)	26.55(5.61)
Medication condition	**No drug (%)**	83.36(0.05)
	Statins (%)	15.76(0.05)
	Fibrates (%)	0.89(0.01)

Table 2 contains mean values of the covariates of four subclasses based on the contrast-specific propensity scores. The means of these covariates vary somewhat across the subclasses, except BMI, SBP and DBP. We found that the subclasses in which statins tended to be more effective were those where patients had higher levels of HbA1c, LR, LDL, and TG (subclass 1). Also, patients were younger, more likely to be male, and to have had a history of smoking in those subclasses (subclass 1 and 2).

Table 2. Details of patient-visits by subclass and treatment recommendation

	Subclass			
	1	**2**	**3**	**4**
Patient age at diagnosis (years)	50.7	53.5	56.0	59.6
HbA1c (%)	8.0	7.6	7.4	7.2
SBP (mmHg)	131.6	131.2	131.5	133.5
DBP (mmHg)	75.7	74.3	73.1	72.0
BMI (kg/m^2)	26.6	26.4	26.2	27.0
LDL (mmol/L)	3.4	2.8	2.6	2.3
LR	5.5	4.1	3.4	2.8
TG (mmol/L)	5.1	3.6	3.0	2.6
Percent females (%)	36.7	49.2	60.4	74.1
Percent Chinese (%)	78.6	78.1	73.7	51.6
Percent smokers (%)	7.5	4.8	3.4	2.4
Number of patient-visits without medication	128765	122156	117205	114035
Number of patient-visits on statins treatment	13320	21226	26524	30077
Number of patient-visits on fibrates treatment	2524	1226	879	497
Recommended treatment	Statins	Statins / Fibrates	Statins / Fibrates	Fibrates

Conclusion

The differences in statin effectiveness across subclasses could be helpful to clinicians for evidence-based decision making to control dyslipidaemia in patients with type 2 diabetes.

[1] S. Han, J. Goh, F. Meng, M. Leow, D. Rubin. Causal inference of multiple treatment effects using contrast specific propensity scores, working paper, 2019.

AN INVERSE RELATIONSHIP BETWEEN AGE OF ONSET OF TYPE 2 DIABETES MELLITUS AND ALL-CAUSE MORTALITY: A RETROSPECTIVE COHORT STUDY

Dr Ang Yee Gary, Dr Yap Chun Wei, Teow Kiok Liang

HIGHLIGHTS

- **The inverse relationship between the age of diagnosis of type 2 diabetes and all-cause mortality has been replicated in a Singapore population.**
- **Preventing early onset of type 2 diabetes may help in reducing premature mortality.**

Introduction

The prevalence of type 2 diabetes (T2DM) has risen in adolescents and young adults throughout the world. International studies have suggested an inverse relationship between the age of onset of T2DM and all-cause mortality. However, the impact of the age of onset of T2DM on all-cause mortality in Singapore is unknown. This study aims to explore the relationship between the age of onset of T2DM and all-cause mortality, and identify potential risk and protective factors.

Methods

This is a retrospective cohort study of 84,182 NHG T2DM patients seen in 2012. Patients were followed-up till death or 31 March 2019, whichever was earlier, and the outcome of interest was all-cause mortality. Univariate Cox proportional-hazards regressions were used to assess the association between each predictor variable and all-cause mortality. Significant variables were then entered into multivariate Cox proportional-hazards regression models for mortality. The level of significance for univariate regressions was set at $p \leq 0.20$, and backward elimination of non-significant variables ($p > 0.05$) was used for the multivariate models.

Results

At the end of the study, 16,281 patients (20.0%) died. Baseline characteristics and multivariate analysis results are shown in Table 1 and 2, respectively. T2DM patients who were diagnosed below 40 years old had higher mortality compared to those who were diagnosed later. Other risk factors include higher study start age, male gender, higher Charlson comorbidity index, higher Diabetes Complications Severity Index, higher systolic blood pressure, lower estimated glomerular filtration rate, higher HbA1c and higher low density lipoprotein.

Conclusion

We found a probable inverse relationship between diagnosis age of T2DM and all-cause mortality among T2DM patients in Singapore. If T2DM can be prevented or delayed, premature mortality may be reduced and future studies are needed to evaluate this further.

Table 1. Baseline characteristics

Mean age in years (standard deviation) at start of study		63.7 (13.0)
Mean age in years (standard deviation) at DM diagnosis		57.5 (13.1)
Age group at DM diagnosis, n (%)		
	<40 years	7,636 (9.1)
	40-49 years	15,723 (18.7)
	50-59 years	25,335 (30.1)
	60-69 years	20,432 (24.3)
	>=70 years	15,056 (17.9)
Gender		
	Male, n (%)	41,775 (49.6)
	Female, n (%)	42,406 (50.4)
Ethnicity		
	Chinese, n (%)	57,184 (67.9)
	Malay, n (%)	10,063 (12.0)
	Indian, n (%)	12,595 (15.0)
	Others, n (%)	4,340 (5.2)
Mean Diabetes duration in years (SD)		6.3 (5.4)
Mean Charlson comorbidity index (SD)		4.1 (2.6)
Mean Diabetes Complication Severity Index (SD)		1.2 (1.7)
Mean Systolic blood pressure in mmHg (SD)		131.4 (17.1)
Mean Diastolic blood pressure in mmHg (SD)		71.4 (10.8)
Mean estimated glomerular filtration rate (SD)		77.1 (26.1)
Mean HbA1c (SD)		7.6 (1.6)
Mean low density lipoprotein cholesterol in mmol/L (SD)		2.6 (0.8)

Table 2. Mutivariate Analysis

		Hazard Ratio (95% Confidence Interval)
Age in years at start of study		1.06 (1.06-1.07)
Age group at DM diagnosis		
	60-69 years	Reference
	<40 years	1.39 (1.22-1.59)
	40-49 years	1.14 (1.03-1.25)
	50-59 years	1.03 (0.96-1.10)
	>=70 years	1.08 (1.02-1.15)
Gender		
	Male, n (%)	Reference
	Female, n (%)	1.43 (1.37-1.49)
Charlson comorbidity index		1.13 (1.12-1.14)
Diabetes Complication Severity Index		1.14 (1.13-1.16)
Systolic blood pressure in mmHg		
	130-139	Reference
	<130	1.08 (1.02-1.15)
	140-149	1.04 (0.96-1.12)
	150-159	1.15 (1.04-1.26)
	>=160	1.32 (1.20-1.44)
Estimated glomerular filtration rate		
	>=90	Reference
	<15	3.24 (2.87-3.65)
	15-29	1.94 (1.75-2.15)
	30-44	1.32 (1.20-1.45)
	45-59	1.10 (1.00-1.20)
	60-89	1.07 (0.99-1.15)
	HbA1c	1.08 (1.07-1.10)
	Low density lipoprotein cholesterol	1.04 (1.02-1.07)

REDUCING OUTPATIENT PHARMACY QUEUE TIME BY CHANGING MANPOWER SHIFTS

Teow Kiok Liang, Lim Woan Chyi[1], Kwa Ca Lynn[1], Chen Shen Onn[1]
[1] Outpatient Pharmacy, Tan Tock Seng Hospital

HIGHLIGHTS

- **Pharmacy waiting time could be reduced without an increase in overall manpower by early deployment of manpower to suppress the queue, when such deployment flexibility is possible.**

Introduction

TTSH Outpatient Pharmacy sees a large volume of patients. The pharmacy has been continuously improving its operations to reduce waiting time of patients. Some previously implemented improvement initiatives include automated picking, and "soft-partitioning" of counters to serve patients with different needs.

Patient arrivals to TTSH Outpatient Pharmacy has a strong "double-peak" temporal pattern. The operating hours of the pharmacy is long, thus requiring staff to report to work at different timings. These factors make outpatient pharmacy manpower shift planning complex. Fortunately, there is flexibility to switch staff between different functions when the dispensing queue is long. This study aimed to investigate how manpower shift changes can reduce TTSH Outpatient Pharmacy waiting time.

Methods

TTSH Outpatient Pharmacy data was collected for 42 days, with daily prescription orders exceeding 1000. These time-stamped data were analysed to provide information on flow patterns and service durations. The planned manpower roster was also collected.

Simul8 was used to create a discrete event simulation model to replicate the flow in the outpatient pharmacy, emphasising temporal demand and manpower staffing. The simulation model was calibrated to reproduce the observed waiting time. Different manpower shifts were created to test out projected waiting times. In these scenarios, the total number of man-hours deployed remained constant.

Results

It was shown that current manpower shifting lagged behind patient load demand. As a result, patient queues were formed, causing a persistent backlog. Even as patient arrivals fell after 5pm, the backlog caused the patient queue to subside only after 6pm.

We simulated a scenario where more staff were brought in just after the outpatient pharmacy opens in the morning, and around 10.30am. This would align more with demand and be ahead of the anticipated rise in waiting time. The total front-end dispensing manpower hours remained constant, and the maximum number of staff at any time can be maintained at 24 without the need to increase with make shift counters. Fewer staff were needed after 5.30pm. The simulated scenario projected average dispensing waiting time (excluding waiting time for registration, picking and packing) would reduce from the current 21 minutes to 14 minutes.

Conclusion

Our study highlights the possibility of reducing outpatient pharmacy waiting time by re-scheduling staffing hours, without affecting total manpower hours. This study suggests injecting manpower supply before the formation of any significant queue. This means that where there is flexibility in deployment, and the demand is finite, clearing the workload as soon as possible is feasible and validated.

Figure 1. Outpatient Pharmacy flow

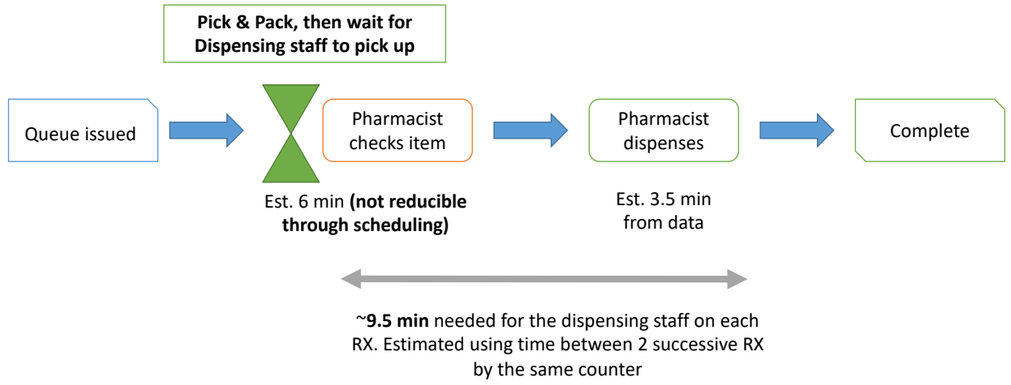
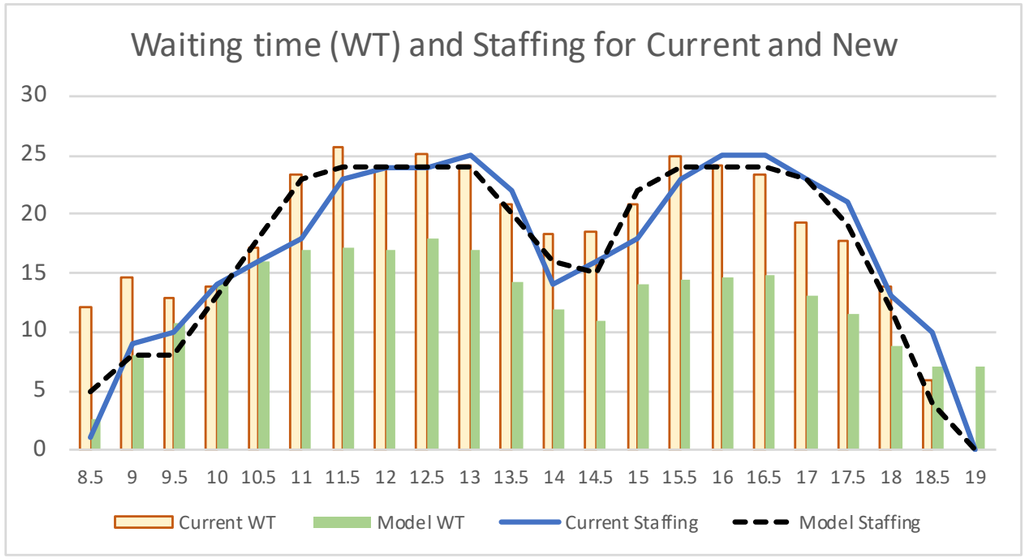
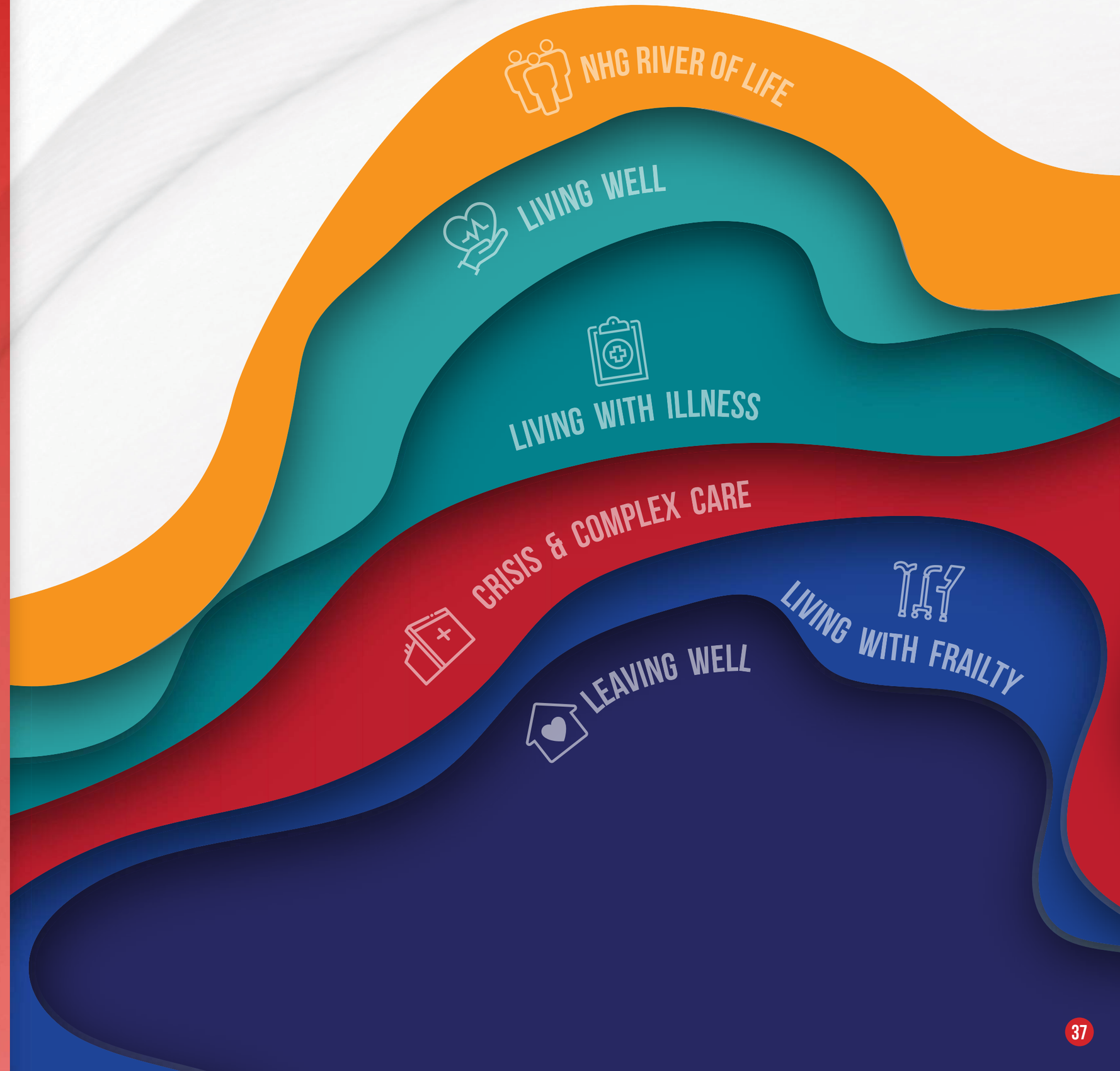


Figure 2. Waiting time and Staffing pattern: Current and New



CRISIS & COMPLEX CARE

A focus on patients who require hospitalisation and complex medical care



IDENTIFYING POTENTIALLY AVOIDABLE READMISSIONS: A LITERATURE REVIEW

Dr Aidan Lyanzhiang Tan, Dr Yap Chun Wei

HIGHLIGHTS

- **Three internationally validated methods of measuring Potentially Avoidable Readmissions have been described in detail in existing literature.**
- **The three methods differ in approach and algorithm, necessitating careful use and interpretation of results.**

Introduction

Hospital admissions, in particular readmissions, pose a high cost to the health system and has been identified as a potential area for cost reductions. However, measuring readmissions is difficult. All-cause readmissions is too crude an indicator as it does not take into account potential avoidability. More attention on understanding and reducing 'potentially avoidable readmissions' (PAR) is needed. Thus, a literature review was carried out with the objective of identifying PAR measurement methodologies based on administrative database information.

Methods

A PubMed search was conducted on 14 November 2019, using the following search terms: "preventable" OR "avoidable" AND "readmissions" OR "rehospitalisations" OR "rehospitalizations". We also performed manual reference list searching. Studies that described database algorithms for identifying and measuring avoidable readmissions were included. Exclusion criteria included non-English publications, those with algorithms for specific disease populations, paediatric studies, abstract only citations, or studies that utilised other methods beyond that of database algorithms. Details regarding algorithms of interest were extracted during full-text review and described qualitatively.

Results

In the literature search, 478 abstracts were identified, and 469 were subsequently excluded during abstract review. Of the 9 studies included for full-text review, we identified 3 PAR measurement methods fitting our inclusion criteria: Striving for Quality Level and Analyzing of Patient Expenses (SQLape), 3M Potentially Preventable Readmissions (3M PPR) and an algorithm described by Blunt and colleagues (2015)[1]. Table 1 describes their characteristics.

The definitions of PAR varied between the three methods. The SQLape algorithm used a broader definition, describing PAR as any readmission that was "not part of an expected programme of phased care" for a previously known condition. In contrast, the other two methods (3M PPR, Blunt 2015) have narrower and criterion-based definitions. This difference in definition is also reflected in the approach to measuring PAR, with SQLape being primarily exclusion-based, while the 3M PPR and Blunt 2015 algorithms were primarily inclusion based.

We found that certain readmissions were universally considered "potentially avoidable", such as healthcare or iatrogenic complications, or recurrence of an initial condition. Readmissions that were universally considered "unavoidable" included obstetric or neonatal readmissions, high complexity conditions such as cancer, or readmissions for treatments such as chemo- or radiotherapy. Trauma was also universally considered "unavoidable". The similarities and differences of the algorithms are illustrated in Table 2.

Conclusions

Methods for measuring PAR using administrative databases are available in the literature. These algorithms differ in their PAR definition and approach (inclusion or exclusion criteria) in triaging hospital readmissions. Choice of algorithm should be considered carefully based on the specific needs and goals of the healthcare provider.

Table 1. Measurement method characteristics

	SQLape	3M PPR	Blunt 2015
Sensitivity	96.0%	Not reported	Not reported
Specificity	95.7%	Not reported	Not reported
Definition of "Potentially Avoidable"	Unforeseen readmission for previously known affection	Readmission related to: (1) Quality of care, (2) Discharge planning, (3) Post-discharge follow-up, (4) Coordination between healthcare settings	Readmission due to probable / possible suboptimal care
Measurement Approach	Primarily exclusion-based, excluding "unavoidable" readmissions	Primarily inclusion-based, following an initial exclusion of "unavoidable" broad categories	Inclusion based on pre-defined criteria

Table 2. Comparison of measurement method algorithms

	SQLape	3M PPR	Blunt 2015
Readmission reasons included as PAR			
Healthcare / iatrogenic complications	Y	Y	Y
Preventable disease (e.g. DVT, PE, decubitus ulcer)	Y		Y
Deterioration of known secondary condition	Y	Y	
Recurrence of initial condition	Y	Y	Y
Readmission reasons excluded as PAR			
Planned readmission or rehabilitation	Y		All readmissions not meeting inclusion criteria are excluded
Obstetric or Neonatal	Y	Y	
Chemo- or radiotherapy	Y	Y	
High-complexity conditions (e.g. Cancer)	Y	Y	
Trauma	Y	Y	
Opthalmological conditions		Y	

[1] Blunt I, Bardsley M, Grove A, Clarke A. Classifying emergency 30-day readmissions in England using routine hospital data 2004-2010: What is the scope for reduction? Emergency Medicine Journal. 2015 Jan; 32(1):44-50. doi: 10.1136/emermed-2013-202531.

CRISIS & COMPLEX CARE

INTERIM RESULTS OF THE ACUTE INTERNAL MEDICINE SERVICE EVALUATION

Dr Joseph Antonio D. Molina, Prof Jackie Tan Yu-Ling[1], Dr Endean Tan[1]
[1]Department of General Medicine, Tan Tock Seng Hospital

HIGHLIGHTS

- **Targeted selection of patients for admission to the AIMS unit may potentially save the hospital more than 1,000 bed-days over 15 months.**

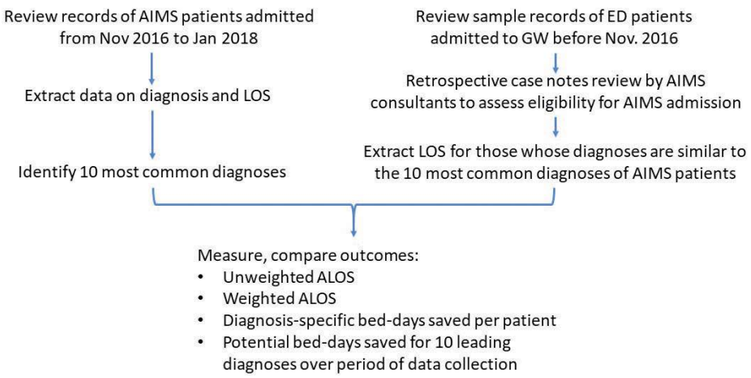
Introduction

The Acute Internal Medicine Service (AIMS) at Tan Tock Seng Hospital (TTSH) manages patients anticipated to require up to 72 hours of in-hospital care. AIMS' admission criteria is based on a list of specific medical diagnoses including (but not limited to) infections (e.g. cellulitis, gastroenteritis, pneumonia, viral illness), cardiac (e.g. acute heart failure, atypical chest pain), endocrine (e.g. hypo- or hyper-glycaemia, hypo- or hyper-thyroidism), vascular (e.g. venous thrombosis, stable pulmonary embolism), respiratory (e.g. asthma, COPD) conditions and other medical issues (e.g. giddiness and syncope) which typically do not require prolonged hospitalization (>3 days). Operational since November 2016, the service aims to provide eligible patients with earlier specialist care access and management in the appropriate care setting. AIMS involves frontloading of assessment by the General Medicine consultant and expedited investigations to shorten time-to-intervention with allied health assessments if required. The team comprises the head of service, nurse manager, advance practice nurse, consultant, registrar and medical officers, registered and enrolled nurses, and representatives of ancillary services including diagnostic radiology, laboratory medicine, allied health and pharmacy. As of 2019, there were 8 AIMS beds in service.

Evaluation design

This interim study aimed to evaluate the effectiveness of the AIMS unit in reducing length of hospital stay, and to estimate the potential number of patient bed-days saved due to admissions to the unit. This evaluation utilized a retrospective cohort design with historical controls (Figure 1).

Figure 1. Workflow for the evaluation



Patients admitted to the AIMS unit from November 2016 to January 2018 were compared to TTSH general ward patients before November 2016 who would have been eligible for AIMS had it been in service. AIMS consultants identified suitable controls by reviewing the case notes of these potential historical patients and applying the AIMS admission criteria. The analysis was restricted to admissions for the 10 most common diagnoses for the AIMS arm and involved univariate statistics.

Results

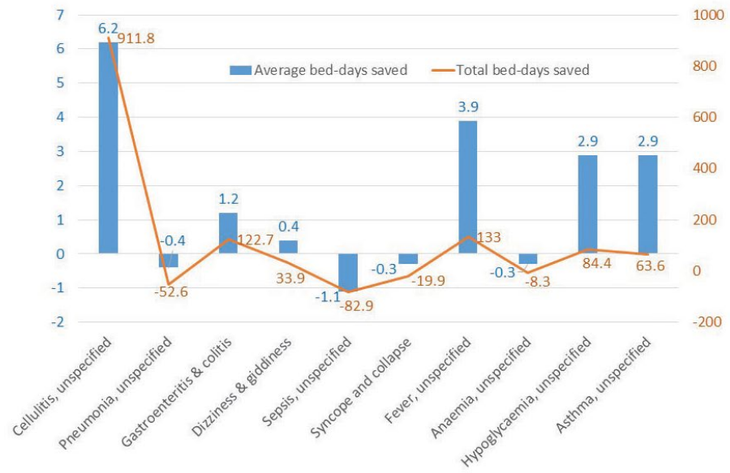
For this study, 718 AIMS and 134 Control patients were included. The 10 most common diagnoses for AIMS patients are presented in Table 1 and represented 66% of all diagnoses to the unit during the study period. Cellulitis, the most common diagnoses for both groups, had the greatest difference in average length of stay (ALOS, 10.8 and 4.6 days for Control and AIMS, respectively), whilst ALOS for sepsis was 1 day longer for AIMS than Controls.

Table 1. Comparison of outcomes for AIMS and Control

Primary ED Diagnosis	AIMS		CONTROL	
	No. of patients	ALOS (Unweighted)	No. of patients	ALOS (Unweighted)
Cellulitis, unspecified	147	4.64	20	10.84
Pneumonia, unspecified	125	4.54	12	4.12
Gastroenteritis & colitis	102	3.33	17	4.53
Dizziness & giddiness	91	3.26	18	3.63
Sepsis, unspecified	77	6.10	7	5.02
Syncope and collapse	58	2.73	16	2.38
Fever, unspecified	34	3.20	5	7.12
Anaemia, unspecified	29	3.14	14	6.05
Hypoglycaemia, unspecified	29	3.14	14	6.05
Asthma, unspecified	22	2.71	9	5.60
TOTAL	718	3.55	134	5.09

Adjusting for the difference in disease distribution in each group, the overall weighted ALOS was >1.5 days longer for Controls than for AIMS patients. Savings in bed-days were observed for 6 out of the 10 most common diagnoses (Figure 2). The difference in ALOS translates to a savings of 1,186 bed-days for the hospital over a period of 15 months.

Figure 2. Bed-days saved, by specific ED diagnosis



Conclusion

Control patients stayed longer in hospital than AIMS patients by 1.5 days. The range of bed-days saved varies by diagnosis but ranges from -1.1 days for sepsis, to +6.2 days for cellulitis. With a capacity of 8 beds, the service may potentially save the hospital more than 1,000 bed-days over 15 months for the 10 most common diagnoses. Inclusion of other outcomes such as mortality and readmission, as well as risk adjustment for demographics and other clinical data can be conducted in subsequent analysis.

COST EFFECTIVENESS ANALYSIS OF HEPATOCELLULAR CARCINOMA SCREENING AMONG AT-RISK PATIENTS: NON-CONTRAST MRI VERSUS ULTRASOUND

Dr Sun Yan, Dr Lee Chau Hung[1], Dr Tan Cher Heng[1]
[1]Department of Radiology, Tan Tock Seng Hospital

HIGHLIGHTS

- **It is cost effective to screen for hepatocellular carcinoma every 6 months from the patient's perspective in Singapore.**
- **Non-contrast magnetic resonance imaging is a more cost effective surveillance tool than ultrasound.**

Introduction

Hepatocellular carcinoma (HCC) is a common primary cancer of the liver, accounting for 85% to 90% of all primary liver cancers. Established guidelines recommend 6-monthly ultrasound screening test for HCC among at-risk patients. However, ultrasound screening has low sensitivity ranging between 58-89% and a specificity of approximately 90%. Moreover, in cirrhotic livers, the generalised coarsened and nodular appearance of the parenchyma makes it challenging for the operator to detect focal lesions. Non-contrast magnetic resonance imaging (MRI) appears to be a good alternative as it generally requires a shorter scan time and provides higher detection sensitivity. Hence, this study aimed to analyse the cost effectiveness of imaging surveillance for HCC among at-risk patients in Singapore using non-contrast MRI, compared to ultrasound.

Methods

A cost effectiveness analysis using Markov modelling and microsimulation was conducted. A disease transition model with 7 states was developed to mimic the disease progression from at-risk to cancer stages 0, A, B, C, D and to death (Figure 1). An at-risk patient cohort was simulated and they were followed-up for 40 years to estimate their disease status as well as their direct medical costs and effectiveness following various screening approaches. Screening approaches included were no screening, screening using ultrasound and screening using 2-sequence MRI (Figure 2). The analysis was conducted from a patient's perspective. Direct medical costs for screening, treatment and follow-up care management at subsidised rates were collected for evaluation. The incremental cost effectiveness ratio (ICER) was calculated and applied to identify the most cost effective screening approach for HCC among at-risk patients in the Singapore context. The transition cycle is 6 months.

Figure 1. Disease progression diagram

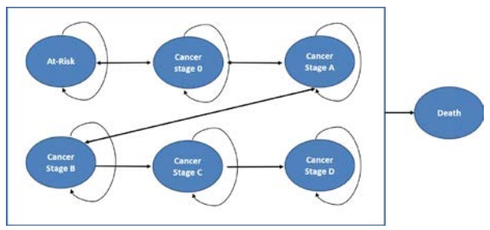
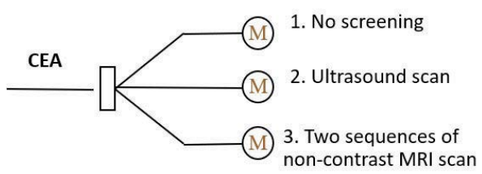


Figure 2. CEA of various screening approaches



Results

A simulated cohort of 200K at-risk patients with an average age of 40 years was studied. After 40 years, all at-risk patients would have died if there was no screening. Around 9% and 10% of at-risk patients would still be alive at 40-year follow-up, if screening was done by ultrasound and non-contrast MRI, respectively. The average total costs and QALYs for the three scenarios of no screening, screening with ultrasound or non-contrast MRI were: S$1193 / 7.460 QALYs, S$8,099 / 11.195 QALYs, and S$9720 / 11.366 QALYs (Figure 3 and Figure 4).

Figure 3. QALY of the simulated cohort over 40 years

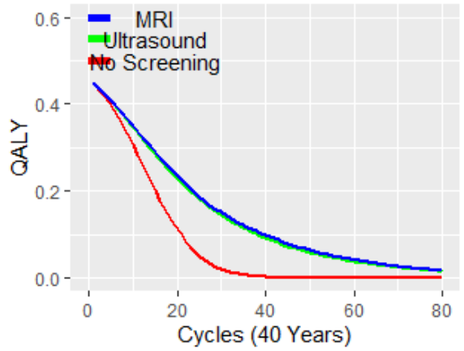
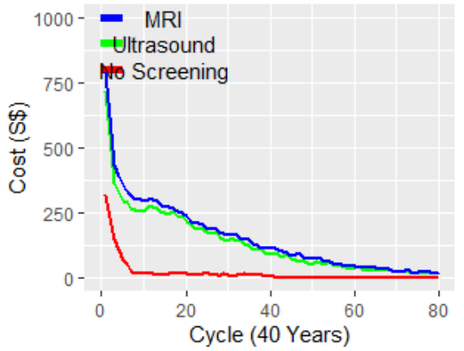


Figure 4. Cost of the simulated cohort over 40 years



The costs, effectiveness and ICERs of the three screening approaches are shown in Table 1. Overall, the ICERs of ultrasound and non-contrast MRI screenings over no screening were S$1848 and S$2183 per QALY gained, respectively. The ICER of non-contrast MRI screening over ultrasound screening was S$9824 per QALY gained.

Table 1. Comparison of costs, effectiveness and ICER of the three screening approaches

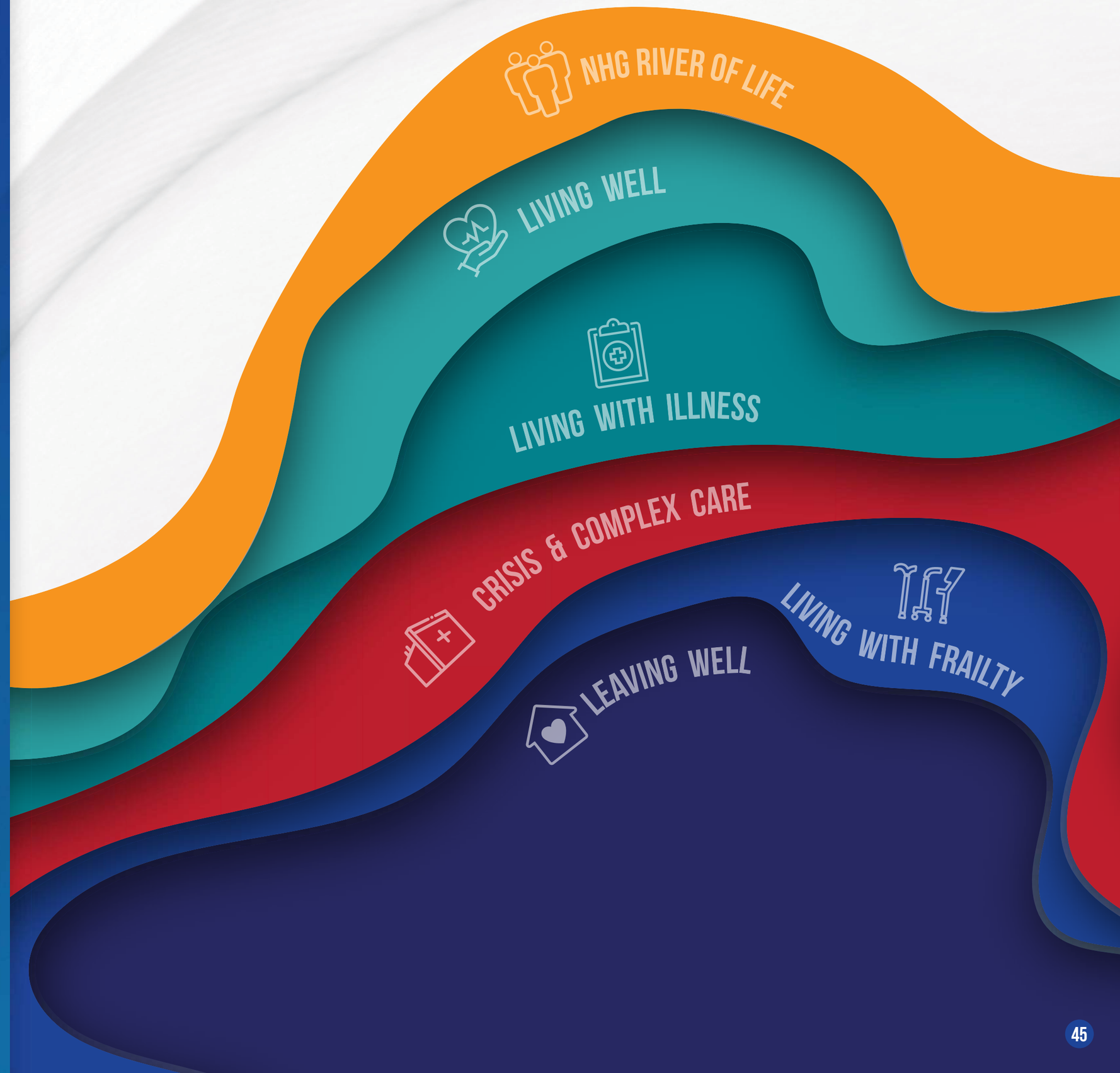
Approach	Total cost Mean (SE)	Total QALYs Mean (SE)	Incremental cost (S$)	Incremental QALYs	ICER
No Screening	1193(64)	7.460(0.044)			
Ultrasound screening	8099(93)	11.195(0.074)	6906(82)	3.736(0.052)	1848
MRI screening	9720(88)	11.366(0.075)	9824	3.907(0.051)	2183
MRI versus ultrasound			1680	0.171	9824

Conclusion

This cost effectiveness study showed that 2-sequence non-contrast MRI is a cost-effective alternative surveillance tool for HCC detection within an at-risk population. Policymakers may consider this tool to improve current guidelines for at-risk patients.

LIVING WITH FRAILTY

A focus on ageing and frail patients



ASSOCIATION OF NUTRITIONAL STATUS WITH PHYSICAL FUNCTION AND DISABILITY IN OLDER COMMUNITY-DWELLING ADULTS: A LONGITUDINAL DATA ANALYSIS

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

HIGHLIGHTS

- **Undernutrition, regardless whether recently developed or persistent over one year, was associated with poorer physical function and disability.**
- **Older adults with improved nutritional status were similar to those with nutritional status that remained normal, in physical function and frequency of participation.**

Introduction

Studies using cross-sectional data have documented that undernutrition is an important factor affecting the wellbeing of the older population. However, little is known how the duration of undernutrition or change in nutritional status affects physical function and disability. This study aimed to investigate how changes in nutritional status is associated with physical function and disability among community-dwelling older adults using longitudinal data.

Methods

Baseline and 1-year follow-up data of 593 community-dwelling residents aged 60 years and older were obtained from the Population Health Index survey, a longitudinal health survey conducted in the Central Region of Singapore. The 18-item Mini Nutritional Assessment (MNA®) was used to evaluate nutritional status with a cut-off of ≥24 indicating normal nutritional status and <24 indicating undernourished (Table 1). A new categorical variable was created to reflect the change in nutritional status between baseline and 1-year follow-up as an independent variable" before "(Table 1). The Late-Life Function and Disability Instrument was used to assess physical function and disability. Multiple linear regressions were applied to examine the associations between the change in nutritional status over a year and physical function and disability levels at 1-year follow-up.

Results

Compared to older adults with normal nutritional status at both baseline and 1-year follow-up, those who became undernourished or remained undernourished reported poorer physical function (B= -6.36 and -5.96, respectively; both p<0.01), and had less frequent involvement (B= -3.95 and -2.86, respectively; both p<0.01) and more limitation in performing life tasks (B= -13.24 and -16.02, respectively; both p<0.01) at 1-year follow-up. However, older adults with improved nutritional status did not differ in physical function and frequency of involvement in life tasks compared to those with normal nutrition.

Conclusions

Undernutrition is associated with poorer physical function and disability in community-dwelling older adults regardless of whether it developed or was persistent over one year. Improving nutritional status could be an effective strategy to improve physical function in older adults.

Table 1. Categories of nutritional status and change in nutritional status

Nutritional status at baseline	Nutritional status at 1-year follow-up	Change in nutritional status
Normal	Normal	Remained normal
Undernourished	Normal	No longer undernourished
Normal	Undernourished	Became undernourished
Undernourished	Undernourished	Remained undernourished

Table 2. Association of change in nutritional status with physical function and disability at 1-year follow-up

Change in nutritional status	Function			Frequency			Limitation		
	B	Std. Err.	p	B	Std. Err.	p	B	Std. Err.	p
Remained normal		Ref			Ref			Ref	
No longer undernourished	0.09	1.81	0.959	-0.99	0.91	0.278	-7.92	2.60	0.002
Became undernourished	-6.36	1.68	0.000	-3.95	0.85	0.000	-13.24	2.40	0.000
Remained undernourished	-5.96	1.87	0.002	-2.86	0.97	0.003	-16.02	2.68	0.000

LIVING WITH FRAILTY

ASSOCIATION OF PATIENT-REPORTED FUNCTION MEASURES WITH INCIDENT FALLS

Dr Yip Wanfen, Ge Lixia, Dr Heng Bee Hoon, Dr Tan Woan Shin

HIGHLIGHTS

- **The Function Component of the Late-Life Function and Disability Instrument is associated with incident falls and may potentially be used as a falls risk screening tool for community-dwelling elderly adults.**

Introduction

Weak lower extremity muscle power, decreased balance control and functional limitations have been highlighted as key examples of modifiable risk factors of falls. The Late-Life Function and Disability Instrument (LLFDI) is a self-report questionnaire designed to measure a person's functional limitations and disability. Specifically, the Function Component of the LLFDI assesses standing, stooping, fundamental walking ability, as well as physical ability and endurance of an individual. Importantly, the ability to carry out these activities will be affected with decreasing lower extremity strength and balance control. Hence, in this study, we aimed to examine the association between the Function Component of LLFDI and incident falls in a group of community-dwelling elderly adults.

Methods

A total of 283 community-dwelling adults (aged ≥65 years) from a prospective population-based study (Population Health Index survey) were included for this analysis. Assessment of an individual's physical function was done using the Function Component of the LLFDI tool, which comprised of three dimensions: upper, basic lower extremity and advanced lower extremity. Information on falls was obtained through a standardised questionnaire administered by trained personnel. Multivariate Poisson regression analyses were performed to examine the association between Function Component scores (basic lower extremity functioning domain score, advanced lower extremity functioning domain score and overall Function Component score) and incident falls, adjusted for age, gender, race, hypertension, polypharmacy, nutritional status, self-reported history of heart attack or failure, stroke, osteoarthritis, osteoporosis, vision or hearing impairment, and dementia.

Results

At 1-year follow-up, 15.2% (43) of the participants experienced their first fall. In the multivariate analysis, decreasing advanced lower extremity functioning domain scores (incidence rate ratio [IRR]: 1.57, 95% confidence interval [CI]: 1.01 - 2.45, p value: 0.047) and overall function component score (IRR: 1.90, 95% CI: 1.20 - 3.02, p value: 0.006) were associated with incident falls (Table 1).

Conclusions

Our findings provide evidence that the LLFDI Function Component can be considered as a falls risk screening tool for community-dwelling elderly adults.

Table 1. Association of baseline basic and advance lower extremity functioning domain score and overall Function Component score with incident falls

	Model 1 IRR (95% CI)	pv-value
Basic lower extremity functioning domain score, per 18.4 SD decrease	1.46 (1.13, 1.87)	0.004
Advanced lower extremity functioning domain score, per 23.5 SD decrease	1.58 (1.20, 2.06)	0.001
Overall Function Component score, per 17.0 SD decrease	1.79 (1.38, 2.33)	<0.001
	Model 2 IRR (95% CI)	**pv-value**
Basic lower extremity functioning domain score, per 18.4 SD decrease	1.41 (0.91, 2.20)	0.128
Advanced lower extremity functioning domain score, per 23.5 SD decrease	1.57 (1.01, 2.45)	0.047
Overall Function Component score, per 17.0 SD decrease	1.90 (1.20, 3.02)	0.006

IRR: incidence ratio; CI: confidence interval; Model 1: adjusted for age, gender, race; Model 2: additionally, adjusted for hypertension, polypharmacy, nutritional status, self-reported history of heart attack/failure, stroke, osteoarthritis, osteoporosis, vision/hearing impairment, and dementia

ASSOCIATION OF PRE-FRAILTY AND FRAILTY WITH FALLS AMONG COMMUNITY-DWELLING ADULTS

Dr Yip Wanfen, Ge Lixia, Dr Heng Bee Hoon, Dr Tan Woan Shin

HIGHLIGHTS

- **Pre-frailty status is significantly associated with fall risk.**
- **Community-based outreach programmes to screen for pre-frailty is important to reduce risk of falls & delay the progression towards frailty.**

Introduction

Falls are one of the most frequent causes of injury in the community-dwelling elderly population, with one in ten falls leading to emergency department and hospital admissions. Despite the increasing prevalence of frailty in Singapore, local literature evaluating the association between pre-frailty and frailty with falls is scant. Therefore, in this study, we examined the associations between frailty and falls among community-dwelling adults.

Methods

Data was drawn from the Population Health Index longitudinal survey examining the health of a representative sample of community-dwelling adults residing in the Central region of Singapore. Frailty status was determined at baseline using the Clinical Frailty Scale (CFS), scored from 1 to 9. Frailty was categorised as: non-frail (CFS1–3), pre-frail (CFS4), and frail (CFS5-9). Information about falls was collected at 1-year follow-up by asking participants if they experienced a fall in the past year. Fallers were defined as individuals who fell at 1-year follow-up. Logistic regression analyses were performed to examine the associations between pre-frailty and frailty with falls, adjusting for socio-demographic factors, medical history and lifestyle.

Results

We included 1,145 participants aged ≥40 years in this study, of which, 122 (10.7%) participants experienced at least one fall at follow-up (Figure 1). Comparison of baseline characteristics between those who fell and those who did not are shown in Table 1. Specifically, those who fell during the 1-year follow-up were more likely to be pre-frail or frail at baseline as compared to those who did not fall (Figure 2) In the multivariate analyses, compared to non-frail participants, pre-frailty (odds ratio [OR]: 1.84, 95% confidence interval [CI]: 1.05 – 3.23, p value: 0.034) was significantly associated with higher likelihood of falls after adjusting for age, gender, ethnicity, living arrangement, intake of medication, loneliness status, presence of vision/ hearing impairment, alcohol intake, and history of falls. Frailty (OR: 1.21, 95% CI: 0.52 – 2.84, p value: 0.654) was also associated with higher likelihood of falls, however, this association did not reach statistical significance (Table 2).

Conclusions

Pre-frail adults & frail adults are at higher risk of falling, although the association between frailty and falls did not reach statistical significance. Community-based outreach programmes to screen for pre-frailty is important to reduce risk of falls & delay the progression towards frailty.

Figure 1. Flowchart of participants aged ≥40 years old included in the analysis

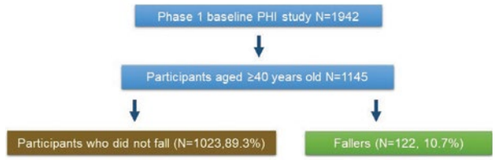


Figure 2. Comparison of baseline frailty status of those who did not fall and those who fell

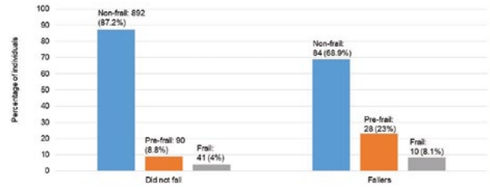


Table 1. Comparison of baseline characteristics of those who did not fall and those who fell

	Did not fall (N=1023) Mean (s.d.)/ N (%)	Fallers (N=122) Mean (s.d.)/ N (%)	P value
Age, years	**59.9 (11.9)**	**66.5 (13.2)**	**<0.001**
Gender, female	557 (54.5)	76 (62.3)	0.099
Ethnicity			
Chinese	817 (79.9)	103 (84.4)	
Malay	71 (6.9)	8 (6.6)	0.488
Indian	113 (11.1)	8 (6.6)	
Others	22 (2.1)	3 (2.4)	
Living arrangement			
Alone or with domestic helper	149 (14.6)	19 (15.6)	
Spouse only	188 (18.4)	19 (15.6)	
Spouse & children/grandchildren	445 (43.5)	37 (30.3)	**<0.001**
Children/ grandchildren only	117 (11.4)	30 (24.6)	
Relative/ friends/ tenants	124 (12.1)	17 (13.9)	
Intake of medication(s), yes	1010 (98.7)	120 (98.4)	0.735
Lonely (UCLA loneliness scale ≥5), yes	65 (6.4)	13 (10.7)	0.075
Vision/ hearing impairment, yes	62 (6.1)	9 (7.4)	0.569
Alcohol intake, yes	83 (8.1)	6 (4.9)	0.213
History of falls, yes	55 (5.4)	29 (23.8)	<0.001
Non-frail (CFS 1-3)	892 (87.2)	84 (68.9)	
Pre-frail (CFS 4)	90 (8.8)	28 (23)	<0.001
Frail (CFS ≥5)	41 (4.0)	10 (8.1)	

N: number; s.d.: standard deviation; UCLA: University of California, Los Angeles

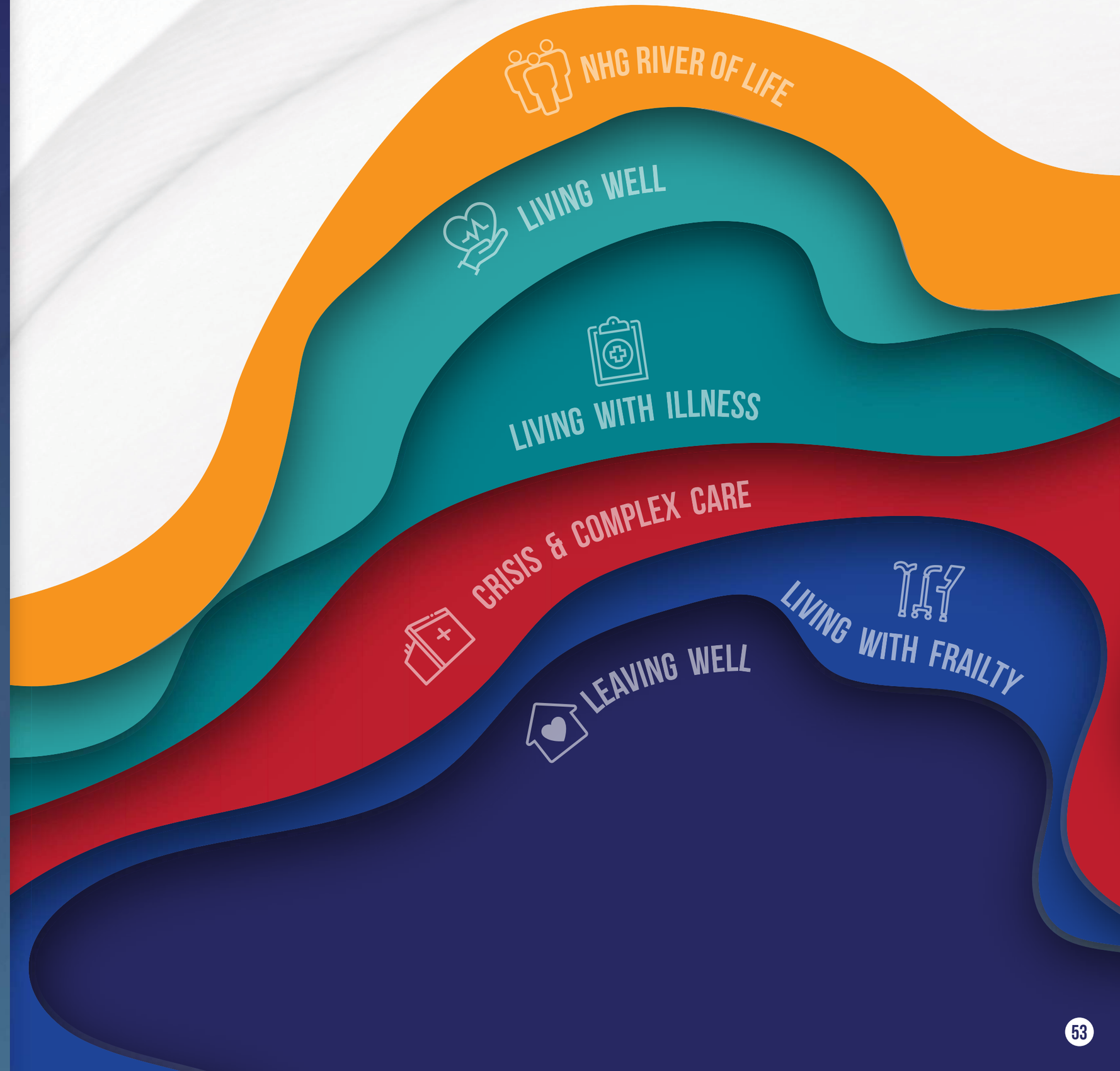
Table 2. Association of frailty status with falls

	At risk, N	Fallers, N (%)	OR (95% CI)*	P value
Non-frail (CFS 1-3)	976	84 (8.6)	Reference	
Pre-frail (CFS 4)	118	28 (23.7)	**1.84 (1.05 – 3.23)**	**0.034**
Frail (CFS ≥5)	51	10 (19.6)	1.21 (0.52 – 2.84)	0.654

*Adjusted for age, gender, ethnicity, living arrangement, intake of medication, loneliness status, presence of vision/ hearing impairment, alcohol intake, history of falls

LEAVING WELL

A focus on end-of-life care and considerations



FACTORS INFLUENCING MORTALITY IN PATIENTS WITH DEMENTIA: A SCOPING REVIEW

Palvinder Kaur, Dr Tan Woan Shin, Dr Pradeep Paul George, Dr Yew Yoong Ding[1,2], Reuben Ong, Dr Wu Huei Yaw[3,4], Dr Allyn Hum[2,3,4]

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[2] Geriatric Education and Research Institute
[3] Palliative Care Centre for Excellence in Research and Education
[4] Department of Palliative Medicine, Tan Tock Seng Hospital

HIGHLIGHTS

- **Biochemical parameters, vital signs, dementia-relevant symptoms, and treatment variables should be considered in prognostic models of mortality in patients with dementia.**
- **Future research should focus on replicability of such mortality prognostic models for patients with dementia.**

Introduction

Identifying prognostic variables relevant to dementia across healthcare settings is key to facilitating appropriate care plans and ensuring timely access to palliative care options. We aimed to identify the types of factors included in research studies examining mortality in patients with dementia, and to stratify the identified factors by care settings.

Methods

The framework outlined by Arksey and O'Malley for scoping reviews was adopted. We systematically searched PubMed, Embase, PsycINFO and CINAHL databases, and identified grey literature from the Networked Digital Library of Theses and Dissertations, Open Grey and Grey Literature Reports. Two authors independently screened studies for eligibility. Independent reviewers extracted relevant study information. We conducted a narrative synthesis of the data.

Results

We identified 8,254 articles, of which 94 met the inclusion criteria. More than half (n=53) were published between 2009 and 2018, with half being from Europe. Studies were conducted across hospices/nursing homes (n=25), hospital (n=23), outpatient clinics (n=21), mixed settings (n=15) and the community (n=10). Nearly 60% adopted a prospective cohort study design, with 87% performing multivariable analysis.

For the 82 studies that conducted multivariable regression analysis, we identified 239 variables and classified them into six categories: individual factors, health status, functional ability, cognition and mental health, treatments and health system factors (Figure 1). We found that cardiovascular comorbid conditions, illness symptoms, infections and poor functional ability were associated with higher mortality risks in persons with dementia. Conversely, the concurrent burden of mental disorders and quality of life rarely influenced mortality risks. Prognostic studies often do not consider the impact of treatment on mortality risk. In this review, we found that the use of anti-dementia medications was associated with reduced mortality risks whereas anti-psychotic medications had the opposite effect. Neglecting to include treatments that might modify survival likelihood may result in a misestimation of patients' mortality risk if the prognostic models were subsequently applied to populations who had received these treatments.

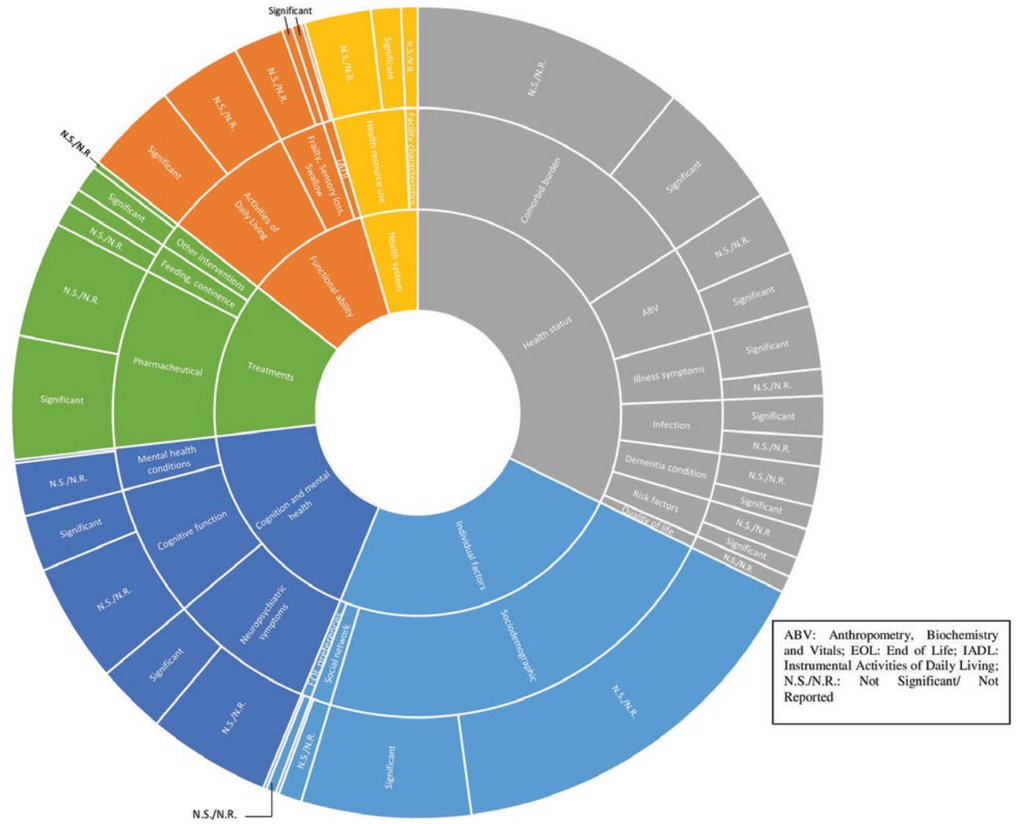
Factors predictive of mortality do differ across settings, but the variation was not substantial. This could be due to the availability of information in different settings. Illness symptoms such as anorexia, reduction in meal consumption, malnutrition and dehydration were included in studies carried out in community and outpatient settings. Community-based studies often accounted for the effect of social support and network on mortality, albeit the risk of death was predominantly insignificant. Variables relating to anthropometric measurements (e.g. body mass index, weight loss), biochemical variables (e.g. albumin, haemoglobin, blood cholesterol) vital signs (e.g. blood pressure, pulse rate) and infections were commonly included studies based in hospitals, hospices or nursing homes.

Certain gaps in the current literature that needs to be addressed include the lack of differentiation between dementia-related and non-dementia-related factors as well as the lack of standardisation of the various approaches to ascertain cognitive function.

Conclusions

Our study highlights the need to incorporate biochemical parameters, vital signs, dementia-relevant symptoms, and treatment variables above the usually studied demographic and clinical factors. Future research should also focus on ensuring the replicability of prognostic models and to better understand the direct and interacting influence of the identified factors on mortality.

Figure 1. Factors included in studies with multivariable analyses to examine mortality in dementia populations



HEALTHCARE UTILIZATION & COSTS OF THE TERMINALLY ILL IN THE LAST YEAR OF LIFE: A HEALTH SYSTEMS PERSPECTIVE

Palvinder Kaur, Dr Tan Woan Shin, Dr Wu Huei Yaw[1,2]

[1] The Palliative Care Centre for Excellence in Research and Education
[2] Department of Palliative Medicine, Tan Tock Seng Hospital

HIGHLIGHTS

- **The average gross cost for healthcare use for the terminally ill in the last year of life at Tan Tock Seng Hospital was SGD$38,451.**

Introduction

Our objective was to describe and compare healthcare utilization and costs in the last year of life for the terminally ill.

Methods

Decedents who died between 2015 and 2017, with previous in- or outpatient encounters at TTSH were included. End of life (EoL) was defined as patients with a prognosis of ⩽12 months. Healthcare services included visits to inpatient (IP) emergency, IP elective, day surgery (DS), emergency department (ED), specialist outpatient clinics (SOC) and polyclinics. Gross charge was defined as the total cost incurred by the healthcare system for the provision of any medical care and service. Using ICD-10-CM diagnostic codes and disease-specific clinical criteria, we identified EoL patients diagnosed with advanced cancer (AC), heart failure (HF), end stage renal failure (ESRF), respiratory failure (RF), severe liver disease (SLD), Parkinson's disease (PD) and advanced dementia (AD). A look-back approach was used to compute the volume of healthcare services consumed and gross charges incurred in the last year of life for all EoL patients and by disease group stratification. Costs incurred elsewhere, outside of TTSH (e.g. intermediate and long-term care, community-based services), was not included in this analysis.

Results

Mean age at death of the 6,598 EoL patients included was 74.8 years (SD:12.7). 55% were males and 83% were ethnically Chinese. Nearly half (46.9%) were diagnosed with AC (Table 1). Half of these EoL patients were referred to palliative care (PC) and 14.6% had documented preferences for advance care plans (ACP). Mean time to death from terminal diagnosis was 15.3 months (SD:18.2) and 64.2% of deaths occurred in the hospital. Unplanned healthcare utilization such as inpatient emergency and ED visits increased closer to death (Figure 1). Average gross costs in the last year of life was SGD$38,451. A two-fold fold increase in costs was seen between the last 2 months of life (Figure 1). When stratified by disease groups, variations were seen in terms of palliative care referrals, documented care plans, healthcare utilization and home deaths (Table 1). The average 1-year gross healthcare costs for disease groups studied ranged between SGD$27,300 – 57,991 (Table 1).

Conclusions

EoL patients in their final year of life are a heterogenous population group. Future studies should include costs incurred at other healthcare institutions and settings.

Table 1. Profile of EoL patients – overall and stratified by disease groups

Variables	TTSH (n=6,598)	AC (n=3,095)	HF (n=438)	ESRF (n=1,765)	RF (n=197)	SLD (n=442)	PD (n=698)	AD (n=916)
1-year utilization (units) (mean, SD)								
IP Emergency	2.6 (2.2)	2.2 (1.7)	1.7 (4.3)	2.8 (2.6)	4.4 (3.0)	3.3 (3.2)	2.1 (2.3)	3.8 (2.1)
IP Elective	0.1 (0.4)	0.2 (0.4)	0.4 (0.1)	0.1 (0.4)	0.1 (0.3)	0.2 (0.6)	0.1 (0.3)	0.1 (0.3)
DS	0.2 (0.7)	0.3 (0.7)	0.7 (0.2)	0.2 (0.7)	0.1 (0.4)	0.3 (0.5)	0.1 (0.7)	0.1 (0.5)
ED	2.9 (3.0)	2.4 (2.0)	2.0 (4.8)	3.2 (3.1)	4.9 (4.2)	3.8 (5.4)	2.5 (2.5)	4.3 (3.5)
SOC	13.7(17.9)	17.6 (22)	22.0(13.2)	13.1(14.7)	11.2(11)	13.2(17)	7.8 (8.7)	7.7 (9.2)
Polyclinic	1.9 (4.9)	2.1 (4.9)	4.9 (2.4)	2.2 (6.2)	1.5 (2.9)	2.1 (5.1)	1.1 (2.9)	0.2 (3.0)
Average 1-year gross cost (SGD)	38,451	36,286	57,991	45,240	57,210	44,582	27,300	42,527
PC referral (column %)	50.2	76.5	32.9	33.7	42.1	53.6	18.9	25.2
ACP done (column %)	14.6	12.2	12.6	12.6	15.2	12.0	19.1	33.6
Place of death (column %)								
Hospital	64.2	54.0	80.1	75.8	83.8	72.6	63.8	69.1
Home	20.1	23.5	13.0	15.6	9.6	14.3	26.1	16.2
Nursing Home	14.0	20.5	5.0	7.1	5.1	10.6	9.0	14.1
Unknown	1.4	1.7	0.9	1.2	1.0	1.6	1.0	0.5
Public Place	0.4	0.3	0.9	0.3	0.5	0.9	0.1	0.1
Time to death from ICD diagnosis (months) (mean, SD)	15.3 (18.2)	9.6 (12.8)	18.8 (17.5)	21.6 (22.3)	17.7 (18.0)	12.8 (16.6)	25.2 (18.1)	21.3 (20.1)

Figure 1. Monthly gross cost in the last year of life for all EoL patients (n=6,598)

PUBLICATIONS

1. **George PP**, Chng OSY, Siow K, Saxena N, Heng BH, Car J, Lockwood C. Is there scope for expanding the optometrist's scope of practice in Singapore? – A survey of optometrists, opticians in Singapore. Contact Lens and Anterior Eye. 2019; 42(3):258-64.

2. **George PP**, Zhabenko O, Kyaw B, Antoniou P, Posadzki P, Saxena N, Lockwood C. Online Digital Education for Postregistration Training of Medical Doctors: Systematic Review by the Digital Health Education Collboration. Journal of Medical Internet Research. 2019; 21(2):e13269.

3. Kyaw B, Saxena N, Posakzki P, Vseteckova J, Nikolaou C, **George PP**, Divakar U, Masiello I, Kononowicz A, Zary N, Car L. Virtual reality for health professions education: Systematic review and meta-analysis by the Digital Health Education Collaboration. Journal of Medical Internet Research. 2019; 21(1):e12959.

4. **Meng FW**, Li E, Yen P, Leow MSK. Hyperthyroidism in the Personalized Medicine Era – the Rise of Mathematical Optimization. Journal of the Royal Society Interface. 2019; 16(155):20190083.

5. Chanchaichujit J, Tan A, **Meng FW**, Eaimkhong P. Healthcare 4.0 - Next Generation Processes with the Latest Technologies. Palgrave Macmillan. 2019.

6. **Pereira M**, Comans, T, Sjøgaard G, Straker L, Melloh M, O'Leary S, Chen X, Johnston V. The impact of workplace ergonomics and neck-specific exercise versus ergonomics and health promotion interventions on office worker productivity: A cluster-randomized trial. Scandinavian Journal of Work, Environment and Health. 2019; 45(1):42-52.

7. **Tan AL**, Chiew CJ, Wang S, Abdullah HR, Lam SSW, Ong MEH, T HK, Wong TH. Risk factors and Reasons for Cancellation within 24 hours of Scheduled Elective Surgery in an Academic Medical Centre. International Journal of Surgery. 2019; 66:72-8.

8. **Tan AL**, Lyer NHG, N Putri, Nadkarni N, T Skanthakumar, Wong TH, Tay GCA. Factors driving frequent attendance at emergency departments for patients with head and neck cancer. Head & Neck. 2019; 41(11):3798-805.

9. **Tan AL**, Trauma Coordinators and Trauma Service representatives, Nadkarni N, Wong TH. The Price of Personal Mobility: Burden of Injury and Mortality from Personal Mobility Devices in Singapore - a Nationwide Cohort Study. BMC Public Health. 2019; 19(1):880.

10. **Tan WS**, Bajpai R, Ho AHY, Low CH, Wu HY, Car J. A retrospective cohort analysis of real-life decisions about end-of-life care preferenes in a Southeast Asian country. BMJ Open. 2019; 9(2).

11. **Tan WS**, Bajpai R, Low CH, Ho AHY, Wu HY, Car J. Individual, clinical and system factors associated with home deaths: A linked national database study. PLOS One. 2019;14(4).

12. **Tan WS**, Car J, Lall P, Low CK, Ho AHY. Implementing Advance Care Planning in Acute Hospitals: Leading the transformation of norms. Journal of American Geriatric Society. 2019; 67(6):1278-85.

13. Jimenez G, **Tan WS**, Virk AK, Low CK, Car J, Ho, AHY. State of Advance Care Planning research: A descriptive overview of systematic reviews. Palliat Support Care. 2019; 17(2):234-44.

14. Dutta O, Lall P, Victor P, Car J, Low CK, **Tan WS**, Ho AHY. Patient autonomy and participation in end-of-life decision-making: an interpretive-systemic focus group study on for peer review perspectives of Asian healthcare professionals. Palliative and supportive care. 2019: 1-6.

15. Prabhakaran L, **Yap CW**, Neo LP, Gan CC, Tham LM, Abisheganaden J, Lim TK. Effectiveness of the eCARE programme: a short message service (SMS) for asthma monitoring. BMJ Health & Care Informatics. 2019; 26(1).

CONFERENCE PRESENTATION AWARDS

SINGAPORE HEALTH & BIOMEDICAL CONGRESS 2019

YOUNG INVESTIGATOR AWARD (SILVER)

ASSOCIATION OF PRE-FRAILTY AND FRAILTY WITH FALLS AMONG COMMUNITY-DWELLING ADULTS (ORAL)
Dr Yip Wan Fen

BEST POSTER AWARD FOR NURSING (BRONZE)

ASSOCIATION OF NUTRITIONAL STATUS WITH PHYSICAL FUNCTION AND DISABILITY IN COMMUNITY-DWELLING ADULTS: A LONGITUDINAL DATA ANALYSIS
Ge Lixia

RESEARCH GRANTS

AI SINGAPORE — **$15M**
AI IN HEALTH GRAND CHALLENGE

An end-to-end Adaptive AI-Assisted 3H Care (A3C)
Prof Miao Chunyan (PI)
Dr Sun Yan (Collaborator)

MINISTRY OF HEALTH — **$10M**
HEALTH SERVICES DEVELOPMENT PROGRAMME

Reducing the spread of carbapenemase-producing gram negative bacteria via rapid and direct detection from surveillance and clinical samples
Dr Shawn Vasoo (PI)
Dr Sun Yan (Collaborator)

NATIONAL MEDICAL RESEARCH COUNCIL — **$713K**
COMPETITIVE RESEACH GRANT
HEALTH SERVICES RESEARCH GRANT

Predicting survival in end stage organ disease: developing and validating prognostic models
Dr Allyn Hum (PI)
Dr Tan Woan Shin (Co-I), Dr Pradeep Paul George (Co-I), Palvannan RK (Co-I), Palvinder Kaur (Co-I)

GERIATRIC EDUCATION AND RESEARCH INSTITUTE — **$335K**
INTRAMURAL GRANT

Prediction of Survival in Advanced Dementia: Developing Prognostication Models
Dr Allyn Hum (PI)
Dr Tan Woan Shin (Co-I), Dr Pradeep Paul George (Co-I), Palvannan RK (Co-I)

REHABILITATION RESEARCH INSTITUTE OF SINGAPORE — **$300K**
RRIS RESEARCH GRANT CALL

Gait analysis in knee osteoarthritis
Dr Bryan Tan Yijia (PI)
Dr Michelle Jessica Pereira (Co-I), Dr Cyril John William Donnelly (Co-I), Dr Michael Yam Gui Jie (Co-I), Dr Jason Lim (Co-I), Dr Matthew Tay (Co-I)

NATIONAL MEDICAL RESEARCH COUNCIL — $240K
COMPETITIVE RESEACH GRANT
HEALTH SERVICES RESEARCH GRANT

Diabetic foot ulcers - lifelong cost, risk prediction and CEA of risk tailored intervention
Dr Sun Yan (PI)
Dr Ang Yee Gary (Co-I), Dr Michelle Jessica Pereira (Co-I), Dr Heng Bee Hoon (Collaborator)

KHOO TECK PUAT HOSPITAL — $202K
SCIENCE-TRANSLATION AND APPLIED RESEARCH GRANT

Economic burden of progressive Type 2 diabetes and its complications in Singapore - direct, indirect and intangible cost
Dr Serena Low (PI)
Dr Tan Woan Shin (Co-I)

MINISTRY OF HEALTH — $184.9K
HEALTH SERVICES DEVELOPMENT PROGRAMME
PROGRAMME EVALUATION STUDY

Evaluation of the Home Ventilation and Respiratory Support Programme
Dr Chan Yeow (Programme Director)
Dr Tan Geak Poh (PI)
Dr Joseph Antonio D. Molina (Co-I), Dr Michelle Jessica Pereira (Co-I), Christina Chieh Pann Pei (Co-I)

LIEN FOUNDATION — $120K

Non-Palliative Care Professionals Caring for End-of-life Patients: A Lived Experience Study on Needs, Challenges and Actions for Strengthening Clinical Competency and Psycho-Socio-Emotional Capacity in Singapore
Prof Andy Ho (PI)
Dr Tan Woan Shin (Co-I)

NATIONAL HEALTHCARE GROUP — $100K
SENIOR MANAGEMENT INTRAMURAL FUNDING

Development and Validation of a Health Resilience Index
Dr Tan Woan Shin (PI)
Ge Lixia (Co-I), Dr Yip Wan Fen (Co-I), Eric Chua Siang Seng (Co-I), Christina Chieh Pann Pei (Co-I)

TRAINING

HEALTHCARE OPERATIONS RESEARCH APPRECIATION COURSE @ PANTAI HOSPITAL, KUALA LUMPUR — February, April

Dr Meng Fanwen
Palvannan RK
Teow Kiok Liang
Dr Zhu Zhecheng

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

INTRODUCTION TO HEALTH SERVICES RESEARCH — September

Dr Pradeep Paul George
Dr Joseph Antonio D. Molina
Dr Michelle Jessica Pereira
Palvannan RK
Dr Sun Yan
Dr Yap Chun Wei

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

CONFERENCE PRESENTATIONS

APRIL 2019

19th International Conference on Integrated Care, Spain

Integrated-care clinics: patient management and return to work rates
(Poster)
Tan AL, Ho SF, Fong YT

JULY 2019

18th Asian Colloquium of Nephrology, Singapore

Annual annual eGFR decline based on albuminuria status in patients with DM, hypertension and an eGFR>60/min/1.73m2
(Poster)
Weng W, Ang GY, Yap CW, Liew A

JULY - AUGUST 2019

Operational Research Applied to Health Services Conference 2019, Germany

A Mathematical Model for Optimal Personalized Anti-thyroid Drug Dosing for Patients with Graves' Disease
(Poster)
Meng FW, Li E, Yen PM, Leow M

AUGUST 2019

World Psychiatry Association's 19th World Congress, Portugal

A non-inferiority study of non-mental healthcare utilisation outcomes from care models for mental health patients with specific coexisting chronic diseases
(Poster)
Pereira M, Molina J, Yap CW, Lum A, Ng BL, Chua HC

OCTOBER 2019

14th Singapore Public Health & Occupational Medicine Conference, Singapore

Age of onset of T2DM and all-cause mortality
(Oral)
Ang GY, Yap CW, Teow KL

Singapore Health & Biomedical Congress 2019, Singapore

Implementing Advance Care Planning: Transformation of Norms
(Oral)
Tan WS (Invited Speaker)

Association of pre-frailty and frailty with falls among community-dwelling adults
(Oral)
Yip WF, Ge L, Heng BH, Tan WS

Collaborative Model of Care between Orthopaedics and Allied Healthcare Professionals Trial (CONnACT): Pilot Study
(Oral)
Tan B, Ding B, Pereira M, Skou S, Thumboo J, Car J

Age of onset of T2DM and all-cause mortaltiy
(Poster)
Ang GY, Yap CW, Teow KL

Annual eGFR decline based on albuminuria status in patients with DM, hypertension and eGFR≥60ml/min/1.73m2
(Poster)
Weng W, Ang GY, Yap CW, Liew A

Age differences in relationship between socioeconomic status with social isolation
(Poster)
Ge L, Tan WS, Heng BH

Association of nutritional status with physical function and disability in community-dwelling adults: A longitudinal data analysis
(Poster)
Ge L, Yap CW, Heng BH

Recurrent Event Survival Analysis to Assess Body Mass Index (BMI)'s disease risk
(Poster)
Ong R, George PP, Palvannan RK, Heng BH

The hidden economic burden of common chronic diseases among older adults
(Poster)
Pereira M, Yap CW, Heng BH

HALT-CKD – Median Time to Optimisation of ACE-I/ARB Therapy in Primary Care
(Poster)
Yap CW, Lim CK, Ang GY, Liu DYK, Ang XY

NOVEMBER 2019

American Society of Nephrology Conference 2019, USA

Cost Effectiveness Analysis of SGLT-2 Inhibitors Treatment in Patients with Diabetic Kidney Disease for Cardiovascular and Renal Protection in Singapore
(Oral)
Liew A, Weng W, Ang GY, George PP, Heng BH, Lim CK

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