HEALTH SERVICES & OUTCOMES RESEARCH

ANNUAL REPORT

2021

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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.

FOREWORD

ENABLING NHG'S JOURNEY TOWARDS POPULATION HEALTH AND ACCOUNTABLE CARE

A rapidly ageing population, rising healthcare costs and gaps in care integration are the big challenges to NHG today. While we continue to add years of healthy life with prudence, a transformation is needed. In 2021, NHG reorganized itself to enable an accountable care framework with its network of public and private partners - accountable for the health and well-being of its regional population, accountable for care when sought, and accountable for resources it is entrusted with. This report begins with our very early attempts in supporting NHG's accountable care initiative, along with our mission of evidence-based work in knowledge translation, program evaluation and timely decision support for stakeholders.

Accountable care has 3 premises in our local context: improving population health, integrating care with partners and funding by capitation. We began with a mapping of the inputs and activities of an Accountable Care Organization (or ACO) with the end goals of population health outcomes. This collaborative exercise with our stakeholders suggested a minimum set of indicators for performance monitoring. To reduce cost growth rates, MOH has adopted funding by capitation, shifting from volume-driven financing to person-based budgeting. A literature review of capitated systems showed the need for risk-adjustment of healthcare cost by demographics and diseases of the population. This is a basis for us to develop our own cost risk-adjustment model to address these differences within the NHG region, for equitable funding.

Moving upstream, we explored tools to better understand determinants of health, such as resilience, activation, and engagement. Interviews on health resilience of patients who had coped well with their health adversities showed they had past tough experiences, guiding principles, strong personality traits and health literacy. When faced with health crises, they sought social, healthcare and informational support on their road to recovery. Diabetes remains as one of the diseases with the highest cost for NHG. NHGP piloted a Chronic Care Plan where patients were motivated with financial incentives to adhere to their care plan and improve health outcomes. With a large enrolled patient group, results showed improved adherence to care, providing useful lessons for larger health plans. Turning to end of life care, a prognostic model for patients with advanced dementia showed promising results in advising on suitable referral for palliative care or continued treatment. Close collaboration with geriatric and palliative clinicians increases the viability and acceptance of such predictive models in clinical decision making. Another study of patients who had passed on, under a palliative home care program, showed that they spent less time in the hospital and a large number of them had their wishes of place of death honored.

The above are a few examples of HSOR's value-add to the work of our providers in delivering evidence-based and data-driven best practice and care on the ground, in the context of population health and accountable care. I am sure much more of such useful studies will take place in time to come as we journey further and deeper into population health, accountable care and capitation funding. We hope you find this report interesting and useful.

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Chief Executive Officer,
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NHG

RIVER OF LIFE

NHG RIVER OF LIFE

ACCOUNTABLE CARE

LIVING WELL

LIVING WITH ILLNESS

CRISIS & COMPLEX CARE

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DEVELOPING POPULATION HEALTH OUTCOMES AND PROCESS INDICATORS FOR NATIONAL HEALTHCARE GROUP, GROUP ACCOUNTABLE CARE (NHG GAC)

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HIGHLIGHTS

- **Development of an indicator set to measure performance is necessary during care transformations.**
- **Indicator selection is informed by evidence and an underlying systems framework.**
- **A systematic stepwise approach is recommended to ensure a valid and agreed-upon set of measures.**

Introduction

Healthcare costs is a major concern for stakeholders. Efforts to curb rising costs include health system reorganisation and financial reform. In 2021, the National Healthcare Group (NHG) cluster in Singapore transformed itself akin to an accountable care organization. As part of this transformation, it was necessary to develop a set of indicators for the Accountable Care Office (ACO) to hold care providers accountable for: improving care, improving population health, and reducing costs per capita. We outline a possible stepwise approach to developing such a set. [Table 1]

Table 1. Proposed approach to indicator set development

Indicator development process
1. Define ACO goals based on the U.S. Institute for Healthcare Improvement's (IHI) triple aims
2. Review literature on ACO outcome indicators
3. Create a framework (logic model)
4. Propose criteria for selection of indicators
5. Propose indicators attributable to ACO
6. Obtain stakeholder consensus and ratification

Methods

The purpose of the indicator set is threefold: measure providers' performance towards the desired outcomes, measure any deviations from pre-defined requirements, and identify any potential negative consequences. The first step in the development process is identifying and defining the goals: outcomes and any other prevailing requirements. For the NHG ACO, the goals were based on the NHG Population Health Aims: Outcome, Care, Cost, Partnership, People.

Once these goals have been appropriately defined, an underlying systems framework, or logic model, should be drawn up. The logic model covers the inputs, activities, outputs and outcomes linked to the goals. This serves to map out the goals and its related domains, thereby ensuring that all relevant areas are identified and appropriately measured. The mapping of the logic model would also allow for identification of any potential negative consequences that may arise from changes in the related domains or areas being intervened upon to achieve the outcomes. The logic model also aids in relating higher level outcomes with the actions and interventions of relevance on the ground level, as it provides a visual translation of long-term macro outcomes to the operational processes provided by clinical teams or services. [Figure 1]

Concurrently, a literature review to identify existing frameworks and indicator sets of relevance to defined goals should be conducted. In our review, we covered the OECD Healthcare Quality Framework, Canterbury Health System Outcomes Framework and System Level Measures Improvement Plans (New Zealand), US IHI Whole System Measures, US CMS Core Quality Measures, and UK Incentives Framework for Integrated Care Providers. These indicators identified serves the purposes of: providing a prototype set of indicators for further refinement to Singapore's context, substantiating areas that should be measured, aiding in identification of potential harms, and future international comparators. These review findings should be categorized within the logic model. Any areas of concern not measured should have novel indicators conceptualized.

Subsequently, a first-cut indicator set should be drawn from the extensive set of indicators (review findings and novel indicators). A set of guiding principles for indicator selection should be developed. For NHG, these guiding principles included the selection of indicators that were goal-oriented, guided by a logic model, sensitive to changes, accurate and measurable. To avoid any extraneous reporting burden, the indicator set should be also comprehensive yet parsimonious. [Table 2]

Table 2. Guidelines for indicator selection

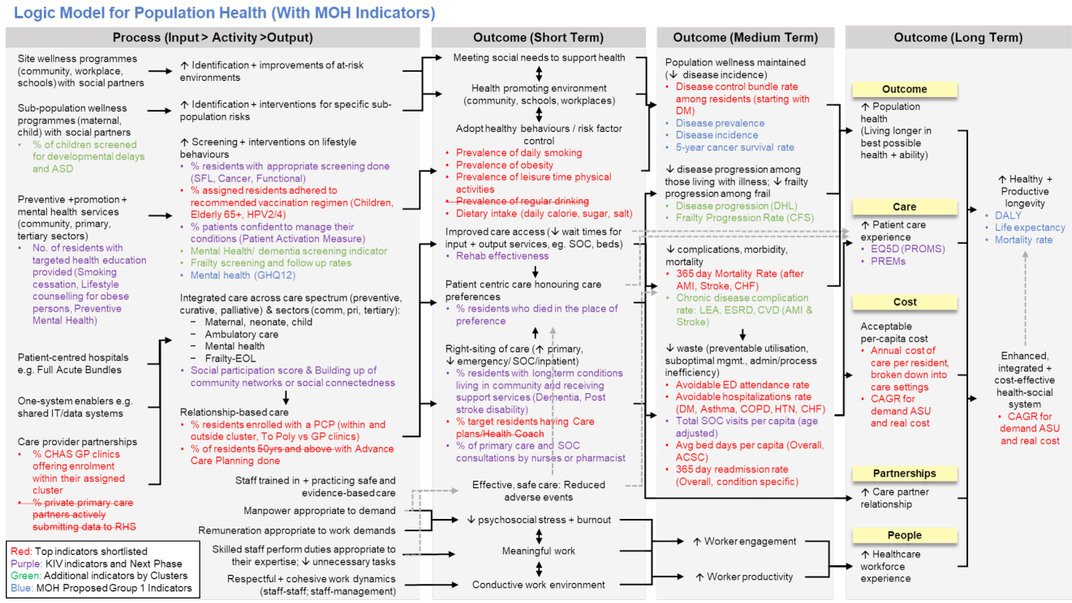
Guiding Principles
• Justification for each indicator's inclusion
• Outcomes must have the potential to be improved by available interventions
• Accurate and reliable data is available
• Indicators are unambiguous – defined by a numerator & denominator
• Guided by a logic model
• Comprehensive yet parsimonious

Based on this first-cut indicator set, further consensus and ratification by stakeholders should be sought, such as from NHG senior management, hospital and care provider leadership. An iterative process of refinement is expected to develop a final set of agreed-upon indicators. The Delphi method is a potentially useful method for such consensus building.

Results

The logic model for the NHG ACO indicators was developed and served as an overarching framework for the indicators. Preliminary indicators were overlaid within various constructs in the logic model.

Figure 1. Logic model for NHG ACO indicators



Conclusions

Development of an indicator set to measure performance is necessary during care transformations. A systematic stepwise approach is recommended to ensure a valid and agreed-upon set of measures.

A REVIEW OF RISK-ADJUSTMENT APPROACHES IN FIVE CAPITATED PAYMENT SYSTEMS

Dr Yip Wan Fen, Dr Ang Yee Gary, Palvannan R.K., Teow Kiok Liang, Dr Tan Woan Shin

HIGHLIGHTS

- **Case-mix adjustments (e.g. socio-demographics, HCC) should be used when funding levels are set.**
- **Capitating only primary care, without hospital care, could have limited cost containment effect.**

Broadly, capitation may be defined as the payment of a pre-specified amount per person for a particular set of services, for a specified time period, taking into consideration a system's budget constraints. As capitation is seen as an important mechanism to reduce cost growth, we summarised risk-adjustment approaches in five capitated payment systems. Specifically, this summary sought to provide an overview on 1) how sponsors pay health districts/plans and describe the variables included in the risk-adjusted payments; 2) whether health districts/plans pay providers by capitation and describe the variables included in the risk-adjusted payments to providers. We first conducted a review on published information on systems in New Zealand, Alzira - Spain, Netherlands, England - U.K., and U.S. Medicare. As healthcare systems change rapidly, our review provided a snapshot of the state of each health system at the point of our review (February – August 2021). Since then, New Zealand and Alzira have experienced changes to their healthcare landscape.

New Zealand - New Zealand had 20 District Health Boards (DHB), and the Ministry of Health of New Zealand paid each DHB by per capita based on a Population Based Funding Formula (PBFF). The aim of the formula was to assist in achieving equality of access by residents to core personal health services according to need. The PBFF had 2 components: core model and adjustors (Table 1). Separately, each health district paid their primary care organisations by capitation (Table 2). However, in April 2021, the New Zealand Government announced that DHBs would be abolished and replaced by a single health organisation called Health New Zealand to centralise the healthcare system.

Alzira, Spain - Spain had 17 Autonomous Communities (AC), and each AC received a global budget from the Government. This budget was calculated based on population size, economic status, referrals from other regions and presence of "centres of excellence". In Alzira, situated within the AC of Valencia, the Department of Health paid the private provider by per capita payment without any adjustments (Table 2). The Alzira model was terminated in 2018 and reverted to direct public management by the Valencian government.

Netherlands - Unlike New Zealand and Spain, residents in Netherlands were required to purchase health insurance. On top of the premiums paid by the residents, private and not-for-profit insurers also received capita-payment from the Central Health Insurance Fund. Separately, the insurers funded general practitioners via a mix of payment methods (per capita, fee-for-service (FFS), bundled payment for chronic disease care, pay-for-performance) (Table 2).

England, United Kingdom - UK had 135 Clinical Commissioning Groups (CCGs). Budget allocation was based on the size of CCG registered population, adjusted per capita for age and gender, unmet needs and health inequalities, unavoidably higher costs due to cost of living in cities, higher costs of providing emergency ambulance services in sparsely populated areas and higher costs of providing 24-hour accident and emergency services in remote areas. Payment to general practices was via a quarterly-computed and monthly-disbursed capitation amount adjusted for age, gender, additional needs, list turnover (% of new patients), market force and rurality, population density and dispersion. Payment to hospitals was determined on a yearly basis via a health resource group.

United States, Medicare Advantage (MA) Plan C - A capitated amount per month was paid by Centres for Medicare and Medicaid Services (CMS) to private healthcare plans (MA Plan C) for each enrolee and risk-adjustment factors included age, gender, number of CMS-Hierarchical Condition Categories (HCC), dual eligibility for Medicaid, disability status, HCC counts and number of prescription drugs counts (if drugs were covered). Providers were paid via either FFS or, less commonly, capitation for managed care plans.

Implications for Singapore

Specific learning points applicable to NHG and the local healthcare system were identified:

- Capitation at district levels was risk-adjusted for demographic variables, whereas insurance-based programmes included case-mix variables to limit effects of adverse selection on financial risk. Various systems may also account for local market conditions, and to seek to redress for unequal access to care through the funding formula.
- Paying providers by capitation was primarily used for primary care services. Across these 5 systems, hospital services continued to be paid via a global budget or by episodic payment dependent on case-mix.

Table 1. Payment approaches of sponsors to health districts/health plans

Country	Financing Approach	Base	Demography	SES	Disease burden and others
New Zealand	Per capita with DHB-level adjustments	No. of people living in each DHB	Age, gender, ethnicity	NZDep2006	**Disease burden:** - **Others:** Cost of service provision, rurality, overseas eligible & refugees, unmet needs
Netherlands	Per capita with individual-level risk-adjustment	No. of enrollees for each insurer	Age, gender	Income, household size	**Disease burden:** Pharmaceutical cost groups, chronic conditions, mental health conditions **Others:** Labour force status, region
U.K. England	Per capita with CCG-level adjustments	No. of registered CCG population	Age, gender	-	**Disease burden:** - **Others:** Unmet needs, unavoidable cost
U.S. Medicare	Per capita with individual-level risk-adjustment	No. of enrollees for each managed care plan	Age, gender	Medicaid -Dual eligibility	**Disease burden:** CMS-HCC, HCC counts, RxHCC **Others:** Disability status

Table 2. Payment approaches of health districts/health plans to providers

Country	Provider	Financing Approach	Demography	SES	Disease burden and others
New Zealand	Primary Care Organisations	Per capita with added funding per capita for health promotion, improved access	Age, gender, ethnicity	Welfare status	**Disease burden:** Historical utilisation patterns **Others:** -
	Hospitals	Global budget	-	-	**Disease burden:** DRG **Others:** Historical utilisation patterns, manpower cost, needs projections
Spain Alzira	Integrated Care Provider	Per capita without risk adjustments	-	-	**Disease burden: - Others: -**
Netherlands	General Practice	Per capita, fee-for-service, bundled payment for chronic disease care, P4P	Age ≥ 65	Deprivation status (zip code)	**Disease burden:** Cardiovascular risk, Asthma, COPD, Diabetes **Others: -**
	Hospitals	Case-mix with negotiated segment	-	-	**Disease burden:** DTC **Others:** -
U.K. England	General Practice	Per capita with adjustments for locality	Age, gender	-	**Disease burden:** - **Others:** Additional needs, list turnover, market force, rurality, population density & dispersion
	Hospitals	Case-mix	-	-	**Disease burden:** HRG **Others:** -

OUTCOMES OF RISK-ADJUSTMENT APPROACHES IN FIVE CAPITATED PAYMENT SYSTEMS

Dr Ang Yee Gary, Dr Yip Wan Fen, Palvannan R.K.,Teow Kiok Liang, Dr Tan Woan Shin

HIGHLIGHTS

- **Healthcare delivery systems have to be well-integrated to ensure healthcare is accessible to the population regardless of geographical assignment.**
- **Sufficient case-mix adjustment is necessary to prevent insufficient reimbursement which will be financially unviable.**
- **Bundled payment schemes should be scoped to include all services (including specialist care) required for quality chronic disease management.**

Risk-adjusted provider capitation seeks to contain healthcare utilisation and cost but could impact on quality and outcomes of care. To follow-upon our summary of risk-adjustment approaches for capitated healthcare financing, we reviewed published and grey literature to identify outcomes of the five systems. Key outcomes examined depended on the motivations underlying the assessments, and prevailing policy focus in each country. As such, we did not attempt to compare outcomes according to a common set of metrics. Instead, available country-specific outcomes and useful lessons were summarised.

New Zealand: In 2010, a Government-appointed Health and Disability System Review was completed and observed that the current financing and care delivery system was deemed overly complicated and fragmented. This resulted in 1) different pricing and access arrangement by various providers and 2) unequal distribution of the type of services available geographically. The District Health Boards were eventually abolished in 2022 to create a nationwide health service and harmonise the system (Table 1).

Spain, Alzira: Based on published literature, the effectiveness of the Alzira model was mixed. In the latest and most comprehensive study, a total of 26 performance indicators were used to compare the Alzira model with other similar providers in Spain. The Alzira model performed better in only 3 of the 26 indicators (lower age-adjusted rates of adenoidectomy, in-hospital mortality after percutaneous coronary intervention and lower adjusted per capita hospital expenditure). The model officially ceased in 2018 due to a change in political party, governance failure and financial concerns.

Netherlands: Insurers paid providers bundled payments, a risk-adjusted annual fee per patient, for the provision of integrated primary care services for Type 2 diabetes, cardiovascular risk management or chronic obstructive pulmonary disease. Evaluations of bundled payment schemes found an associated increase in healthcare expenditures for patients, which was mainly caused by the use of medical specialist care and medications due to an increase in the identification of unmet needs by primary care practitioners (Table 1). Published materials on the impact of risk-adjusted payments to insurers were not available.

United Kingdom, England: Underperforming Clinical Commissioning Groups (CCGs) were merged with neighbouring CCGs to reduce administrative and operating costs, with 135 of 211 CCGs remaining by April 2020. As of 2019, CCGs reported a net overspend of £41.2 million despite cost-cutting efforts. Plans to streamline them further into 42 Integrated Care Systems to foster collaboration between commissioners and providers in 2022 were delayed due to Covid-19.

United States, Medicare Advantage (MA) Plan C: MA plans saw a 10% growth in enrolees between July 2019 and July 2020, but when compared to previous fee-for-service payment model, payments to MA plans remained higher. This was postulated to be a result of lack of a budget cap by the government, and higher diagnosis coding intensity which resulted in higher risk-adjusted payments to MA plans. In 2019, risk-adjusted readmission rates and mortality rates improved modestly, but overall there was a failure in cost containment due to higher payments to MA plans.

Implications for Singapore

Specific learning points applicable to NHG and the local healthcare system were identified:

- A national health system split by geographical districts (and cared for by different healthcare providers) would need to avoid being overly complicated and inaccessible to the population.
- Design and costing of bundled payments for chronic care patients needed to consider potential increased use of medical specialist care and medications due to better risk assessments.
- Setting of a budget cap was necessary to limit the growth of healthcare expenses and reduce the potential impact of higher diagnosis coding intensity arising from the use of risk adjusted payments.

Table 1. Summary of Observations

Observations [Country]	Lessons
1. Accountable Care Districts Complicated and fragmented system, with different pricing and access arrangement by various providers [NZ]	System should have fewer agencies and better integration, and should establish services that focus on the needs of the communities
Unequal distribution of type of health services available by geographical assignment [NZ]	Links between healthcare system planning and district planning should be strengthened, and health infrastructure planning should be considered alongside local government, education, and transport planning
Payment system influenced health promotion and preventive care efforts [USA/UK]	Assignment of patient to a GP, coupled with capitated funding was associated with increased preventive care efforts as GP took a long-term view on health and costs
2. Capitation Funding Principles Tertiary DHBs were underfunded due to insufficient reimbursement of complicated cases [NZ]	Insufficient adjustment may lead to insufficient reimbursement which will be financially unviable
Risk-adjusted payment resulted in an increase in payment to health plans over time [USA]	Not setting an upper budget limit led a bottom-up budget that exceeded historical costs
Capitation of only GP services led to an increase in referrals of complex patients to specialists to contain cost [UK]	Capitation should include services (e.g. medical specialist, diagnostic tests) required for holistic patient care
3. Bundled Payments Bundled payments (including only primary care services) increased healthcare expenditure for patients [NT]	Bundled payments should be scoped to include services (e.g., specialists, diagnostic tests) required for quality chronic disease management
To avoid costs that exceeded the bundled payment, GPs referred more complex patients with multi-morbidity to secondary care [NT]	A combination of strategies (e.g., benchmarking of referrals and financial incentives for general practitioners) needed to reduce avoidable referrals of complex patients to specialist care
4. Quality and Outcomes of Care Health insurers paid a fixed price per patient without being informed of the type of care at the patient level [NT]	Important to monitor quality of care indicators and conduct formal evaluations
5. System Enablers Information sharing between care groups and partner providers facilitated seamless care for patients [NT/SP]	Ability to share patient and cost information across providers would be essential

DHB: District Health Board; GP: general practitioner; NT: Netherlands; NZ: New Zealand; SP: Spain; UK: United Kingdom; USA: United States of America

FACTORS ASSOCIATED WITH HEALTHCARE SUBSIDY – A PATIENT-LEVEL ANALYSIS

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HIGHLIGHTS

- **Age and CCI accounted for 12-14% of variation in National Healthcare Group and total government healthcare subsidy received by patients in 2018.**
- **Average unadjusted subsidy differed significantly across planning areas, but less variation was found after adjustment of baseline patient-level characteristics.**

Introduction

We aimed to (1) build explanatory models to identify factors associated with healthcare subsidies received by patients living within National Healthcare Group (NHG) catchment in 2018 and (2) determine the impact of planning areas (PAs) after accounting for baseline patient-level characteristics.

Methods

We used a cross-sectional study design. Patients who (1) utilised any NHG services, namely, inpatient, emergency department, specialist outpatient clinic, day surgery and intermediate-and-long-term care or polyclinic settings in 2018, (2) were Singaporean/permanent residents, (3) were living in central/north zones of Singapore and (4) were ages of 0 to 110 years, were included in this analysis. Patients residing within the NHG catchment area but did not use any NHG services in 2018 were excluded.

Subsidy, defined as patient's payable amount subtracted from gross charges, was summed across all the healthcare settings. Linear regression models were built for NHG patients receiving (Model 1; M1) NHG subsidy in 2018 and (Model 2; M2) total government subsidy in 2018, which also included subsidies received at the two other healthcare clusters – Singapore Health Services (SHS) and National University Health System (NUHS). Patient-level characteristics in 2018 were accounted for in the multivariable analysis (Table 1). As patients in Singapore's healthcare system can choose between healthcare providers on an episodic basis, we defined out-of-network subsidy (OON) as the proportion of a patient's subsidy received at SHS and NUHS over the total subsidy received at all three healthcare clusters. Anonymised data was retrieved from the national healthcare administrative database, Omnibus. We only assessed for patient-level factors. Provider and delivery-associated factors were beyond the scope of this analysis.

Results

625 thousand out of 1.56 million residents who utilised NHG services in 2018 were included. Age and CCI accounted for 12-14% variation in NHG and total subsidy (Table 2). For M1: patients who were older (≥60 years), of male gender, of Malay ethnicity, living in housing < 4-room or on government support incurred more NHG subsidy in 2018. Higher comorbidity burden was associated with higher subsidy and the amount of NHG subsidy varied among comorbidity conditions. Before adjustments, subsidy amounts varied significantly among PAs. While some PAs were still statistically significant in M1, there was less variation in the subsidy amounts. Similar observations were seen for M2. Figure 1 illustrates the unadjusted and adjusted NHG (M1) and total government subsidy (M2) across the PAs.

Conclusions

Age and CCI accounted for 12%-14% of variation of NHG and total government subsidy among cross-sectional utilisation. While PA was a statistically significant factor, there were less variation in subsidy across them after adjusting for baseline patient-level characteristics.

Table 1. Variables included in M1 (NHG Subsidy in 2018) and M2 (Total government subsidy in 2018)

Variables	Specification	M1	M2
Age bands	0-9*, 10-19, 20-29, 30-39, 40-49, **50-59**, 60-69, 70-79, ≥80	✓	✓
Gender	**Female,** Male	✓	✓
Ethnicity	**Chinese,** Malay, Indian^ Others	✓	✓
Housing type	1-2 room; 3 room; **4 room**; 5 room, landed/condo	✓	✓
On government support	Receiving CHAS blue, public assistance or living in rental flat	✓	✓
Charlson comorbidity Index (CCI)	-	✓	✓
Cognitive problems	Presence of anxiety, bipolar, depression or schizophrenia	✓	✓
Individual Comorbidities	Benign prostatic hyperplasia, Epilepsy, Hyperlipidemia, Hypertension, Osteoarthritis, Osteoporosis, Parkinson, Psoriasis	✓	✓
PA	PA1*, PA2, PA3*^, PA4^, PA5*, PA6*, **PA7**, PA8*, PA9, PA10^	✓	✓
OON (%)	Formula: (SHS+NUHS subsidy 2018)/(SHS+NUHS+NHG subsidy 2018)	✓	-

*Reference groups indicated in bold. √. Variables included in the models; *. Factors that were not statistically significant for M1; ^. Factors that were not statistically significant for M2.*

Table 2. Incremental effects of variables on M1 (NHG Subsidy in 2018) and M2 (Total government subsidy in 2018)

Variables	M1:R^2	M2:R^2
Age bands	4%	4%
Age bands, gender, ethnicity	4%	4%
Age bands, CCI	12%	14%
Age bands, gender, ethnicity, housing type, on government support, CCI, cognitive problems, comorbidities	13%	14%
Age bands, gender, ethnicity, housing type, on government support, CCI, cognitive problems, comorbidities, PA, OON **(M1)**	14%	NA
Age bands, gender, ethnicity, housing type, on government support, CCI, cognitive problems, comorbidities, PA **(M2)**	13%	14%

R^2. % variation in an outcome that can be explained by factors in the model.

Figure 1. Unadjusted and adjusted subsidies across PA

[1]M1. Adjusted for age bands, gender, ethnicity, housing type, on government support, CCI, cognitive problems, comorbidities, PA, OON.
[2]M2. Adjusted for age bands, gender, ethnicity, housing type, on government support, CCI, cognitive problems, comorbidities, PA.

MODELLING THE HEALTHCARE EXPENDITURE RISK OF A PATIENT IN THE NEXT YEAR

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HIGHLIGHTS

- **A predictive model to identify the healthcare expenditure risk of a patient in the next year was developed.**
- **The model may be used to identify patients with high healthcare expenditure for early interventions in the future.**
- **The model can help inform decisions on funding amounts for providers in a capitated system.**

Introduction

Healthcare expenditure in Singapore is growing at an unsustainable rate. To slow down this growth, we need to identify patients who will have high healthcare expenditure in the future, to allow interventions to be initiated at an earlier stage. The objective of this work was to develop a predictive model to identify the future risk of healthcare expenditure of a patient.

Methods

Singaporeans and permanent resident patients who had at least one visit to any healthcare setting (polyclinics, specialist outpatient clinics, emergency department, day surgery, inpatient hospital, community hospital) in public healthcare institutions from financial year (FY) 16 to FY18 were identified from the Population Health Staple Dataset (PHSD), an administrative database maintained by the Ministry of Health. Pre-subsidy patient bills of these patients were extracted, and summed to obtain the total pre-subsidy bill for each patient in a FY. For each FY, the mean total pre-subsidy bill across all patients was computed. The healthcare expenditure risk of a patient in that FY was calculated by dividing the total pre-subsidy bill of that patient with the mean total pre-subsidy bill for the FY as shown:

$$Healthcare\ expenditure\ risk\ _{Patient\ x\ in\ FY\ A} = \frac{Total\ pre-subsidy\ bill\ _{Patient\ x\ in\ FY\ A}}{Mean\ total\ pre-subsidy\ bill\ _{FY\ A}}$$

Demographics (age, gender, race), socioeconomic status (SES), disability and comorbidities of patients were also determined from PHSD. Patients living in rental flats, requiring public assistance, receiving Medifund or using Community Health Assist Scheme Blue tier subsidies were identified as having low SES. Presence of disability was identified from diagnosis codes and comorbidities for each patient in PHSD. A prospective model, where factors input into the model were determined at a time point before the FY (i.e. factors' values in FY15 and earlier were used for FY16 healthcare expenditure risk), was built. Constrained linear regression was used to model the healthcare expenditure risk of a patient in the next year, using demographic, SES, disability and comorbidity information. FY16 and FY17 data were used for training the model and FY18 data were used for validation.

Results

4,077,583 patients in FY16 and 4,107,969 patients in FY17 were used for the constrained linear regression modelling and 4,137,349 patients in FY18 were used for validation. The coefficients of the various factors are listed in **Table 1**.

Table 1. Model coefficients from constrained linear regression on FY16 and FY17 data

Factors	Coefficients
Age, Female	
0 to 5	0.266
6 to 40	0.225
41 to 60	0.310
61 to 70	0.581
71 to 80	0.974
81+	0.731
Age, Male	
0 to 5	0.345
6 to 40	0.161
41 to 60	0.362
61 to 70	0.829
71 to 80	1.262
81+	0.990
Chinese	0.000
Malay	0.153
Indian	0.026
Others	0.000
Low SES	0.568
Disability	1.608

Factors	Coefficients
Anxiety	0.446
Asthma	0.356
Bipolar disorder	1.193
BPH	0.901
CKD	2.855
COPD	1.855
Dementia	1.150
Depression	0.915
Diabetes	1.068
Dyslipidaemia	0.071
Epilepsy	1.573
Hypertension	0.568
Myocardial infarction	1.192
Osteoarthritis	0.659
Osteoporosis	0.753
Parkinson	0.649
Psoriasis	1.364
Rheumatoid arthritis	1.494
Schizophrenia	3.886
Stroke	0.829
Angina	0.984
Atrial fibrillation	1.327
Heart failure	3.128
Peripheral vascular disease	4.749

BPH: benign prostatic hyperplasia; CKD: chronic kidney disease; COPD: chronic obstructive pulmonary disease; FY: financial year; SES: socioeconomic status.

Generally, males were more likely to have higher healthcare expenditure at all ages except between 6 to 40 years old. Among the ethnic groups, Malays were at higher risk of higher healthcare expenditure. Having disability, chronic kidney disease, chronic obstructive pulmonary disease, epilepsy, schizophrenia, heart failure and peripheral vascular disease greatly increased the risk of healthcare expenditure (coefficients > 1.5). The R^2 of the model validated on FY18 data was 0.103 and 0.099, with a mean absolute error of 1.29 and 1.32 on the training and validation set, respectively.

Conclusions

A predictive model to identify the risk of healthcare expenditure of a patient in the next year was developed. This model can possibly be used to identify subgroups of patients who are likely to have high healthcare expenditure, to potentially allow interventions to reduce their healthcare consumption to be initiated at an earlier stage. The model can also help inform decisions on funding amounts for providers in a capitated system.

DEVELOPING A DASHBOARD TO DESCRIBE NATIONAL HEALTHCARE GROUP CLUSTER'S PATIENT POPULATION

Dr Zhu Zhecheng

HIGHLIGHTS

- **The Integrated Care Organisation planning dashboard was a platform developed for stakeholders to explore patient population information geographically.**
- **It provided three views of different granularities: map, chart and table view.**

Introduction

The purpose of developing an Integrated Care Office (ICO) planning dashboard was to provide a platform for stakeholders to explore demographics, chronic disease prevalence, healthcare cost and utilisation of patients residing in the National Healthcare Group (NHG) catchment.

Methods & Results

The interactive dashboard was developed on the R Shiny platform, and enabled users to explore patient population information at varying geographical resolutions. There were three views available in the ICO planning dashboard: map view, chart view and table view. The views were interlinked, and allowed users to toggle between different geographical resolutions by zooming in and out as desired. Information made available through this dashboard included demographics, chronic disease prevalence, River of Life (RoL) segment distribution, healthcare utilisation, as well as overall and per capita healthcare cost of known patients. Additionally, the dashboard also included information on Community Health Assist Scheme General Practitioner (CHAS GP) clinics within the NHG catchment, as well as clinic-level data.

Figure 1. Pop-up summary information outcomes using the ICO planning dashboard

By ICO	By URA planning area	By URA subzone	By postal code
ICO: **Yishun Health**	Planning area: **YISHUN**	Subzone: **YISHUN WEST**	Postal code: **760734**
Patients known to NHG: 267K Active patients in 2019: 143K % of active patients 65+: 19% % CMIO: 67%, 17%, 9%, 6% % RoL: 62%, 34%, 3%, 0.3%	Patients known to NHG: 193K Active patients in 2019: 104K % of active patients 65+: 21% % CMIO: 67%, 18%, 9%, 6% % RoL: 61%, 35%, 4%, 0.3%	Patients known to NHG: 52K Active patients in 2019: 27K % of active patients 65+: 25% % CMIO: 66%, 18%, 10%, 6% % RoL: 59%, 36%, 5%, 0.4%	Patients known to NHG: 395 Active patients in 2019: 215 % of active patients 65+: 27% % CMIO: 71%, 15%, 8%, 5% % RoL: 57%, 36%, 5%, 1.3%
Mean DCSI: 1.9 Mean CCI: 1.1	Mean DCSI: 1.9 Mean CCI: 1.1	Mean DCSI: 2.1 Mean CCI: 1.2	Mean DCSI: 1.7 Mean CCI: 1.3
Dyslipidemia: 66K Hypertension: 53K Type 2 Diabetes: 32K CKD 3+: 7K Stroke: 8K AMI: 3K	Dyslipidemia: 49K Hypertension: 40K Type 2 Diabetes: 24K CKD 3+: 5.5K Stroke: 5.9K AMI: 2.1K	Dyslipidemia: 14.3K Hypertension: 12K Type 2 Diabetes: 7.3K CKD 3+: 1.7K Stroke: 1.8K AMI: 654	Dyslipidemia: 126 Hypertension: 115 Type 2 Diabetes: 56 CKD 3+: 18 Stroke: 14 AMI: 4
Gross charge (total): $318M Gross charge (per active patient): $2.2K Top 5%tile utilizer, 7K: 56% of total cost Top 20%tile utilizer, 29K: 83% of total cost	Gross charge (total): $237M Gross charge (per active patient): $2.3K Top 5%tile utilizer, 5.3K: 56% of total cost Top 20%tile utilizer, 22K: 83% of total cost	Gross charge (total): $72M Gross charge (per active patient): $2.7K Top 5%tile utilizer, 1666: 61% of total cost Top 20%tile utilizer, 6231: 86% of total cost	Gross charge (total): $566K Gross charge (per active patient): $2.6K Top 5%tile utilizer, 13: 52% of total cost Top 20%tile utilizer, 63: 86% of total cost

Figure 1 displayed information at four geographical resolutions in increasing levels of detail: by ICO, by Urban Redevelopment Authority (URA) planning area, by URA subzone, and by postal code. The mouse-over action over locations on the map would trigger a popup window, showing summary information of the specific location. A heat map could also be toggled to focus on a location of interest.

Figure 2 illustrated the information provided when the user clicked a specific location in the map view. The information was captured in 3 panels: demographic information, NHG utilisation and cross- cluster utilisation.

Figure 2. Chart view of the ICO planning dashboard

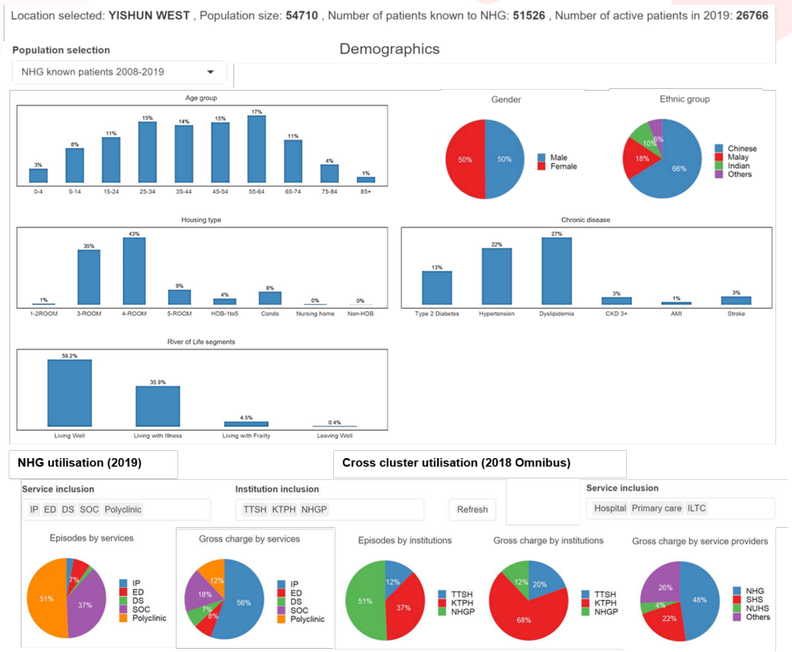

Figure 3. Table view of the ICO planning dashboard

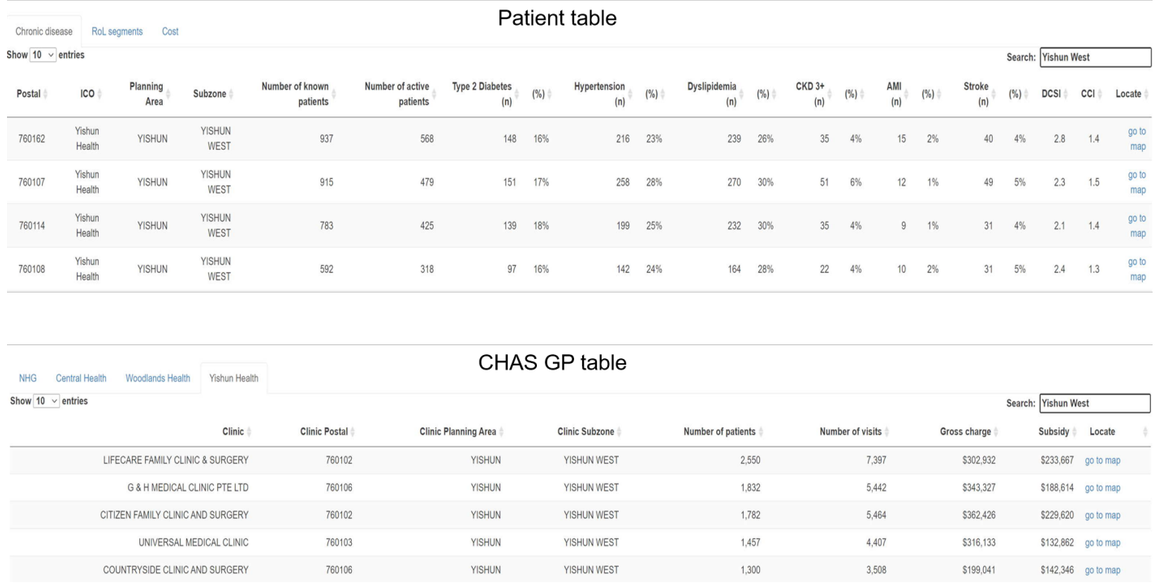

Figure 3 displayed information at the postal code level. The Patient table included patient information on chronic conditions, RoL segments and healthcare cost information. The CHAS GP clinic tables provided clinic-level information such as patient and visit count and healthcare expenditure incurred.

Conclusions

The ICO planning dashboard provided both summarised and detailed patient and population information for stakeholders to gain a deeper understanding of those residing within NHG catchment.

READINESS TO SCALE – A LITERATURE REVIEW OF FRAMEWORKS AND TOOLS

Sheryl Ng Hui Xian, Dr Tan Woan Shin, Dr Joseph Antonio D. Molina, Dr Heng Bee Hoon

HIGHLIGHTS

- **Demonstrated efficacy, relevance to the problem, presence of infrastructural support, implementation fidelity and sustainability are important considerations for assessing scalability of pilot interventions.**
- **The Intervention Scalability Assessment Tool (ISAT) can be easily adapted for use alongside current evaluation frameworks.**

Introduction

Scaling up an intervention refers to the deliberate efforts to increase the impact of successfully tested health interventions, with the aim of expanding benefits to more people, and to foster long-term policy and programme development.[1] An intervention can be scaled either vertically, by expanding the enrolment within a single site; or horizontally, by replicating across additional sites. While evaluations of piloted interventions provide information on the impact attributable to the program, they are often insufficient to advise on whether the necessary organisational and infrastructural resources and implementation processes are in place for scaling up. To guide funders' assessments on whether to invest in scaling up a pilot, we aimed to identify frameworks and tools measuring readiness to scale to be integrated into current evaluation frameworks used.

Methods & Results

We conducted a literature review of frameworks and tools that either measured the construct of readiness to scale, or explicitly included scalability as a component of the framework. We identified 5 frameworks and tools that examine readiness to scale (Table 1). Of these, the Intervention Scalability Assessment Tool (ISAT) was found to be the most adaptable for use, due to the comprehensiveness of domains assessed and straightforward scoring. Evaluation results would be first described in Part A (Figure 1), before scalability would be assessed in Part B. Each of the domains would be rated on a scale from 0 to 3, with 3 indicating higher readiness to scale. The results of the scoring would then be plotted on a radar chart for an overview of the intervention's readiness to scale.

Figure 1. Domains of the ISAT

Part A: Background and context	Part B: Implementation and feasibility factors
A1: The problem	B1: Fidelity and adaptation
A2: Intervention characteristics	B2: Reach and acceptability
A3: Strategic/political context	B3: Delivery setting and workforce
A4: Evidence of effectiveness	B4: Implementation infrastructure
A5: Intervention costs and benefits	B5: Sustainability

Conclusions

Across different frameworks and tools, there are common areas for consideration when assessing scalability: (1) demonstration of evidence-based efficacy of the piloted intervention; (2) the relevance of the intervention in addressing an important problem; (3) the presence of organizational and infrastructural support; and (4) the likely fidelity of implementation and sustainability in the long run. The ISAT would be a tool easily adapted for use alongside current evaluation frameworks, and would inform the discussion among funders on whether the intervention would merit scaling up, or would require more information before a decision can be made.

Table 1. Frameworks and tools on readiness to scale

Framework/tool	Objective	Assessment
European Scaling-up Strategy in Active and Healthy Ageing Framework[2]	Identify and classify interventions for replication	• Knowledge - gaps between knowledge and practice, existence of tested solutions • Reaction time- time needed for implementation and assess impact • Stewardship - administrative and political capacity • Political agenda - political context • Costs and affordability - cost of the programme • Acceptability - support or opposition • Monitoring capability - ability to monitor processes and outcomes
Scaling Integrated Care in Context (SCIROCCO) tool [United Kingdom][3]	Assess a region's readiness for integrated care, on a scale from 0-5 across 12 dimensions	• Readiness to change • Structure and governance • eHealth services • Standardisation and simplification • Funding • Removal of inhibitors • Population approachandcitizen empowerment • Evaluation methods • Breadth of ambition • Innovation management • Capacity building
CORRECT framework [World Health Organization][1]	Describe attributes of an innovation that increases likelihood of success in scaling up	• Credible - Based on sound evidence • Observable - Results can be seen in practice • Relevant - Addresses persistent/sharply felt problems • Relative advantage - Costs of implementation are warranted by benefits • Easy - Simple to transfer or adopt • Compatible - Alignment with established values, norms and facilities • Testable - Intervention can be tested on a small scale prior to large-scale adoption
Intervention Scalability Assessment Tool[4]	Assess scalability of a health program or intervention	• A - consideration of context • B - potential implementation and scale-up requirements • C - graphical representation of strengths and weaknesses of readiness
Innovation Scalability Self-administered Questionnaire[5]	Assess scalability of primary care innovations using 16 criteria grouped into 5 dimensions	• Theory – Use of theory, model, or framework to inform the development of the innovation • Impact – Availability of data on effectiveness • Coverage – Availability of data on reach, adoption, fidelity and maintenance • Setting - Implementation in a setting comparable to that of the new setting, or compatibility with similar innovations in the same setting • Cost – Availability of data on cost-effectiveness, financial and human resources required

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LIVING WELL

KEEPING INDIVIDUALS HEALTHY

NHG RIVER OF LIFE

ACCOUNTABLE CARE

LIVING WELL

LIVING WITH ILLNESS

CRISIS & COMPLEX CARE

LIVING WITH FRAILTY

LEAVING WELL

FACTORS OF HEALTH RESILIENCE AMONG COMMUNITY-DWELLING ADULTS IN SINGAPORE: A QUALITATIVE EXPLORATORY STUDY

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HIGHLIGHTS

- **Health resilience is a multi-dimensional concept, influenced by intrapersonal factors, reactions to illness, as well as interpersonal, community and system-level resources.**
- **The factors of health resilience are inter-linked and interactively influence one's illness and recovery experiences.**

Introduction

Resilient individuals have been found to be more self-reliant and have less healthcare utilisation while having better subjective well-being. With community efforts in creating supportive environments to strengthen individuals' health resilience, this study aimed to identify the factors of health resilience and underlying processes that support individuals to recover from health adversities. This report is an extension of a previous study that sampled mainly older adults[1].

Methods

This qualitative lived experience study used purposive sampling to recruit participants who met the following inclusion criteria: 1) aged 21 years or above; 2) participated in existing community health programmes, and had experiences of being unwell for a period of time, or served as a caregiver to a family member who was ever unwell in the past 5 years; 3) able to take part in a conversation regarding their experience about how they or the person they cared for prepared for and dealt with difficulties due to health adversities; and 4) a Singapore citizen or permanent resident. The sampling frame was set up to capture the perspectives of individuals from different age groups (aged 21-34, 35-44, 45-64, and 65+ years, respectively) and caregivers. Potential participants were mainly identified and referred by study collaborators or their designated respective programme leads at referral sites or through the research team's personal contacts.

As guided by the pre-developed interview guide, 65 in-depth semi-structured interviews were conducted after an eligibility screening and consent process. These interviews focused on participants' or their care recipients' experiences of how they prepared for, dealt with, and overcame challenges and impacts of health adversities. The audio recordings of interviews were transcribed into textual data. Framework analysis[2], which enabled themes to be developed both inductively from experiences and views of participants, and deductively from existing resilience literature, were conducted.

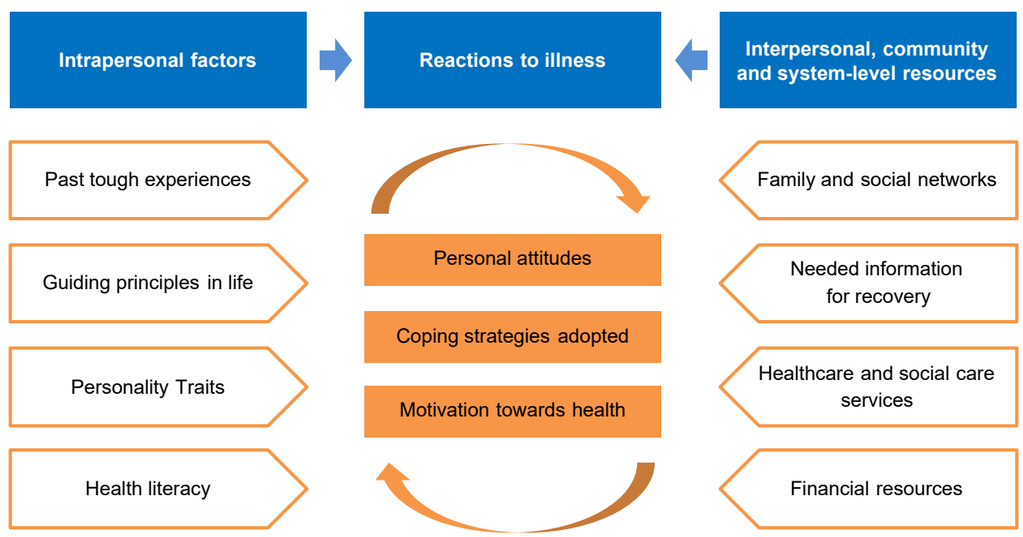
Results

The participants included 51 community-dwelling adults and 14 caregivers. The ages of the participants ranged from 21 to 85 years old, and they were mainly Chinese (n=43, 66%), females (n=45, 69%), and had experiences of health adversities (n=47,72%). As guided by the socio-ecological model[3], themes that emerged were broadly categorised into 1) intrapersonal factors, 2) reactions to illness, and 3) interpersonal, community and system-level resources, that were inter-linked and of interactive influence on one's illness and recovery experiences (Figure 1). Intrapersonal factors like past tough life experiences, guiding principles in life, personality traits, and health literacy worked closely together with perceived availability, accessibility or supportiveness of interpersonal, community and system-level resources. These resources included family and social networks, needed information for recovery, healthcare and social care services, and financial resources. Both these factors then influenced one's reactions to illness like personal attitudes, coping strategies adopted and motivation onwards health, which ultimately influenced a person's ability in managing the external and internal demands of the health challenges.

Conclusions

Health resilience is a dynamic process that is comprised of and influenced by multi-layer interactions across various inter-linked intrapersonal, reaction-related, interpersonal, community and system-level factors. Identifying the factors influencing health resilience and understanding their processes and interactions can inform public health services on how to better support individuals to minimise or overcome the ill-effects of health adversities.

Figure 1. Factors influencing health resilience and their processes and interactions



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EXAMINING HEALTH RESILIENCE OF COMMUNITY-DWELLING INDIVIDUALS: A PRELIMINARY QUALITATIVE ANALYSIS

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HIGHLIGHTS

- **Health resilience is multi-dimensional and driven by fixed and modifiable elements.**
- **Programmes are essential for empowering healthcare and social care professionals in carrying out their critical role in helping individuals adapt positively to health adversity.**

Introduction

Health resilience is a dynamic process of positive adaptation when an individual encounters health-related adversity. Strengthening health resilience is crucial in bringing about positive health outcomes and well-being. However, there is a lack of local literature on health resilience in Singapore. Specifically, there is a lack of understanding on the role that healthcare (HCPs) and social care professionals (SCPs) perform in promoting health resilience in the community. This is important because health resilience may potentially be modified and strengthened when supported by a strong and responsive health and social care sector. As such, we seek to explore elements of health resilience, and the role of HCPs and SCPs in patients' health adversity journeys.

Methods

This qualitative phenomenological study was informed by the interpretive systemic framework of inquiry, which guided the design of the sampling frame. Healthcare and social care professionals, working in hospitals, voluntary welfare organisations or community teams sited in community neighbourhoods were invited. Focus group discussions, each lasting about 90 minutes, were conducted (between Jan-Jun 2021) via Zoom.

An interview guide was designed based on a literature review on concepts of resilience and Bennett and Windle's "The Resilience Framework". The interview guide covered three topics: 1) their experience on how their patients/clients dealt with health adversity, 2) their perceived factors associated with an individual's capacity to deal with health adversity, and 3) the role of health and social care sector in supporting patients/clients coping with or recovery from adversities.

Transcripts were analysed thematically using an inductive-deductive approach. The deductive analysis was informed by Bennett and Windle's "The Resilience Framework". Three independent coders coded two transcripts to ensure coding consistency. The remaining nine transcripts were coded by two coders in conjunction with regular meetings with the larger research team to define and review emerging themes.

Results

A total of 11 focus group discussions were conducted. Each group had four to six HCPs or SCPs (Table 1). Twelve themes were derived and organised into three categories: 1) intrapersonal characteristics, 2) interpersonal resources and 3) system-level factors (Table 2). HCPs played the role of motivators, influencing the perception of hope and acting as a bridge between family members. SCPs perceived themselves to be conduits, connecting individuals to healthcare or social services and accessing healthcare subsidy. An observation unique to our multicultural community was that language could be a potential barrier to effective help-seeking from HCPs and SCPs.

Conclusions

Health resilience is multi-dimensional and included fixed and modifiable elements. Findings highlighted the role of HCPs and SCPs as complex and multi-factorial in supporting individuals during times of adversities. Programmes to empower HCP and SCP with relevant skillsets will be essential to better support individuals adapt positively to health adversity.

Table 1. Profile of Focus Group participants (n=53)

Characteristics	n (%)
Age group	
21-40	**39 (73.6)**
41-60	**14 (26.4)**
Gender, female	**39 (73.6)**
Ethnicity	
Chinese	**46 (86.8)**
Other ethnicity	**7 (13.2)**
Occupation Type	
Healthcare professionals	**40 (75.5)**
Social care professionals	**7 (13.2)**

Table 2. Elements of health resilience

Intrapersonal characteristics	Interpersonal resources	System-level factors
Resourcefulness	Social support	Healthcare financing and payment
Motivation	Role of healthcare and social care professionals	Healthcare and social care integration
Hope	Family dynamics	
Coping strategy		
Health prioritisation		
*Life experience**		
*Personality**		

** Non-modifiable factors; modifiable factors otherwise*

A DESCRIPTIVE ANALYSIS OF PERSONAL RESILIENCE BETWEEN COMMUNITY-DWELLING ADULTS AND HEALTH AND SOCIAL CARE PROFESSIONALS

Chieh Pann Pei, Ge Lixia, Dr Yip Wan Fen, Eric Chua Siang Seng, Assoc Prof Ringo Ho Moon-Ho[1], Evon Chua Yiwen[2], Tham Sinma[3], Adj Assoc Prof Ian Leong Yi Onn[4], Assoc Prof Andy Ho Hau Yan[1,5], Dr Tan Woan Shin

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HIGHLIGHTS

- **The level of personal resilience dimensions in community-dwelling adults differs from health and social care professionals.**

Introduction

Research on resilience has gained attention in recent years as societies seek greater understanding of how individuals could regain healthy functioning after a disruptive health event. Healthcare workers have been found to exhibit higher levels of psychological resilience compared to the general public. This study aimed to describe the differences in level of personal resilience between community-dwelling adults (CAs) and health and social care professionals (HSCPs).

Methods

The 33-item Resilience Scale for Adults (RSA) is a self-report instrument that evaluates six protective dimensions of resilience at both interpersonal and intrapersonal levels. Interpersonal dimensions comprises 'Family cohesion' (n=6) which measures family conflict, cooperation, support, loyalty and stability; and 'Social resources' (n=7) which measures the degrees of social support and resources, and also the quality of the support received. The other 4 are intrapersonal dimensions, namely: 'Perception of self' (n=6) measuring individuals' views of their own strengths and abilities, 'Planned future' (n=4) that measures individuals' beliefs about opportunities for realizing future plans and goals, 'Social competence' (n=6) measuring the extraversion, adeptness, cheerfulness, ability to initiate activities, communication skills and flexibility in social matters. And lastly, 'Structured style' (n=4) measuring individuals' conscientiousness which positively relates to recovery after trauma. RSA responses ranges from 1 to 7; with higher scores reflect higher levels of protective factors of resilience.

A questionnaire containing demographic information and RSA-33 was completed by 65 CAs and 53 HSCPs. The characteristics of these two groups were compared using Fisher's Exact tests. Each dimension score for the RSA-33 was computed and compared between CAs and HSCPs using the Independent t-tests.

Results

Study participants were mainly Chinese (CAs: 66%; HSCPs: 87%), females (CAs: 71%; HSCPs: 74%), with post-secondary education (CAs: 55%; HSCPs: 100%). Majority of CAs were aged 50 years and above (45%), while HSCPs were mainly aged 21-40 years (74%). About 73% CAs and 13% HSCPs had experienced personal health adversities (Table 1). HSCPs scored higher in Family Cohesion and Social Resources, but lower in Social Competence when compared to CAs (Table 2).

Table 1. Characteristics of participants (N=118)

Characteristics	Community-dwelling adults (n = 65)	Healthcare and social care professionals (n=53)
	n (%)	n (%)
Gender		
Male	19 (29)	14 (26)
Age group*		
21-30	14 (21)	10 (19)
31-40	17 (26)	29 (55)
41-50	5 (8)	9 (17)
≥ 51	29 (45)	5 (9)
Ethnicity*		
Chinese	43 (66)	46 (87)
Non-Chinese	22 (34)	7 (13)
Education*		
No formal qualification/Lower primary/Primary	13 (20)	NIL
Secondary	16 (25)	NIL
Diploma / Professional qualification	10 (15)	3 (6)
Bachelor's degree and above	26 (40)	50 (94)
Living arrangement		
Alone	3 (5)	1 (2)
Family members	59 (90)	49 (92)
Non family members	3 (5)	3 (6)
Experienced health-related adversities in the last 5 years*		
Self only	29 (45)	2 (4)
Self and others (Family, Friends and Clients)	18 (28)	5 (9)
Others only (Family, Friends and Clients)	16 (24)	41 (77)
None	2 (3)	5 (9)

** p-value<0.05 using Fisher's Exact tests.*

Table 2. Comparison of RSA-33 dimension scores

RSA-33 Dimensions	Community-dwelling adults		Healthcare and social care professionals		P value
	Mean	SD	Mean	SD	
Family Cohesion [1]	4.9	1.3	5.5	0.9	0.008
Perception of the Self [2]	5.4	1.2	5.4	0.7	0.961
Planned Future [2]	5.1	1.2	5.3	0.8	0.179
Social Competence [2]	5.4	1.1	4.9	1.0	0.011
Social Resources [1]	5.7	1.0	6.0	0.7	0.046
Structured Style [2]	5.1	1.0	5.1	0.9	0.827

[1] Interpersonal dimensions; [2] Intrapersonal dimensions.

Conclusions

Compared to CAs, HSCPs scored higher in the family cohesion and social resources dimensions. This is likely due to the nature of HSCPs' work, which involves constant exposure to clients' health-related crises, so they could be more familiar with the availability of social services and be more aware of the importance of family support. In contrast, the CAs in our study appeared to have higher social competence. Further studies would be needed to obtain larger and representative samples and control for potential confounders to confirm the differences in dimensions of resilience between CAs and HSCPs.

AN OVERVIEW OF INSTRUMENTS TO MEASURE HEALTH ACTIVATION

Palvinder Kaur, Ge Lixia, Dr Joseph Antonio D. Molina, Dr Heng Bee Hoon

HIGHLIGHTS

- **Mixed results were seen in the psychometric analysis of the Patient Activation Measure and Altarum Consumer Engagement in Singapore.**

Introduction

There are only a few instruments for health activation available for the general population – namely, Patient Activation Measure (PAM-13), Altarum Consumer Engagement (ACE-12) and Consumer Health Activation Index (CHAI-10). We aimed to provide an overview of these instruments and the associated key findings from validation studies done in Singapore.

Methods & Results

Table 1 describes the three instruments and key validation studies done in Singapore. PAM-13 was the first assessment tool to operationally define health activation, and is widely used as a gold standard. Validation in cardiac patients in Singapore suggested mixed results.[1] Similar to findings in the original validation study in the United States (US), PAM-13 was found to be uni-dimensional with strong internal consistency (i.e. the items are reliable indicators to measure patient activation). However, high ceiling effects were observed where >15% of respondents achieved the highest possible score for the nine items. As activation levels and scores are based on the original item difficulty, which was found to differ locally, the original scoring system needs to be used with caution in our population. A cognitive interview study conducted on the same Singapore population reported that certain terms used in the items and rating scale options were poorly understood.[2]

ACE-12 was validated in an adult population in Singapore.[3] Two items were removed from the questionnaire due to lack of relevance, leaving eight items from the Commitment and Navigation subscales post-psychometric analysis. [4] No floor and ceiling effects were seen for the eight items. There was good internal consistency for items in the Commitment subscale. However, items in the Navigation subscale demonstrated poor reliability. Moderate correlation was seen with PAM-13.

Developers of the CHAI-10 instrument expanded on the constructs used to define health activation control.[5] CHAI-10 was found to be easy to administer and score, and was appropriate for use among those with limited health literacy. However, there is a lack of validation studies for this instrument in Singapore, and a local study would be required to determine its validity and reliability prior to use.

Conclusions

Mixed results were seen in the psychometric analysis of PAM-13 and ACE-8 in our local population.

Table 1. Overview of instruments to measure health activation

Instrument (Year developed)	PAM-13 (2004)	ACE-12[3] (2015)	CHAI-10[5] (2018)
Definition of activation/ engagement	An individual's knowledge, skills, and confidence for managing their health and healthcare	Adopted adopt a broad, behavioural definition of engagement: "actions individuals must take to obtain the greatest benefit from the health care services available to them"	No specific definition
Constructs	Knowledge, skills, confidence	Commitment, ownership, informed choice, navigation	Knowledge, self-efficacy, motivation and beliefs, actions, internal locus of control
Number of Items; rating scale	13 items; 5-point Likert scale (strongly disagree to strongly disagree)	12 items; 5-point Likert scale (strongly disagree to strongly disagree)	10 items; 5-point Likert scale (strongly disagree to strongly disagree)
Scoring system	Raw scores are converted to PAM-13 scores (0-100) and categorised into 4 levels of activation with proposed interventions	Raw scores are multiplied by 6.25 to create a subscale score (0 to 25); subscales are summed to get ACE scores (0 to 100)	Raw scores (10-60) are transformed to CHAI scores (0–100); preliminary cut-offs for low, moderate and high activation
Population developed on	General US population, ≥45 years, 79% reported at least 1 chronic disease	General US adult population, unknown % with chronic disease	General US adult population, <6% with chronic condition
Key findings of SG validation studies	• Validated in SG cardiac population[1,2] • Supports assumption of unidimensionality • Ceiling effects seen in nine items • Differed from original US PAM-13 in terms of item difficulty • Low, negative correlation with depression; moderate, positive correlation with self-efficacy • Poor understanding of items and scale	• Validated in SG general population(ACE-8)[4] • Mixed psychometric results • Removal of 2 items not applicable to SG • 8 items in Commitment and Navigation subscales • No floor and ceiling effect; internal consistency was poor for Navigation • Moderately correlated with PAM-13	None
Strengths	• Widely accepted across 30 countries • Endorsed by national quality forum • Implemented in different health systems (NHS, selected Medicare and Medicaid services, ACO) • Available in EPIC health system	• APublicly available and free for use • Easy to understand • Validated in SG • Each subscale can be used separately	• Publicly available and free for use • Easy to understand
Limitations	• Proprietary, costly • May not be appropriate for individuals with poor health literacy due to item readability	• Captured only two constructs • Items in Navigation subscale may need further refinement	• Not validated in SG • Only one validation study in South Korean University Students

ACO: Accountable care organization; NHS: National Health System; SG: Singapore; US: United States;

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PSYCHOMETRIC PROPERTIES OF THE PATIENT ACTIVATION MEASURE IN COMMUNITY-DWELLING ADULTS IN SINGAPORE

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

HIGHLIGHTS

- **The Patient Activation Measure (PAM-13) has acceptable construct validity and good internal consistency among community-dwelling adults in Singapore.**
- **Some items could potentially be further refined to improve item fit.**
- **Item difficulty differed from the original sequence, cautioning usage of the original scoring system in our population.**

Introduction

Measuring the general population's health activation using valid instruments is needed to evaluate health education and behavioural programs in the community. The 13-item Patient Activation Measure (PAM-13) has been well validated internationally among patients with chronic diseases but rarely validated in the general population. The objective of this study was to assess the psychometric properties of the PAM-13 among community-dwelling adults in Singapore.

Methods

Cross-sectional data was collected face-to-face by trained interviewers during a follow-up survey of the NHG Population Health Index (PHI) study. Participants with valid responses to the English-version of the PAM-13 measure (N=824) were included for analysis (mean age: 47.7 years, SD: 14.1 years, 52.4% female, 70.0% Chinese, and 9.0% had primary school education or lower). The psychometric properties of the PAM-13 were assessed by demonstrating evidence for uni-dimensionality using Rasch Principal Component Analysis of Residuals (PCAR), item difficulty, known-group validity, convergent and divergent validity, and internal consistency reliability using Cronbach's alpha.

Results

Responses were unevenly distributed for all 13 items: The "agree" and "agree strongly" options were the most frequently selected responses, while the "disagree strongly" was the least selected response for all items (range: 0 – 0.4%), indicating no floor effects. Ceiling effects assessed based on the proportion of "agree strongly" responses in all 13 items ranged from 16.1% (PAM_12) to 64.8% (PAM_1).

The uni-dimensionality of the PAM-13 was supported by the Rasch PCAR results: the variance explained by the measure was 63.3% (above 50% of the total variance), and the variance explained by the first principal component of residuals was 14.2% (slightly lower than 15%), forming a ratio of 4.5:1, which met the 3:1 criterion for uni-dimensionality. The eigenvalue of the first contrast was 1.85 (lower than 2.0).

The results of Rasch item fit statistics showed that both Infit mean-square (MNSQ, range: 0.63 to 1.14) and Outfit MNSQ (range: 0.57 to 1.25) were within the acceptable range of 0.6 to 1.4 for all items, suggesting that this is a productive measurement with a good fit of the Rasch model. However, there were seven items (PAM_3, PAM_5, PAM_9 – PAM_13) having standardized Infit MNSQ (ZSTD) and eight items (PAM_1, PAM_3, PAM_5, PAM_9 – PAM_13) having Outfit ZSTD beyond the acceptable range (between -2 and 2), suggesting that these items were useful to the measurement but required further refinement.

Based on the difficulty parameters, the ranking of items derived from this cohort was different as compared to the ranking of items in the original PAM-13. Participants in this study found it easier to agree to items PAM_7, PAM_10 and PAM_13. On the other hand, items PAM_3, PAM_6, PAM_8 and PAM_9 were harder to be endorsed by the participants.

As shown in table 1, participants who were multimorbid or experienced polypharmacy had significantly lower PAM scores and level, compared to their respective counterparts. Participants who were more active in physical activity or perceived better health status had higher PAM score or activation levels than their counterparts. These results provided the evidence of known-group validity.

The correlation between PAM-13 and health confidence (r=0.38) was higher than that between PAM-13 and depressive symptoms (r=-0.13), providing evidence of good convergent and divergent validity. Cronbach's alpha for PAM-13 was 0.82 and item-rest correlations ranged from moderate (items PAM_1- PAM_10, and PAM_13) to strong correlations (items PAM_11 and PAM_12), indicating strong internal consistency reliability.

Conclusions

In conclusion, the PAM-13 has acceptable construct validity and good internal consistency among community-dwelling adults in Singapore. Item difficulty differed from the original sequence. However, as activation levels and scores are based on the original item difficulty, the original scoring system needs to be used with caution in our population. Further research is required to investigate the expansion of response options, validate the cut-off scores for the activation levels and examine the test-retest reliability and responsiveness.

Table 1. Associations between PAM-13 and other variables or measures

Variable	n (%)	PAM level				P value	PAM score	p-value
		Level 1 (n=20)	Level 2 (n=79)	Level 3 (n=563)	Level 4 (n=162)		Mean±SD / r (95%CI)	
Multimorbidity								
No	584 (70.9)	11 (55.0)	52 (65.8)	392 (69.6)	129 (79.6)	0.020[a]	66.7±12.3	0.021[c]
Yes	240 (29.1)	9 (45.0)	27 (34.2)	171 (30.4)	33 (20.4)		64.9±11.4	
Polypharmacy								
No	723 (87.7)	15 (75.0)	60 (76.0)	500 (88.8)	148 (91.4)	0.001[a]	66.6±12.0	0.008[c]
Yes	101 (12.3)	5 (25.0)	19 (24.0)	63 (11.2)	14 (8.6)		63.4±12.4	
Physical activity participation								
Inactive	364 (44.2)	11 (55.0)	48 (60.8)	254 (45.1)	51 (31.5)	<0.001[a]	63.9±10.9	<0.001[c]
Active	460 (55.8)	9 (45.0)	31 (39.2)	309 (54.9)	111 (68.5)		68.0±12.7	
Self-perceived health status								
Not as good/ do not know	108 (13.1)	8 (40.0)	27 (34.2)	64 (11.4)	9 (5.6)	<0.001[a]	60.2±10.6	<0.001[b]
As good	353 (42.8)	6 (30.0)	31 (39.2)	248 (44.0)	68 (42.0)		65.8±11.7	
Better	363 (44.1)	6 (30.0)	21 (26.6)	251 (44.6)	85 (52.5)		68.4±12.3	
PHQ-9 depressive symptoms	824 (100)	2.3±3.5	1.3±3.2	0.4±1.8	0.3±1.0	<0.001[b]	-0.13 (-0.19, -0.06)	<0.001[d]
Health confidence	824 (100)	6.1±1.9	6.9±1.3	7.8±1.0	8.5±1.1	<0.001[b]	0.38 (0.32, 0.44)	<0.001[d]
Low	89 (10.8)	13 (65.0)	24 (30.4)	47 (8.3)	5 (3.1)	<0.001[a]	58.7±11.0	<0.001[c]
High	735 (89.2)	7 (35.0)	55 (69.6)	516 (91.7)	157(96.9)		67.1±11.9	

[a] Chi-squared test; [b] One-way ANOVA; [c] Independent sample t-test; [d] Pearson's correlation test.

PSYCHOMETRIC EVALUATION OF THE 8-ITEM ALTARUM CONSUMER ENGAGEMENT MEASURE™ IN COMMUNITY-DWELLING ADULTS IN SINGAPORE

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

HIGHLIGHTS

- **The two-factor structure of the Altarum Consumer EngagementMeasure (Commitment and Navigation) was verified by confirmatory factor analysis.**
- **The two subscales demonstrated good hypothesis-testing validity and concurrent validity, but results on internal consistency were mixed.**

Introduction

A valid and reliable measure is essential to assess patient engagement and its impact on health outcomes. This study aimed to examine the psychometric properties of the 8-item Altarum Consumer Engagement Measure™ (ACE Measure) among English-speaking community-dwelling adults in Singapore.

Methods

This cross-sectional study involved 400 randomly selected community-dwelling adults (mean age: 49.7 years; female: 50.0%; Chinese: 72.3%) who completed the English version of the 8-item ACE Measure independently. Item-level statistics were described. Internal consistency of the measure was measured by Cronbach's alpha and item-rest correlations. Validity of the tool was assessed in three aspects: 1) factorial validity using confirmatory factor analysis (CFA); 2) hypothesis-testing or construct validity by correlating ACE subscales (Commitment (CM) and Navigation (NG)) with health-related outcomes, such as health-related quality of life using the EQ-5D-5L, self-perceived health status, and frequency of activity participation; and 3) criterion validity against the Patient Activation Measure (PAM) and Health Confidence Measure.

Results

There was no floor or ceiling effects for CM and NG sub scales. Cronbach's alpha for each subscale was 0.76 and 0.54, respectively. The individual inter-item and item-rest correlations for the CM subscale ranged from 0.18-0.23 (ideal range of 0.15-0.50) and 0.50-0.61 (≥0.50), respectively. However, the average inter-item correlation for NG subscale was 0.15, with items ACE8_4 and ACE8_6 falling below 0.15 (Table 1). The two-factor structure was confirmed by CFA, with good fit (Figure 1). All four items under the CM subscale had a factor loading higher than 0.50. Two items under the NG subscale had relatively lower factor loadings (0.48 for item ACE8_2 and 0.30 for item ACE8_7).

In general, both subscales were positively correlated with frequency of activity participation (CM: p=0.30, 95% CI=0.21-0.38; NG: p=0.33, 0.24-0.41) and EQ-5D visual analog scale scores (CM: p=0.30, 0.21-0.39; NG: p=0.15, 0.05-0.24). Only CM was positively associated with EQ-5D-5L Index scores (p=0.15, 0.05-0.24). Individuals who perceived themselves to have better health status than their peers had higher subscale scores (p<0.01). Each subscale score had moderate and positive correlations with PAM scores (CM: p=0.55, 0.48- 0.62; NG: p=0.48, 0.40-0.55) and Health Confidence scores (CM: p=0.47, 0.39-0.54; NG: p=0.35, 0.26-0.43).

Conclusions

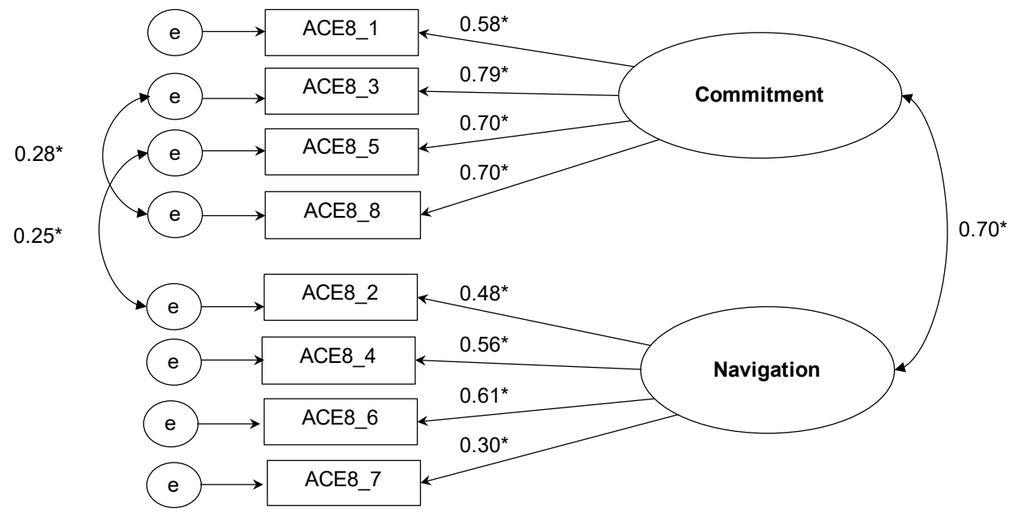
The two-subscale ACE Measure with eight items demonstrated good factorial, construct, and criterion validity in English-speaking Singapore community-dwelling adults. Evidence on internal consistency was mixed, indicating that further investigation into the psychometric performance of this tool is needed.

Table 1. Item-level statistics, item-rest correlation, and average inter-item covariance for the two-subscale ACE Measure (N=400)

Item	Mean	SD	Floor / ceiling effect (%)	Item-rest correlation	Average inter-item covariance
Commitment					
ACE8_1. Even when life is stressful, I know I can continue to do the things that keep me healthy.	3.0	0.7	0.3 / 17.8	0.50	0.22
ACE8_3. When I work to improve my health, I succeed.	2.9	0.7	0.5 / 14.8	0.61	0.18
ACE8_5. I can stick with plans to exercise and eat a healthy diet.	2.8	0.8	0.5 / 15.5	0.59	0.18
ACE8_8. I handle my health well.	3.1	0.6	0 / 19.0	0.56	0.23
Navigation					
ACE8_2. I feel comfortable talking to my doctor about my health.	3.1	0.6	0.5 / 22.5	0.29	0.19
ACE8_4. I have brought my own information about my health to show my doctor.	2.6	0.9	2.3 / 12.8	0.39	0.10
ACE8_6. I have lots of experience using the health care system.	2.4	0.9	1.3 / 8.5	0.45	0.09
ACE8_7. Different doctors give different advice; it's up to me to choose what's right for me.	2.9	0.7	0 / 13.8	0.21	0.21

Response options for each item: 0=strongly disagree, 1=disagree, 2=neither agree nor disagree, 3=agree, and 4=strongly agree.
ACE: Altarum Consumer Measure; SD: standard deviation.

Figure 1. The path diagram for the two-factor CFA model: standardized estimates



**p<0.001.Chi-square test: $x^2(17) = 27.43$, p=0.05; Comparative fit index=0.98, Tucker-Lewis index=0.97, root mean square error of approximation=0.04. ACE: Altarum Consumer Measure; CFA: Confirmatory factor analysis.*

LIVING WITH ILLNESS

MANAGING PATIENTS WITH ILLNESSES TO PREVENT DISEASE PROGRESSION

NHG RIVER OF LIFE

ACCOUNTABLE CARE

LIVING WELL

LIVING WITH ILLNESS

CRISIS & COMPLEX CARE

LIVING WITH FRAILTY

LEAVING WELL

DISEASES OF HIGH COST TO NATIONAL HEALTHCARE GROUP INSTITUTIONS

Palvannan R.K.

HIGHLIGHTS

- **Diabetes, stroke and acute myocardial infarction ranked among the diseases of highest healthcare costs incurred at National Healthcare Group institutions.**
- **Circulatory and respiratory systems, as well as trauma, were the costliest when costs were grouped by broader organ systems.**

Introduction

What are the diseases of highest cost in National Healthcare Group (NHG)? Who are the costliest patients in NHG? These are common questions posed to us by our stakeholders.

Patient-level analyses could reveal that the disparity in healthcare costs incurred by a patient with heart failure, along with their multiple co-morbidities, compared with someone without heart failure, ranks amongst the highest. But the actual number of patients with heart failure may be thankfully small, so the total cost of heart failure from the institution's perspective would be lower. In contrast, looking at diseases of highest cost would reflect the resource demands of managing the condition on the organization. To address the issue of identifying the diseases of highest cost, we looked at episodes of healthcare utilization, mapped the primary diagnosis of each episode into suitable groupings, and ranked the totalled disease costs.

Methods

We used administrative data of all patients who sought care in NHG institutions in 2019, across all healthcare settings: inpatient, specialist outpatient clinics (SOCs), emergency department, polyclinics, and sub-acute care. While all visits at a healthcare institution have a primary diagnosis tagged, most are recorded routinely, except at the SOC setting. As the diagnoses were coded using the International Classification of Diseases (ICD-10) and number over 60,000, they were classified into either 283 ICD groups or 18 organ systems, using mapping tables from the Agency for Healthcare Research and Quality Clinical Classifications Software. Healthcare cost was defined as the gross charge to patients before governmental subsidy, and was summed by either individual ICD groups or organ system levels for analyses. The 18 conditions with the highest cost burdens for each analysis was reported. We did not rank the costs by Diagnosis Related Groupings (DRG) as these reflected procedures at inpatient and day surgeries, and we intended to focus on diseases, as opposed to life-saving procedures.

Results

Table 1 shows the diseases of highest cost in descending order. In the left column, diabetes was the costliest disease out of 283 possible disease groups, potentially due to the large number of lower cost polyclinic episodes and small number of high-cost complications in the acute hospitals. This was in contrast to previous trends from using inpatient DRGs alone, and aligned with the national attention on the War on Diabetes.

Acute cerebrovascular disease, or stroke, was in second place, followed by pneumonia, acute myocardial infarction (AMI) and cataract. Secondary cancers and colon cancers did not appear in the table as they were placed after the 25th ranking. At the broad organ system level, we found cancer at the 5th position.

Table 1. Ranking of diseases with highest cost in NHG (2019)

Disease level (n = 283)	Organ System level (n = 18)
Diabetes with/without complication	Circulatory
Acute cerebrovascular disease	Respiratory
Pneumonia	Injury and poisoning
Acute myocardial infarction	Digestive
Cataract	Neoplasms
Urinary tract infection	Endocrine
Hypertension	Nervous/sense organs
Spondylosis	Musculoskeletal
Osteoarthritis	Genitourinary
Device complication	Mental illness
Upper respiratory infection	Ill-defined conditions
Biliary tract	Infectious
Skin/subcutaneous infections	Skin and subcutaneous
Coronary atherosclerosis	Unclassified other conditions
Hip fracture	Blood and blood forming organs
Septicaemia	Perinatal conditions
Intestinal infections	Congenital anomalies
Connective tissue diseases	Pregnancy and childbirth complications
... 265 more disease groups	-

Conclusions

Diabetes, stroke and AMI ranked among the diseases incurring the highest cost in NHG. This affirmed our empirical knowledge of these diseases' resource usage. We noted that pneumonia was amongst the most costly conditions as well, as pneumonia often masks the underlying condition of admissions. Also, we found cancers to be less expensive when ranked among conditions and at the organ system level. If oncology department SOC visits had been fully labelled with diagnoses and included in this analysis, the ranking would have been higher, next to circulatory conditions. Hence, it is necessary that all diseases are coded administratively and accurately to inform the ranking of resource consumption at a cluster and national level.

PROCESS AND IMPACT EVALUATION OF A CHRONIC CARE PLAN PILOT AT ANG MO KIO POLYCLINIC

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[1]National Healthcare Group Polyclinics

HIGHLIGHTS

- **Approximately 24% of eligible patients signed up for the pre-paid plan studied.**
- **Participants of the plan had greater improvements in adherence to care processes compared to non-enrolees.**
- **Chronic disease control, primary care utilisation and total polyclinic gross charges were similar between Chronic Care Plan patients and non-enrolees.**

Introduction

To better manage the care of patients with chronic conditions, the National Healthcare Group Polyclinics (NHGP) introduced a pre-paid bundle payment scheme with outcomes rewards to incentivise better adherence to evidence-based care processes and to achieve pre-specified health targets.

The Chronic Care Plan (CCP) was introduced at Ang Mo Kio Polyclinic in January 2019. The key features of the CCP are (Figure 1):

- **Mode of pre-payment**: Payment via Medisave (up to 85%) and cash/Flexi-Medisave (15%)
- **Enrolment incentive**: A 5% discount (10% in 2020 to encourage sign-ups) on chronic disease polyclinic services
- **Shared decision-making**: Use of a monitoring card as a shared decision-making tool to set goals and facilitate discussions on chronic disease management between doctors and patients
- **Financial rewards**: Annual good outcome rewards for achieving pre-specified health targets

We evaluated the impact of CCP on patients' adherence to a pre-defined set of evidence-based care processes, chronic disease control, polyclinic healthcare utilisation and total polyclinic gross charges at one-year.

Methods

CCP patients and non-CCP patients were propensity-score matched using one-to-one matching without replacement. A difference-in-differences approach was used to examine the impact of CCP at one-year to account for differences at baseline. Linear probability models were used to model adherence to care processes and chronic disease control outcomes, Poisson generalised linear models (GLM) with robust variance estimates were used to model health utilisation outcomes, and a gamma GLM with log link was employed for total polyclinic gross charges outcome.

Results

5,401 (23.7% of the eligible) patients with chronic conditions signed up for CCP between January 2019 and January 2020. Of which, 49.8% (2,690) patients were diagnosed with diabetes while the remaining patients were diagnosed with other chronic conditions (e.g., hypertension or/and hyperlipidaemia). 2,359 (87.7%) diabetic patients and 2,455 (90.6%) non-diabetic patients were matched with a non-CCP comparator.

At one-year, the change in probability of adherence to the diabetes test panel (mean difference (MD) [95% confidence interval]: 0.06 [0.04, 0.08]) and diabetic foot screening (care processes) (MD: 0.04 [0.01, 0.06]) was greater in CCP group compared to non-CCP group. No significant differences were observed between the two groups for chronic disease control, polyclinic healthcare utilisation and total polyclinic gross charges outcomes. A significant difference was detected only in the number of chronic doctor consultations. (Figure 2a-c).

Similarly, for the non-diabetes group, the decrease in number of chronic doctor consultations over one year for CCP was greater compared to non-CCP (IRR: 0.93 [0.88, 0.97]) (Figure 3d). Again, no significant differences between CCP non-diabetic patients and non-CCP were observed for chronic disease control, polyclinic healthcare utilisation and total polyclinic gross charges outcomes.

Conclusions

Based on our findings at one-year, CCP had a significant impact on adherence to care processes and chronic doctor consultation. The findings suggest that a pre-paid plan coupled with financial incentives may be part of a strategy to encourage adherence to care processes. However, a longer follow-up period will be needed to observe the impact of CCP on chronic disease control, polyclinic healthcare utilisation and total polyclinic gross charges in the longer-term.

Figure 1. Logic model of CCP

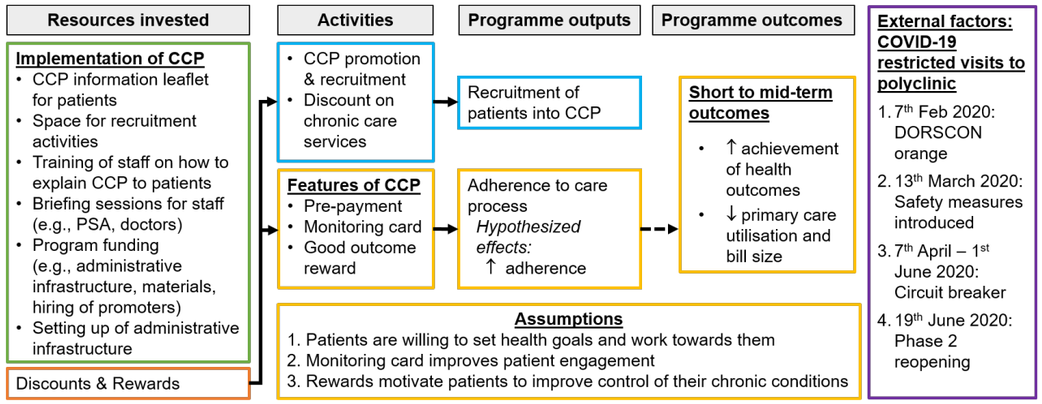
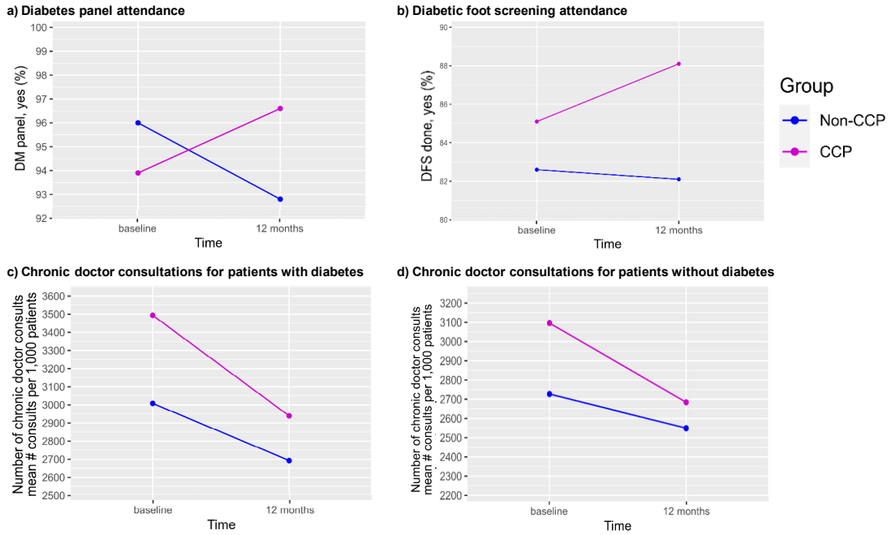


Figure 2. Adherence to care processes and chronic doctor consultations



DEVELOPING A PROGNOSTIC MODEL FOR CHRONIC KIDNEY DISEASE IN HYPERTENSIVE PATIENTS

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HIGHLIGHTS

- **We validated a modified risk equation for our local population.**
- **Our derived risk equation showed high discrimination, but poor calibration.**

Introduction

Stage 3 of chronic kidney disease (CKD) occurs when estimated glomerular filtration rate (eGFR) levels fall between 30 and 59 ml/min/1.73m^2, indicating moderate kidney damage. Nelson[1] et al published an equation developed from 34 multinational cohorts to predict the risk of incident stage 3 CKD. The Nelson model was derived and validated in a predominantly non-Asian population with the use of Black race as a predictor, which is not applicable in Singapore. We aimed to develop a model to identify Hypertensive patients without Diabetes Mellitus (DM) and baseline eGFR above 60 ml/min/1.73m^2, who were at high risk of developing CKD stage 3 within 5 years, in the primary care setting.

Methods

This was a retrospective cohort study. Hypertensive patients without DM with baseline eGFR ≥60 ml/min/1.73m^2, who attended any of 5 NHG Polyclinics clinics (Ang Mo Kio, Hougang, Toa Payoh, Woodlands and Yishun) were included. Data from the Chronic Disease Management Registry was analysed from 1 January 2010 to 31 December 2014 for the derivation cohort and 1 January 2015 to 31 December 2015 for the validation cohort. Baseline variables up to 1 year preceding the study start date were used and the follow up period was 5 years from entry to the study. The outcome of interest was incident eGFR<60 ml/min/1.73m^2. Missing data was handled by including a separate category indicating missing data points for the variables that were missing less than 40% of the time. As Black race was not applicable to the local population, and all the patients had hypertension and urine albumin creatinine ratio was not routinely collected for hypertensive patients, we had to modify the model by Nelson et al. We developed our own model based on a similar set of risk factors. Backward elimination was used to include only significant variables (p<0.05) for the final model and Cox proportional hazard models were used. Discrimination was measured using C-statistic and the calibration slope in the validation set was reported. All analyses were conducted in Stata 16.0.

Results

Table 1 shows the selected baseline characteristics of the derivation cohort and validation cohort. For the derivation cohort of 27,800 patients, 2,823 (10.2%) incident cases of eGFR<60ml/min/1.73m^2 occurred during a mean follow-up of 4.4 years. For the validation cohort of 4,995 patients, 638 (12.8%) incident cases of eGFR<60ml/min/1.73m^2 occurred during a mean follow-up of 4.0 years. The variables used for the modified Nelson's model were age, sex, eGFR, history of cardiovascular disease, smoking history and body mass index. The C-statistic was 0.848 (0.839-0.858) in the derivation cohort and 0.86 (0.84-0.88) in the validation cohort. Our developed equation included age, eGFR, systolic blood pressure, smoking, history of heart failure and low density lipoproteins. (Table 2) The C-statistic was 0.85 (0.85-0.86) for the derivation cohort and 0.87 (0.85-0.88) for the validation cohort. However, calibration in the validation cohort was poor as the predicted risk underestimated the observed risk (slope = 1.056).

Conclusions

The modified Nelson's equation for predicting risk of incident CKD demonstrated high discrimination in the local population. Our locally derived 5-year risk equation also demonstrated high discrimination but poor calibration as it under-predicts the risk of developing the outcome. In future, we will explore other methods to handle missing values, such as multiple imputation and addition of a calibration function to improve calibration.

Table 1. Selected baseline characteristics of derivation and validation cohorts

		2010-2014 cohort (n=27,800)	2015 cohort (n=4,995)	p value
Age, Mean (SD)		58.2 (11.5)	58.8 (11.3)	<0.001
eGFR, Mean (SD)		90.8 (14.1)	89.3 (14.0)	<0.001
Systolic Blood Pressure in mmHg, n (%)	Missing <130 130-139 140-159 160-179 >=180	4,302 (15.5) 6,354 (22.9) 5,248 (18.9) 7,971 (28.7) 3,080 (11.1) 845 (3.0)	312 (6.3) 1,232 (24.7) 1,066 (21.4) 1,549 (31.0) 665 (13.3) 170 (3.4)	<0.001
Smoking, n (%)	Missing Ex-Smoker Non-Smoker Smoker	10,941 (39.4) 440 (1.6) 14,398 (51.2) 2,021 (7.3)	1,793 (35.9) 138 (2.8) 2,591 (51.9) 472 (9.5)	<0.001
Past medical history, n (%)	Heart Failure	204 (0.7)	38 (0.8)	0.837
Low Density Lipoproteins	<2.6 2.6-3.3 3.4-4.0 4.1-4.8 >=4.9 Missing	7,452 (26.8) 10,619 (38.2) 5,962 (21.5) 2,033 (7.3) 552 (2.0) 1,182 (4.3)	1,522 (30.5) 1,889 (37.8) 1,074 (21.5) 295 (5.9) 74 (1.5) 140 (2.8)	<0.001

Table 2. Hazard Ratios for derivation and validation cohorts

		2010-2014 cohort (n=27,800)	2015 cohort (n=4,995)
Age		1.04 (1.04-1.05)	1.02 (1.02-1.03)
eGFR		0.91 (0.91-0.91)	0.89 (0.88-0.90)
Systolic Blood Pressure in mmHg	Missing <130 130-139 140-159 160-179 >=180	1.45 (1.29-1.62) Reference 1.01 (0.89-1.14) 1.15 (1.03-1.28) 1.25 (1.09-1.44) 1.81 (1.48-2.20)	1.48 (1.09-2.01) Reference 1.26 (1.00-1.60) 1.16 (0.93-1.46) 1.64 (1.26-2.14) 2.05 (1.39-3.04)
Smoking	Missing Ex-Smoker Non-Smoker Smoker	Reference 1.21 (1.12-1.31) 1.61 (1.26-2.06) 1.29 (1.12-1.48)	Reference 1.14 (0.96-1.36) 1.41 (0.91-2.18) 1.41 (1.09-1.81)
Past medical history, n (%)	Heart Failure	2.34 (1.86-2.95)	1.89 (1.06-3.38)
Low Density Lipoproteins	<2.6 2.6-3.3 3.4-4.0 4.1-4.8 >=4.9 Missing	1.38 (1.17-1.62) 1.24 (1.11-1.38) 1.09 (0.98-1.22) Reference 1.04 (0.87-1.25) 1.11 (0.84-1.46)	2.27 (1.62-3.18) 1.09 (0.90-1.32) Reference 1.00 (0.79-1.26) 1.09 (0.74-1.60) 2.47 (1.48-4.13)

References

1. Nelson RG, Grams ME, Ballew SH, et al. Development of Risk Prediction Equations for Incident Chronic Kidney Disease. JAMA. 2019;322(21):2104–2114. doi:10.1001/jama.2019.17379.

DEVELOPING A PROGNOSTIC MODEL FOR CHRONIC KIDNEY DISEASE IN DIABETIC PATIENTS

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HIGHLIGHTS

- **We adapted a published prognostic model for chronic kidney diseasefor local diabetic primary care patients and improved on model performance.**

Introduction

A recent publication by Nelson et al (2019) reported a risk prediction equation estimating the five-year risk of incident chronic kidney disease (CKD) stage 3 and above in diabetic patients. Nelson's model was derived predominantly from population screening cohorts instead of primary care patients, precluding applicability to our local clinical cohort. We hence aimed to ascertain the applicability of Nelson's model in our local diabetic population and to improve upon the model.

Methods

Retrospective data of patients aged 18 and above, diagnosed with diabetes (Type 1 or 2) who had an estimated glomerular filtration rate (eGFR) of 60ml/min/1.73m^2 and above (recorded from 2010 to 2019), and at least one follow-up eGFR reading within the five-year follow-up period were drawn from clinical administrative databases. Patients' earliest eGFR reading during the study period was taken as the reference baseline measurement date. The data was partitioned into a model training and validation cohort, with patients with baseline eGFR recorded during 2010 to 2014 and 2015, as the training and validation cohorts respectively.

Cox's proportional hazards regression models were used to model the risk of incident CKD stage 3A and above, defined by eGFR falling below 60ml/min/1.73m^2. We first adapted Nelson's model for use in the local setting, replacing the risk factor of black race with our local multi-ethnic groups. Also, as some patients were on both oral hypoglycaemic agent and insulin, we excluded the interaction effect between haemoglobin A1c (HbA1c) levels and each medication. To improve the model, we included routinely collected biomarkers and bi-directional elimination was used for variable selection. We categorised certain continuous variables for better interpretation and coded missing information as its own category. Model performance was assessed by applying the trained model on the validation cohort, and reported through Harrell's concordance index (C-statistic).

Results

The training and validation cohorts consisted of 18,197 and 3,746 patients, followed for a mean of 4.3 and 4.0 years respectively. Within follow up, 2335 (12.8%) training cohort patients developed CKD stage 3; 608 (16.2%) for the validation cohort. Despite removing variables such as black race, medication and HbA1c levels, the model by Nelson etal performed well in discriminating our local diabetic patients at risk for CKD stage 3, with a C-statistic of 0.85,exceeding the published 0.80 estimate by Nelson et al. We found gender, body mass index, smoking, and history of cardiovascular disease (CVD) to be statistically insignificant in prognosticating CKD stage 3 in our local diabetic patients. However, when looking at the individual CVD diagnoses, we found that only a history of acute myocardial infarction, heart failure or stroke,or hypertension were significantly associated with a higher risk of developing CKD stage 3. The C-statistic of our final model was 0.84, similar to that of the Nelson model applied to our local diabetic population.

Conclusions

We adapted and improved on a published prognostic model, which could improve clinical care through early identification of individuals at elevated risk of CKD, enhancing patient surveillance and management.

Table 1. Hazard ratios and concordance in validation cohort

Risk Factors		Nelson's model	Improved model
Age, per 5 year increase		1.18 (1.13 – 1.24)	1.19 (1.17 – 1.22)
Gender	Female	0.98 (0.84 – 1.15)	-
eGFR 60-90, per -5ml		1.56 (1.49 – 1.63)	1.47 (1.43 – 1.50)
eGFR>=90, per -5ml		1.23 (1.14 – 1.33)	1.26 (1.20 – 1.31)
History of cardiovascular disease		0.95 (0.78 – 1.17)	-
History of acute myocardial infarction		-	1.61 (1.16 – 2.26)
History of heart failure		-	1.87 (1.45 – 2.41)
History of stroke		-	1.23 (1.07 – 1.41)
Ever smoker	Smoker	0.88 (0.67 – 1.16)	-
Systolic blood pressure (mmHg)	<130 130-139 140-159 160-179 180 and above Missing	-	Ref 1.22 (1.08 – 1.38) 1.21 (1.07 – 1.37) 1.64 (1.38 – 2.95) 2.00 (1.52 – 2.63) 1.42 (1.25 – 1.61)
History of hypertension		1.27 (1.08 – 1.50)	-
Triglycerides (mmol/L)	<1.7 1.7-2.2 2.3-4.4 >4.4 Missing	-	Ref 1.08 (0.95 – 1.23) 1.17 (1.02 – 1.34) 2.04 (1.56 – 2.67) 1.87 (1.65 – 2.12)
BMI, per 5 points		0.97 (0.89 – 1.05)	-
HbA1c (%)	<6.0 6.0–6.9 7.0–7.9 8.0–8.9 >=9.0 Missing	-	Ref 1.08 (0.95 – 1.23) 1.17 (1.02 – 1.34) 2.04 (1.56 – 2.67) 1.87 (1.65 – 2.12)
UACR, per 10-fold increase		2.63 (2.36 – 2.93)	-
UACR*	Normal Micro-albuminuria Macro-albuminuria Missing	-	Ref 2.17 (1.89 – 2.48) 5.05 (4.22 – 6.04) 1.28 (1.11 – 1.47)
OHGA use		-	1.41 (1.27 – 1.56)
Insulin use		-	1.61 (1.28 – 2.03)
Concordance		0.85	0.84

**UACR thresholds: Normal, male:<2.5, female:<3.5; Micro-albuminuria, male: 2.5-30, female: 3.5-30; Macro-albuminuria: >30. BMI: body mass index; eGFR: estimated glomerular filtration rate; HbA1c: haemoglobin A1c; OHGA: oral hypoglycaemic agent; UACR: Urine Albumin Creatinine Ratio.*

References

1. Nelson RG, Grams ME, Ballew SH, et al. Development of Risk Prediction Equations for Incident Chronic Kidney Disease. JAMA. 2019;322(21):2104–2114. doi:10.1001/jama.2019.17379

MODEL CALIBRATION: A NECESSARY METRIC FOR EVALUATING PERFORMANCE OF RISK PROGNOSTICATION MODELS

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HIGHLIGHTS

- **Calibration plots are a necessary measure of risk prognostication models as measuring concordance alone is insufficient.**
- **Predicted risk probabilities can be calibrated for clinical application.**

Introduction

Concordance is a measure of model discrimination, which is the ability of a model to classify positive and negative outcomes. A risk prediction model producing predicted probabilities of 0.4 for all observed negative cases and 0.6 for positive cases will have perfect discrimination (at a threshold of 0.5). However, the same model will yield poor prediction accuracy if the observed empirical probabilities vary. In clinical practice, accurate predicted risk probabilities are important to reflect actual risk to the patients and their management. Current literature cautions against the overuse of discrimination alone, and calls for comparing actual and predicted probabilities of risk to ensure model predictions are sound (Van Calster et al, 2019). We used a prognostic model for chronic kidney disease (CKD) in diabetic patients as an illustration of the importance of examining calibration as a measure of model performance.

Methods

Time-to-event Cox regression models for risk of incident CKD stage 3A and above, were trained using retrospective data of diabetic patients from 2010 to 2019 drawn from clinical administrative databases. Details can be found in an earlier report in this compendium. We compared models with different combinations of risk factors. Visual plots of observed risks against predicted risks of the validation cohort are shown in Figure 1. Predicted risks were binned into deciles and observed risks were calculated based on the number of actual observed patient outcomes over the total number of patients in each decile of predicted risks.

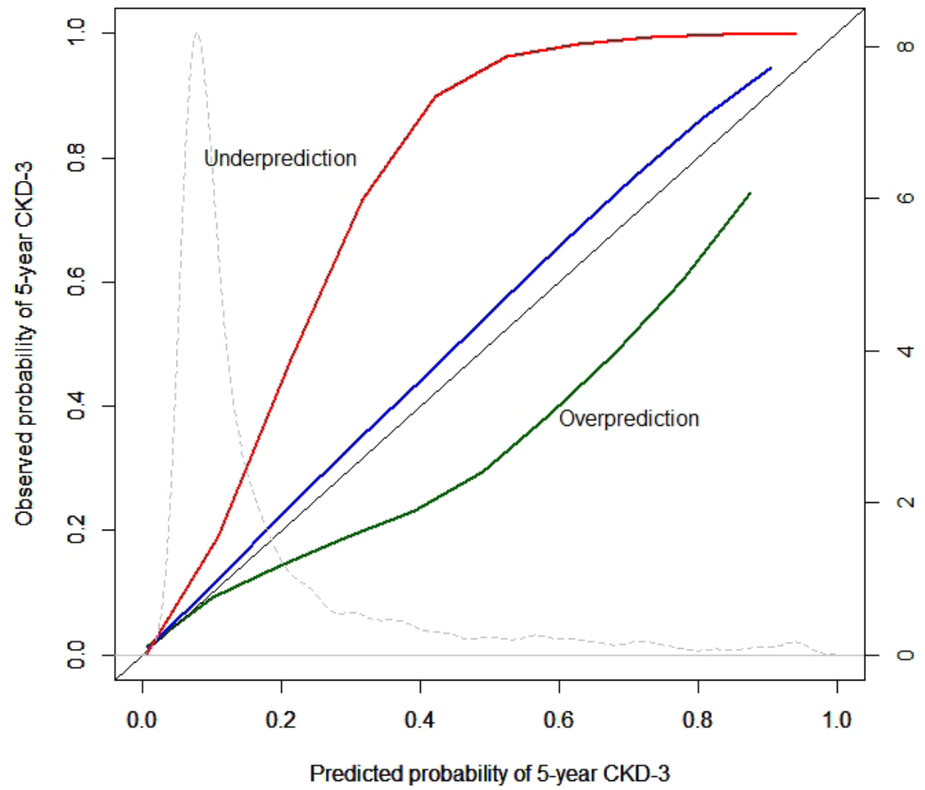
Results

The diagonal line (zero intercept and slope = 1) in Figure 1 showed the scenario of perfect calibration, where the model predictions would be identical to observed data. Any point above this diagonal line would indicate an under-prediction of the model, with observed risks being higher than predicted and vice versa for points falling below the diagonal. The figure highlighted the sensitivity of the models' risk prediction performance to variable selection and transformation. The addition of the HbA1c risk factor (blue and red graphs) or variable transformation (green and blue graphs) could over- or under-predict patients' risk, despite all models having similar concordance (0.82 - 0.83). Despite the similarity in concordance, the discrepancy between observed and predicted risk at higher levels of predicted risk was apparent between the blue model and that of the red or green model.

Conclusions

Model calibration can be done in various ways, but generally it relates the model's predicted risks to actual observed risks. The calibration plots can be used to adjust predicted risk closer to empirical risk values for clinical use. While the concordance statistic is necessary for measure of discrimination, the calibration plots is a necessary measurement of prediction error for correction.

Figure 1. Calibration Plot of 3 models with density plot of predictions



Note	
Blue	Age + Urine albumin creatinine ratio + estimated glomerular filtration rate (knotted spline).
Green	Age + Urine albumin creatinine ratio + estimated glomerular filtration rate (per unit increase).
Red	Age + Urine albumin creatinine ratio + estimated glomerular filtration rate (knotted spline) + HbA1c.
Dashed line	Density function of predicted risk probabilities for red model, all 3 models have similar concordance statistic at 0.82 (blue and green) and 0.83 (red).

References

1. Van Calster B, McLernon DJ, van Smeden M, Wynants L, Steyerberg EW; Topic Group 'Evaluating diagnostic tests and prediction models' of the STRATOS initiative. Calibration: the Achilles heel of predictive analytics. BMC Med. 2019 Dec 16;17(1):230. doi: 10.1186/s12916-019-1466-7. PMID: 31842878; PMCID: PMC6912996.

CHRONIC LOW BACK PAIN AND ITS IMPACT ON PHYSICAL FUNCTION, MENTAL HEALTH, AND HEALTH-RELATED QUALITY OF LIFE IN THE GENERAL POPULATION OF SINGAPORE

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HIGHLIGHTS

- **The local prevalence of chronic low back pain was 8%, among whom, 80.5% sought consultation/ treatments at either primary care, SOC or TCM clinics.**
- **Those with chronic low back pain were more likely to be older, have no partners, have no formal education, live alone, and have other morbidities.**
- **Chronic low back pain was significantly associated with poorer physical function, more limitation and depressive symptoms, and worse health-related quality of life.**

Introduction

Chronic low back pain (cLBP), defined as low back pain lasting more than three months, is a globally prevalent health problem with significantly high medical and economic burden on individuals and society. To date, there is scarce research on cLBP in Singapore. It is important to understand the prevalence of cLBP and its association with health outcomes, such as physical function and limitation, depressive symptoms and health-related quality of life (HRQoL) among community-dwelling adults in Singapore. Hence, this study used population-based health survey data collected in the Central region of Singapore to 1) estimate the prevalence of cLBP and healthcare seeking rates in the community-dwelling adult population; 2) explore the risk factors ofcLBP, and 3) examine the association between cLBP and physical function and limitation, depressive symptoms, and HRQoL.

Methods

Cross-sectional data for 1941 adults (mean age: 52.6 years, range: 21-97 years) from the Population Health Index survey conducted in the Central region of Singapore was analysed. Those with cLBP in the past six months were identified as participants who responded "Yes" to the following question in the survey: "In the past 6 months, have you ever sought medical consultation/treatment for chronic low back pain (lasting for more than three months)?" Health outcomes examined in this study were physical function and limitation, severity of depressive symptoms, and HRQoL, measured using the Late-Life Function and Disability Instrument, Patient Health Questionnaire-9 (PHQ-9) and EQ-5D-5L questionnaire, respectively.

Logistic regression models were built to examine associations between patient characteristics and cLBP. Generalized Linear Models (Gamma family, Log link) were performed to determine the association between cLBP and each health outcome measure. All models were adjusted for socio-demographics (including age group, gender, ethnicity, highest education level, marital status, occupation group, living arrangement, and self-reported money insufficiency), lifestyle factors (smoking status and alcohol misuse), and self-reported multi-morbidity.

Results

The characteristics of the 1941 participants are described in Table 1. The mean age of the participants was 52.5 years old with a standard deviation (SD) of 16.9 years. Majority of the participants were Chinese (78.3%), 56.2% were females, and 36.9% were unemployed or economically inactive. There were 180 participants (weighted percentage: 8.1%) who reported having cLBP in past six months. Of these, 80.5% sought consultation/treatments at either primary care, SOC or TCM clinics. Compared to those who did not report cLBP (n=1761), individuals reporting cLBP (n=180) were older (mean ± SD: 57.2 ± 17.5 vs 52.1 ± 16.7), with a higher proportion aged 75 years and above (19.1% vs 9.2%). Individuals with cLBP were more likely to be divorced/widowed (22.4% vs 10.2%) or to live alone (8.2% vs 5.1%). They were also more likely to have relatively lower levels of education, report money insufficiency (31.4% vs 12.8%) or have two or more chronic conditions (54.7% vs 66.3%). In adjusted analyses, individuals who were female (odds ratio (OR)=1.55, 95% confidence interval (CI)=1.04, 2.32), perceived money insufficiency for basic daily living (OR=2.71, 95% CI=1.84, 3.99), or had one or more existing comorbidities had higher risk of cLBP (one chronic morbidity: OR=2.73, 95% CI=1.68, 3.99; two or more chronic morbidity: OR=3.36, 95% CI=2.09, 5.41).

When examining health outcomes, individuals with cLBP had significantly lower overall physical function, more limitations, greater severity of depressive symptoms and lower HRQoL scores than those without cLBP (Table 1). In adjusted analyses, cLBP remained significantly associated with lower overall physical function (B=-0.08, 95% CI=-0.10, -0.05), more physical limitation (B=-0.04, 95% CI=-0.07, -0.01), greater severity of depressive symptoms (B=0.63, 95% CI=0.32, 0.94), and worse HRQoL (EQ-5D Index: B=-0.07, 95% CI=-0.09, -0.05, EQ VAS: B=-0.10, 95% CI=-0.13, -0.07).

Table 1. Comparison of health outcomes between individuals with and without cLBP

RSA-33 Dimensions	Total		Chronic low back pain				p-value
			No		Yes		
Physical function and limitation, mean score (SD)	Mean	SD	Mean	SD	Mean	SD	
Overall function	84.0	17.8	85.1	17.0	73.6	21.3	**<.001***
Limitation	82.1	17.3	82.7	16.8	76.6	20.5	**<.001***
Severity of depressive symptoms, mean score (SD)	1.1	2.3	1.0	2.1	2.6	3.5	**<.001***
Health-related quality of life							
Problem in mobility (n, %)	138	7.0	102	5.9	36	19.6	**<.001****
Problem in self-care (n, %)	49	2.5	37	2.2	12	6.1	**<.001****
Problem in activity (n, %)	113	5.7	82	4.7	31	16.0	**<.001****
Problem in pain (n, %)	415	20.9	315	17.9	100	54.9	**<.001****
Problem in anxiety (n, %)	93	4.7	69	4.0	24	13.2	**<.001****
EQ-5D index, mean score (SD)	0.94	0.13	0.94	0.12	0.85	0.16	**<.001***
EQ-5D Visual AnalogScore mean (SD)	78.1	14.5	79.0	13.7	69.5	18.2	**<.001***

** Mann-Whitney tests, **Chi-squared tests; SD: standard deviation.*

Conclusions

The prevalence of cLBP was 8.1% among the study population. cLBP was associated with poorer physical function, more limitations and depressive symptoms, and lower HRQoL. The findings highlight the significant impact of cLBP on these outcomes in a general population. Increased awareness on prevention, early and proper management of low back pain and rehabilitation policies are required to better address the disease burden of cLBP in the population.

CAPACITY PLANNING FOR AD HOC DEMAND

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HIGHLIGHTS

- **We present 2 mathematical models based on different operating assumptions.**
- **These models aid in deciding the ring-fenced capacity given estimated demand.**

Introduction

To meet ad hoc or unscheduled demand, additional capacity has to be ring-fenced. However, due to the stochastic nature of the demand, a ring-fenced scenario could result in either of 2 situations. First, too few slots are set aside for ad hoc demand, resulting in patients not getting their appointments, or providers having to work overtime. Second, too many slots are reserved, and some of them will be left unused and wasted. Here we propose using mathematical methods to model and quantify the trade-offs.

Methods

In Model A, we propose using Poisson probability to describe a scenario where demand is needed in 1 to 3 days' time. An example is a patient discharged from the emergency department and needing a Specialist Outpatient Clinic (SOC) or Allied Health appointment within the next couple days.

In Model B, we suggest the M/M/c/k queuing model, which describes a case of finite waiting capacity, and patients are turned away when the waiting capacity is reached. One example is a Falls clinic patient being referred to therapy or another SOC clinic for an immediate assessment. The patient may either receive an immediate empty slot, wait for at most for 1 to 2 patients to be seen prior to their turn, or be turned away because the service provider is overwhelmed.

We ran both models with a range of demand and capacity, and produced the percentages of demand met, and capacity unused.

Results

Because the demand is random, there will be days with excess capacity, and days when demand is not 100% fulfilled. When providers allow more ring-fenced capacity, more demand can be met, but more capacity can also be expected to be left unused.

In such random demand scenarios, economy of scale applies: a system with higher demand can meet the demand better and with lower wasted capacity as compared to a system with lower demand. The trade-offs between expected demand and ring-fenced capacity supplied are presented in tables 1 and 2 and can be used to guide planning.

Conclusions

We propose 2 models, each analysing a scenario of ad hoc demand. A planner can select the model which better applies to the context, estimate the current demand, and decide the capacity to ring-fence based on the trade-offs. In practice, the provider could exercise flexibility to use the excess capacity when there is, such as arranging non-patient fronting work.

Table 1. Expected met demand given capacity reserved and demand
Model A: Poisson Arrival

Percentage of Demand met

Expected Demand \ Capacity Reserved	8	9	10	11	12	13
8	86%	91%	95%	97%	98%	99%
9	81%	87%	91%	95%	97%	98%
10	75%	82%	87%	92%	95%	97%
11	70%	77%	83%	88%	92%	95%
12	65%	72%	79%	84%	89%	92%
13	61%	68%	74%	80%	85%	89%

Percentage of Capacity unused

Expected Demand \ Capacity Reserved	8	9	10	11	12	13
8	14%	19%	24%	29%	34%	39%
9	9%	13%	18%	23%	27%	32%
10	6%	9%	13%	17%	21%	26%
11	4%	6%	9%	12%	16%	20%
12	2%	4%	6%	8%	11%	15%
13	1%	2%	4%	6%	8%	11%

Table 2. Expected met demand given number of providers and demand
Model B: M/M/c/2c model

Percentage of Demand met

Expected Demand \ No. of providers	1	2	3	4	8
1	86%	100%	100%	100%	100%
2	67%	96%	100%	100%	100%
4	43%	78%	95%	99%	100%
8	24%	48%	69%	86%	100%
16	12%	25%	37%	50%	92%

**Patient will wait for at most 1 patient prior to their turn Average service time = 0.5 hour*

Percentage of Capacity unused

Expected Demand \ No. of providers	1	2	3	4	8
1	57%	75%	83%	88%	94%
2	33%	52%	67%	75%	88%
4	14%	22%	37%	50%	75%
8	5%	5%	8%	14%	50%
16	1%	1%	1%	1%	8%

A GRAPH-THEORETIC FACILITY LAYOUT PLANNING FOR AN EYE SPECIALIST OUTPATIENT CLINIC

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HIGHLIGHTS

- **We proposed a practical framework for layout planning for an eye specialist outpatient clinic of a public hospital usinga graph-theoretic approach and incorporating hospital practitioners' inputs.**
- **We developed block layout designs for the new clinic by constructing the maximal planar graph using a modified greedy heuristic algorithm.**

Introduction

The existing building where Alexandra Hospital is currently operating from, a 3-storey building operating a maximum of 300 beds, will undergo a massive redevelopment exercise. There will be up to 1,100 beds in the new facility and an increase in the number of outpatient clinics, motivating the need to look into how the space in the new facility can be optimised operationally and to raise both patient and staff satisfaction levels. Within a new eye specialist outpatient clinic (SOC), service stations will provide services such as registration, consultation, various eye assessments, treatment, and payment. We were interested to apply a graph-theoretic approach for layout planning for this new eye SOC. The aim of this study was to determine the relative positions of the service stations to minimize travelling distances and times of patients, and generate block layout designs for the new eye SOC.

Methods

We modelled the layout planning problem as finding a maximum weight planar sub-graph of the original graph, defined by service stations of the eye SOC and the connectivity information on patient flow between service stations. Each entry in the interaction matrix denoted the quantity or magnitude of interactions between two functional units, which was quantified as the total number of patients moving between them during a certain time period. The graph-theoretic approach involves two steps: (i) construct a graph; (ii) derive a block layout from its dual graph. The underlying mathematical model is shown in Equation (1), where the objective was to maximize the total interactions of units that are adjacent in the layout plan.

$$\max_{x} \sum_{(i,j)\in E'} u_{ij}x_{ij}$$

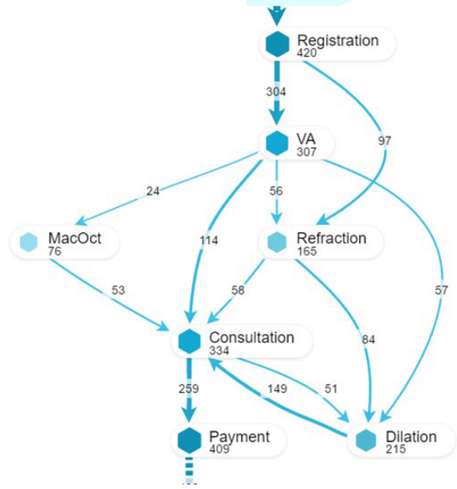
$$s.t.\, G = (V,\, E) \text{ is a planar subgraph of } G' = (V,\, E') \text{ with } E = \{(i,j) \in E' \mid x_{ij} = 1\}. \quad (1)$$

We used a heuristic algorithm to solve Equation (1) and determined an approximation of the optimal layout design. In addition, cluster heatmaps and process mining were used for visual representation of patient flow and to solicit further inputs from the hospital operations team. Patient data was collected by a patient time-motion survey, including information on a typical patient journey in the eye SOC for a period from 04 to 14 January 2021. The duration spent at each service station and waiting duration required at each service station were captured.

Results

There were 420 patient visits in total and the majority of patients (99.3%) were of the general eye, retina and glaucoma sub-specialities, which accounted for 84.5%, 8.1% and 6.7% of visits respectively. We saw that all patients started with registration, followed by consultation (98.3%), payment (95.8%), visual acuity (VA) assessment (72.4%) and eye dilation (52.1%). The cluster heatmap demonstrated the key event pairs, such as registration-VA, consultation-payment, and consultation-dilation. Figure 1 depicts the key aggregated patient flow in the clinic, showing the interactions between service stations.

Figure 1. Flow of patients using process mining



Most patients would do a VA or refraction assessment after registration, and subsequently they would have a dilation or a doctor consultation. It was also not uncommon to have patients directed to refraction after VA, or dilation after a doctor consultation.

We proposed two block layout designs from different perspectives. In both designs, we put the registration and payment together at the entrance to the clinic. In Design 1 (Figure 2), we proposed that patients walk through VA or refraction areas before progressing to the consultation rooms. This was because most patients would need VA or refraction examinations before consulting the doctor. VA and refraction areas were also placed near to each other as the study showed a significant relationship between the 2 services. In Design 2 (Figure 3), the area for consultation rooms was placed at the centre of the clinic as it would connect to as many other service stations as possible. We split VA and refraction into two ends of the clinic, but they remained interconnected at the back of the clinic for ease of patient flow from one service to the other.

Figure 2. Block layout design 1

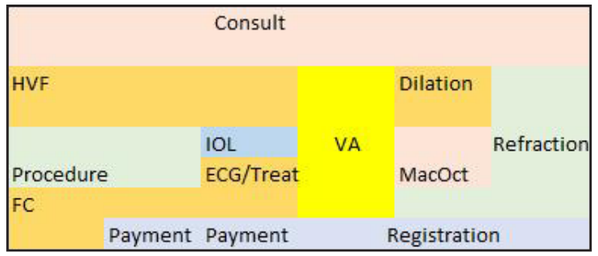
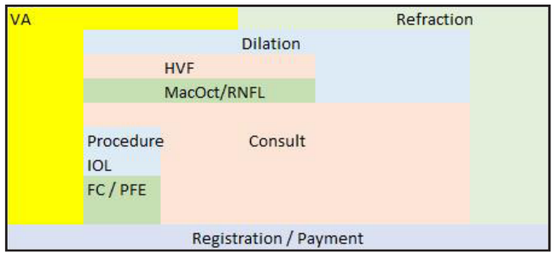


Figure 3. Block layout design 2



Conclusions

This study proposed a framework for layout planning for an eye SOC by applying a graph-theoretic approach. The derived layout design will serve as an input for the architectural design of the new clinic.

CRISIS & COMPLEX CARE

CARING FOR PATIENTS WHO REQUIRE
HOSPITALIZATIONS OR COMPLEX MEDICAL CARE

NHG RIVER OF LIFE

ACCOUNTABLE CARE

LIVING WELL

LIVING WITH ILLNESS

CRISIS & COMPLEX CARE

LIVING WITH FRAILTY

LEAVING WELL

AN INTERIM STUDY ON THE QUALITY OF LIFE IMPACT OF THE HOME VENTILATION & RESPIRATORY SUPPORT SERVICE

Chieh Pann Pei, Dr Michelle Jessica Pereira, Dr Joseph Antonio D. Molina, Dr Chan Yeow[1], Dr Tan Geak Poh[1], Dr Adrian Tan Kok Heng[1], Dr Kor Ai Ching[1], Dr Lee Rui Min[1], Sun Tao[1], Soon Hse Yin Lydia[1], Anura Tamar Peters[1], Janet Chua Pei Lu[1], Aiyu Li[1]

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HIGHLIGHTS

- **Potential improvements were seen in the quality of life for discharged ventilator-assisted individuals and their caregivers receiving ventilation support at home.**

Introduction

Ventilator-assisted individuals (VAIs) suffer from severe chronic respiratory failure and require mechanical ventilation support. Prior to the establishment of Tan Tock Seng Hospital's Home Ventilation and Respiratory Support Service (HVRSS) in 2009, VAIs and their families had limited options: to remain in acute hospitals, or risk going home unsupported. International studies have reported that quality of life (QoL) of VAIs have improved after receiving home ventilation support. However, in Singapore, the QoL impact of home ventilation service for VAIs and caregivers (CGs) was unknown. Hence, we aimed to better understand the QoL impact of these two groups under the care of HVRSS.

Methods

We conducted a prospective 1-year pre-post cohort study on VAIs and their CGs who received HVRSS from July 2020 to January 2022. QoL instruments utilized for VAIs were the Severe Respiratory Insufficiency (SRI) questionnaire, Patient Health Questionnaire-9 (PHQ-9) and Perceived Stress Scale (PSS). As for CGs, PSS and Zarit Burden Interview-22 (ZBI-22) questionnaires were used. Enrolled VAIs and CGs were requested to complete QoL measurements upon hospital discharge (baseline), and at 3 months and 1 year from discharge. A brief description of QoL instruments were shown in Table 1.

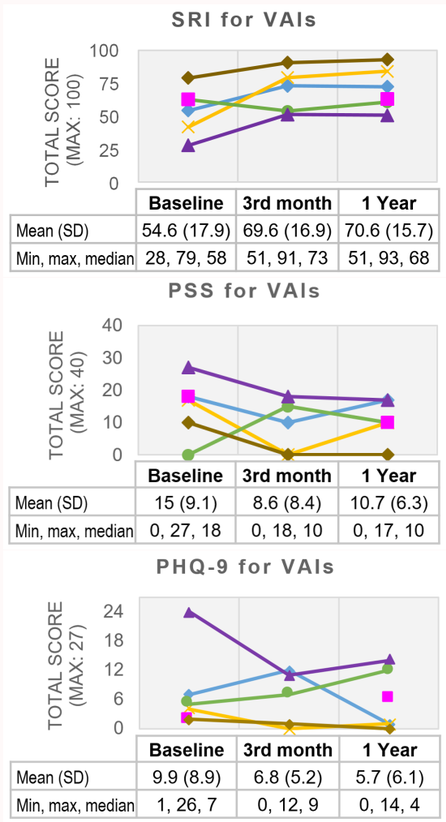
Table 1. Details of instruments utilized

Instrument	Description
Severe Respiratory Insufficiency	Assessment of general health in patients with severe respiratory insufficiency in the previous week. 49 items; Score: 0 - 100. Higher values; better general health.
Patient Health Questionnaire-9	Assessment of depression based on the past 2 weeks. 9 items; Score: 0 - 27. Higher score; greater depression severity.
Perceived Stress Scale	Assessment of perceived personal stress in the past month. 10 items; Score: 0- 40. Higher score; higher stress level.
Zarit Burden Interview-22	Assessment of caregiver burden of caregivers in their current situation. 22 items; Score: 0 - 88. Higher score; greater burden.

Results

To date, 27 VAI and CG dyads were eligible and 11 dyads participated in the study. At the point of this interim analysis, six dyads completed their 1-year follow up, one dyad was terminated from the study as the VAI had successfully weaned off ventilation support, and the remaining four dyads were pending study completion. Of the six dyads who completed the study, one dyad (C) had switched CGs at 3-month, and we excluded their baseline CG data from analysis. Another dyad (E) had defaulted on their 3-month follow up due to personal reasons. From Figure 1, mean VAI SRI scores increased at 3-month and plateaued at 1-year, but mean PHQ-9 values reduced at 3-month and 1-year for VAIs. Mean PSS score for VAIs reduced from baseline to 3-month, but increased slightly at 1-year. For CGs, their mean PSS score was similar at baseline and 3-month, but was lower at 1-year, whereas their mean ZBI-22 score decreased at 3-month and 1-year.

Figure 1. Quality of life outcomesfor 6 VAIs

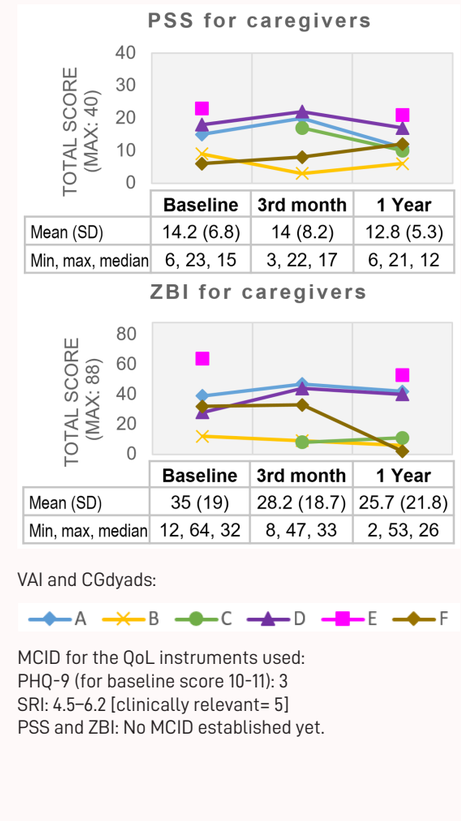


	Baseline	3rd month	1 Year
Mean (SD)	54.6 (17.9)	69.6 (16.9)	70.6 (15.7)
Min, max, median	28, 79, 58	51, 91, 73	51, 93, 68

	Baseline	3rd month	1 Year
Mean (SD)	15 (9.1)	8.6 (8.4)	10.7 (6.3)
Min, max, median	0, 27, 18	0, 18, 10	0, 17, 10

	Baseline	3rd month	1 Year
Mean (SD)	9.9 (8.9)	6.8 (5.2)	5.7 (6.1)
Min, max, median	1, 26, 7	0, 12, 9	0, 14, 4

Figure 2. Quality of life outcomes for 6 CGs



	Baseline	3rd month	1 Year
Mean (SD)	14.2 (6.8)	14 (8.2)	12.8 (5.3)
Min, max, median	6, 23, 15	3, 22, 17	6, 21, 12

	Baseline	3rd month	1 Year
Mean (SD)	35 (19)	28.2 (18.7)	25.7 (21.8)
Min, max, median	12, 64, 32	8, 47, 33	2, 53, 26

MCID for the QoL instruments used:
PHQ-9 (for baseline score 10-11): 3
SRI: 4.5–6.2 [clinically relevant= 5]
PSS and ZBI: No MCID established yet.

**CG: caregiver; MCID: Minimum Clinically Important Differences; PSS: Perceived Stress Scale; PHQ-9: Patient Health Questionnaire-9; QoL: quality of life; SD: standard deviation; SRI: Severe Respiratory Insufficiency; VAI: Ventilator-assisted individual; ZBI-22: Zarit Burden Interview-22.*

Conclusions

In this interim study, SRI results suggested that VAIs experienced better general health in the short-term, but did not improve further at 1-year. There appears to be trends of decreasing depression severity and stress levels for VAIs in the first 3 months, but PSS score increased slightly at 1 year. As care is shifted from healthcare workers to CGs, it may be expected that CGs would experience higher stress and burden levels when VAIs are discharged home. However, these levels appeared to decrease at 1-year. More conclusive results would be shared when data from all dyads after 1-year follow up have been analysed.

INTEGRATED DIABETES CARE PROGRAM (PART 1): COMPARISON OF CLINICAL OUTCOMES

Palvinder Kaur, Dr Michelle Jessica Pereira, Dr Joseph Antonio D. Molina, Dr Quek Zhi Han[1], Oei Chien Wei[2], Dorothy Chen[3], Teo Hwei Yee[3], Dr Quek Peng Lim Timothy[1]

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HIGHLIGHTS

- **There was non-inferiority in clinical outcomes between IDCP and IDCT after adjusting for differences in baseline characteristics.**

Introduction

The Integrated Diabetes Care Program (IDCP) aims to improve hospital-wide inpatient diabetes mellitus (DM) care among patients admitted to Tan Tock Seng Hospital (TTSH) by risk-stratifying them into three categories (low, intermediate and high risk), using an automated information technology (IT) system. Inpatient care teams were deployed based on patient's risk category (low risk: ward nurses, ward pharmacists and primary medical teams; intermediate risk: IDCP pharmacists and IDCP coordinator with endocrinologist oversight; high risk: IDCP doctors led by endocrinologist). Prior to the implementation of IDCP, inpatient DM care was provided for by a pilot programme, the Integrated Diabetes Care Team (IDCT), where manual screening was performed to identify eligible DM patients admitted to Levels 11 and 12 – Division of Surgery, and care was led by a team of endocrinologists.

This evaluation aimed to assess for clinical effectiveness by comparing the clinical outcomes of (A) all eligible patients admitted to IDCP and IDCT, and (B) a subgroup of patients in the intermediate risk groups admitted to IDCP and IDCT. This was to ensure that changing the model of care by electronic risk-stratification of patients and using pharmacists as physician extenders did not result in a deterioration of clinical outcomes.

Methods

We adopted a retrospective study design where we identified IDCT (Division of Surgery, Levels 11 and 12, Nov 2013 to 12 Aug 2018) and IDCP (Division of Surgery, Hospital wide, 18 Dec 2018 to 31 Dec 2020) patients through specific charge codes. During the transition from IDCT to IDCP, risk categories were generated by the IT system for patients admitted to IDCT between 13 Aug 2018 and 17 Dec 2018. Intermediate risk patients in the IDCT group were identified to facilitate the subgroup analysis in (B). Data was obtained from administrative databases. A non-inferiority analysis was undertaken. For the computation of the non-inferiority limit, the difference between the mean glucose per patient per admission was used. To achieve an analytical power of 80%, alpha of 0.05, and a non-inferiority limit of 0.26, a sample size of 1,144 admissions per group was required. Descriptive statistics were used to compare baseline characteristics between (A) IDCP and IDCT (overall) and (B) IDCP and IDCT (intermediate risk). For multivariable analysis, linear and logistic regression were used, adjusted for the following baseline characteristics: age, gender, ethnicity, first glucose reading upon admission, comorbidity burden as measured by the Charlson Comorbidity Index (CCI) and year of admission.

Results

(A) IDCP (n=1,930) and IDCT (n=2,860) – overall
There were no differences in age, gender, ethnicity, mean number of admissions, 7-, 30- and 90-day mortality rates, admission type (emergency or elective), admissions that required parenteral nutrition, surgery type (major or minor) or number of admissions with major surgery done. However, compared to IDCT, IDCP had a significantly higher comorbidity burden (CCI 2.62 versus 2.50) and a significantly higher proportion of admissions that came from general surgery (50.6% versus 44.5%), had surgery done (72.2% versus 68.5%) and were discharged to the community hospital (10.6% versus 8.0%). Compared to IDCT in univariate analysis, IDCP had a lower proportion of patient-days with hypoglycaemia (glucose <4mmol/L) and shorter average lengths-of-stay (Table 1). However, IDCP had higher values for mean glucose per patient-day, mean glucose per patient admissions, higher proportion of patient-days with at least one episode of hyperglycaemia (glucose >16mmol/L) and higher proportion of glucose readings that were <4mmol/L out of all glucose readings done. In the multivariable analysis, these differences were no longer statistically significant.

(B) IDCP (n=1,363) and IDCT (n=175) – intermediate risk
There were no significant differences in patient characteristics for the intermediate-risk groups between IDCP and IDCT, except for a higher mean number of admissions and admissions to general surgery in IDCP. In terms of clinical outcomes, no significant differences were see in both the univariable (Table 1) and multivariable analysis of clinical outcomes.

Table 1. Univariable analysis of clinical outcomes for (A) IDCT and IDCP (overall) & (B) IDCT and IDCP intermediate risk group

	(A) Overall			(B) Intermediate-risk		
	IDCT	IDCP	P	IDCT	IDCP	P
Total number of patients	2,860	1,930	-	175	1363	-
Total number of admissions	3,391	2,310	-	185	1638	-
Total number of patient-days	35,875	22,243	-	1,837	14,700	-
Total number of glucose readings	147,066	95,747	-	7,604	61,336	-
Clinical Indicators						
Proportion of patient-days with glucose <4 mmol/L (% patient-days)	4.12	2.35	<0.001	2.45	2.04	NS
Average length-of-stay (days) (mean, SD)	10.58 (14.67)	9.63 (12.20)	0.01	9.93 (10.17)	8.97 (11.00)	NS
Mean glucose per patient-day (mmol/L per patient-day)	10.89	11.35	-	11.26	11.43	-
Mean glucose per patient-day (mmol/L per patient-day)	10.72 (2.52)	10.98 (2.36)	<0.001	10.75 (1.96)	11.04 (2.14)	NS
Proportion of patient-days on glucose monitoring with at least one episode of >16 mmol/L (% patient-days)	19.88	20.64	0.01	20.20	20.78	NS
Proportion of glucose readings <4mmol/L out of all glucose readings done (%)	1.36	0.74	<0.001	0.70	0.62	NS
Difference of the mean percentage of patient glucose readings within 4-16 mmol/L, comparing between first and last 24 hours of inpatient admission (mean,SD)	9.06 (24.05)	8.11 (23.21)	NS	8.65 (22.43)	7.52 (22.60)	NS
Absolute change in POCT readings between 24 hours prior to highest risk category and 24 hours prior to discharge (mean, SD)	-	-	-	-2.34 (3.73)	-2.35 (3.56)	NS

Conclusions

There was non-inferiority in clinical outcomes between IDCP and IDCT (overall), after accounting for baseline differences in the multivariable analysis. However, one of the major limitations was the small sample size in the subgroup analysis due to the short transition period. Nonetheless, results from the overall comparison of IDCP and IDCT suggests that clinical outcomes of IDCP patients were not inferior to those of IDCT patients despite the use of pharmacists (albeit supervised by Endocrinologists) to care for most of these patients.

INTEGRATED DIABETES CARE PROGRAM (PART 2): COMPARISON OF ECONOMIC OUTCOMES

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HIGHLIGHTS

- **Non-inferiority of economic outcomes was shown by the use of technology-enabled screening and physician extenders for inpatient diabetes care.**

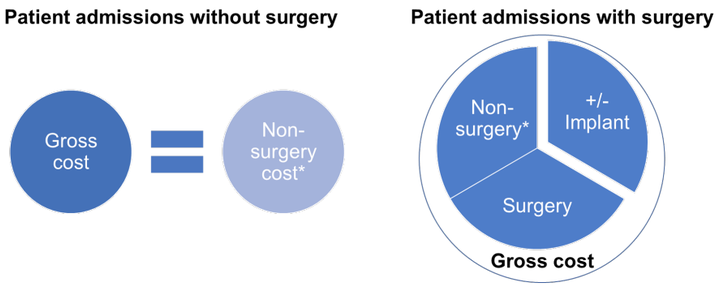
Introduction

The Integrated Diabetes Care Program (IDCP) was hypothesized to: 1. Improve the efficiency of resource use by leveraging on technology to enhance screening reach, 2. Reduce inpatient diabetes-related treatment cost by implementing pharmacist-led inpatient glycaemic management for inpatients identified to be of intermediate risk of dysglycaemia, and 3. Lower inpatient healthcare utilization costs from better glycaemic control during acute surgical admissions. One of the aims of this study was to compare inpatient healthcare utilization cost, in terms of total hospital bills, non-surgery, surgery and implant costs, of patients who received IDCP or IDCT (comparator) interventions during admissions.

Methods

Data from TTSH Division of Surgery admissions (IDCP: Hospital-wide, 18Dec2018-Dec2020; IDCT: Level 11 and 12, Nov2013-12Aug2018) was obtained from administrative databases, and included patient demographics, comorbidity burden, admission- and surgery-related information, daily risk category (if available), charge codes, cost associated with inpatient diabetes-related treatment, and healthcare utilization cost (including inpatient diabetes-related treatment cost and broken down into total hospital bills, non-surgery, surgery and implant cost components - Figure 1) for eligible admissions during the study.

Figure 1. Breakdown of Inpatient Healthcare Utilization Cost Components



** Includes IDCT/IDCP inpatient diabetes-related treatment cost*

We conducted a retrospective cohort study. IDCP admissions with more than 1 IDCP charge code were excluded. Admissions with 1 IDCP charge code were compared to those with IDCT charge codes. Cost data were inflation adjusted according to published annual medical inflation rates from MOH. Comparisons of inpatient healthcare utilization costs were considered using Generalized Linear Models (Gamma family, Log link). The following types of inpatient healthcare utilization costs were compared between IDCP and IDCT admissions (Figure 1):

I. Total hospitalization bill (applicable for patient admissions without surgery)
II. Non-surgery cost (total hospitalization bill without surgery and implant cost, applicable for patient admissions with surgery)
III. Surgery cost (applicable for patient admissions with surgery)
IV. Implant cost (applicable for patient admissions with surgery and surgical implant)

Results

Among the patient admissions analyzed (IDCP=2310; IDCT=3637), 4,163 [IDCP=1,667 (72.2%); IDCT=2,469 (68.6%)] underwent surgery during hospitalization. Of the patient admissions who received surgery, 680 received surgical implants [IDCP = 343 (14.8%); IDCT = 337 (9.3%)].

Several types of adjustments were made in our multivariate comparative analysis of the four types of cost outcomes (Outcomes I – IV). Firstly, all models for inpatient healthcare utilization cost were adjusted for age, gender, ethnicity, comorbidity burden, and surgical specialty (Model 1). Secondly, models were additionally adjusted for discharge location (Model 2). And thirdly, instead of discharge location, models were additionally adjusted for highest risk of dysglycaemia category attained during the inpatient stay [Model 3, only applicable for IDCP and IDCT (with risk-category)]. All modelling results comparing IDCP versus IDCT patient admissions are reported in Table 1. It can be seen that IDCP patient admissions have higher implant costs (except Model 3), with no differences between IDCP and IDCT for the other cost models considered. IDCP patient admissions had 24 – 26% higher implant cost (p-value: 0.012 – 0.015), compared to IDCT patient admissions.

Table 1. Modelling Results of Comparisons of Inpatient Healthcare Utilization Costs

Cost outcome	Model type	Sub-group	Treatment exp (b) (Ref = IDCT)	95% CI	p-value
I. Total gross costs	1	Without surgery	1.06	(0.97 – 1.15)	0.176
I. Total gross costs	2	Without surgery	1.07	(0.99 – 1.16)	0.077
I. Total gross costs	3	Without surgery (IDCT+S versus IDCP)	0.99	(0.84 – 1.18)	0.926
II. Non-surgery costs	1	With surgery	1.06	(0.98 – 1.14)	0.133
II. Non-surgery costs	2	With surgery	1.04	(0.97 – 1.12)	0.306
II. Non-surgery costs	3	Without surgery (IDCT+S versus IDCP)	0.91	(0.78 – 1.06)	0.223
III. Surgery costs	1	With surgery	1.05	(0.98 – 1.11)	0.150
III. Surgery costs	2	With surgery	1.04	(0.97 – 1.10)	0.263
III. Surgery costs	3	Without surgery (IDCT+S versus IDCP)	0.95	(0.81 – 1.11)	0.523
IV. Implant costs	1	Received implant	1.26	(1.05 – 1.52)	0.012
IV. Implant costs	2	Received implant	1.24	(1.04 – 1.48)	0.015
IV. Implant costs	3	Without surgery (IDCT+S versus IDCP)	1.47	(0.93 – 2.30)	0.096

N.B. IDCT+S: IDCT patient admissions with risk category.

Conclusions

There were no significant differences found for all inpatient healthcare utilization cost models considered comparing IDCP and IDCT patient admissions that were within the scope of the intervention. The IDCP model, using an IT-enabled system for screening and risk stratification, and the use of physician extenders through pharmacist-led management for inpatient DM care, shows non-inferiority of economic outcomes compared to a physician-only model.

COST-EFFECTIVENESS ANALYSIS OF DIRECT PCR SCREENING FOR CARBAPENEMASE-PRODUCING CARBAPENEM-RESISTANT ENTEROBACTERIACEAE

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HIGHLIGHTS

- **rPCR achieved the best effectiveness as it was associated with a reduction of 1403 positive cases, 44 infections and 5 deaths in one year compared with culture screening, at an extra cost of S$3.66 million per year.**
- **rPCR screening is cost-effective compared with no screening, with an ICER of S$88,406 /QALY gained.**

Introduction

Carbapenemase-producing carbapenem-resistant enterobacteriaceae (CP-CRE) are emergent antibiotic-resistant organisms resistant to all beta-lactam antibiotics. CRE-related infections have doubled mortality risk compared to similar infections with susceptible strains. Active surveillance, such as screening strategies, and use of additional precautions for cases have been found to be effective for reducing transmission.

This study was conducted in Tan Tock Seng Hospital with the following objectives: 1) to study the effectiveness of using rapid PCR (rPCR) screening for active surveillance to reduce in-hospital bacteria transmission and infection as compared with conventional culture screening; 2) to analyze the cost-effectiveness of screening admitted high risk patients for CRE using rPCR, compared with conventional culture screening and no screening.

Methods

This was a cost-effectiveness analysis using a Markov state transition model with a linked infectious disease transmission equation to model in-hospital bacteria transmission and patient disease status transition over the simulation period. There were six states included in the Markov model: no-risk, at-risk, colonized, infected, discharged and death. State transition probabilities were estimated from literature review if they were not available in local data. A cohort of simulated admitted patients were followed up from admission to death to evaluate their lifelong cost and effectiveness under three different surveillance strategies. The simulation period was divided into 2 phases. Phase 1 was from admission to discharge (either alive or death) with a daily modeling cycle. Phase 2 was a one-off modelling from discharge to death (lifelong). We measured outcomes of numbers of positive patients, colonized, infected and dead patients under three different screening scenarios.

The incremental cost-effectiveness ratio (ICER) was then calculated to evaluate the cost effectiveness of the three screening strategies. We also applied Monte Carlo micro-simulation for probabilistic sensitivity analysis (PSA) to address the uncertainty in parameter estimation and patient heterogeneity. Cost analysis was conducted from the payer's perspective, and costs were defined as the gross charge to patients/payers before subsidy, extracted from institutional financial data. Only direct medical cost was included in this analysis due to lack of data on indirect cost. Effectiveness was measured by quality-adjusted life years (QALYs), with estimates for each disease state derived from literature review.

Results

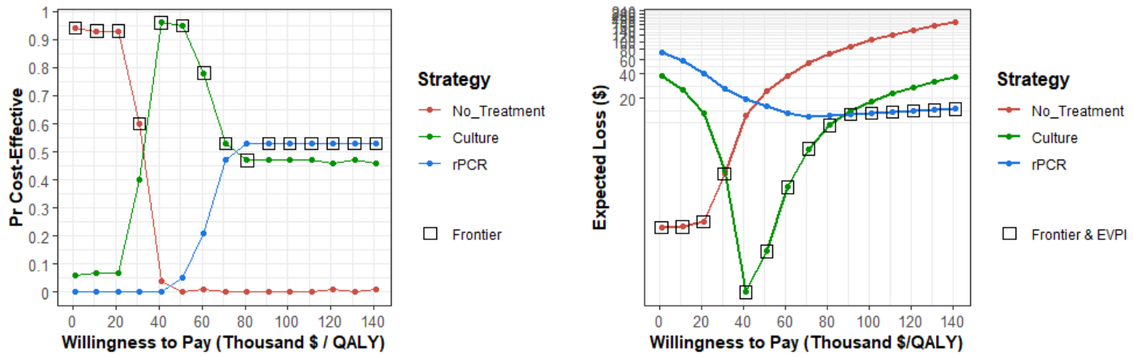
About 1,000,000 admitted patients were simulated in this study. Their lifelong costs and effectiveness were evaluated under the three screening scenarios and shown in Table 1. No screening incurred lowest cost and achieved lowest effectiveness. rPCR was the most costly screening strategy but it achieved highest effectiveness. The ICER of culture screening compared against no screening was S$31,183 per QALY gained, while the ICER of rPCR screening compared against culture screening is S$88,406 per QALY gained.

Table 1. Comparison of cost and effectiveness: rPCR vs. Culture vs. No screening

Approach	Cost per patient	QALYs per patient	Total positive	Total colonization	Total Infection	Total death	ICER (S$/ QALY)
No screening[1]	S$276.26K	7.7296	3947	0	246	2122	
Culture[1]	S$276.30K	7.7309	2631	629	119	2106	**31,184**
rPCR[1]	S$276.33K	7.7313	1228	835	75	2101	**88,406**
Difference in 1 year[1] rPCV-Culture	**↑ 3.66M (tot cost)**		**↓1403**	**↑206**	**↓44**	**↓5**	

The cost-effectiveness acceptable curve (CEAC) and expected loss (EL) curves were evaluated and plotted to help determine the best screening strategy at varying Willingness-To-Pay (WTP) amounts (Figure 1). rPCR screening appeared to be the most cost-effective screening strategy according to both CEAC and EL at a WTP threshold of S$90,000, which is the average Gross Domestic Product per capita in Singapore.

Figure 1. Best strategy for CRE screening by cost-effectiveness acceptable and expected loss curves



Conclusions

rPCR was associated with a reduction in 1403 positive cases, 44 infections and 5 deaths compared with conventional culture screening, at an extra cost of S$3.66 million per year. Screening admitted high risk patients using rPCR is likely to be a cost-effective surveillance strategy, compared with culture screening and no screening.

LIVING WITH FRAILTY

SUPPORTING FRAIL RESIDENTS TO MAINTAIN WELLBEING AND PREVENT CRISES

NHG RIVER OF LIFE

ACCOUNTABLE CARE

LIVING WELL

LIVING WITH ILLNESS

CRISIS & COMPLEX CARE

LIVING WITH FRAILTY

LEAVING WELL

ASSOCIATIONS OF SOCIAL ISOLATION, SOCIAL PARTICIPATION AND LONELINESS WITH FRAILTY IN OLDER ADULTS IN SINGAPORE: A PANEL DATA ANALYSIS

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

HIGHLIGHTS

- **Increase in social participation was longitudinally associated with lower levels of frailty.**
- **Feeling lonely was associated with higher levels of frailty, but social isolation was not associated with frailty.**
- **Gender did not show a moderating effect on the associations of social isolation, social participation and loneliness with levels of frailty among older adults.**

Introduction

There is a dearth of evidence on the longitudinal associations of social connectedness, such as social isolation, social participation and loneliness, with frailty. This study aimed to 1) examine the associations of social isolation, social participation, and loneliness with the level of frailty among community-dwelling older adults in Singapore using panel data, and 2) explore the moderating effect of gender on these associations.

Methods

The study included 606 participants aged 60 years and above from a longitudinal Population Health Index Survey conducted in Central region of Singapore. At each time point, the Clinical Frailty Scale (CFS) was used to determine the level of frailty (CFS1-7) of participants. Social isolation was assessed by the Family and Friends subscales of the 6-item Lubben Social Network Scale (LSNS-6). Social participation was measured using the social role domain of the Late-Life Function and Disability Instrument, and loneliness was assessed using the three-item UCLA Loneliness Scale, with scores below 6 indicating loneliness.

Three fixed-effects ordinal logistic regressions were conducted to examine the associations of social isolation scores, social participation scores and loneliness status with level of frailty (a seven-level ordered variable). Additional covariates adjusted for in each model are described in Table 1.

Table 1. Details of instruments utilized

Model	Adjustors
1	All time-invariant factors (i.e. gender, ethnicity, and highest education level).
2	All time-invariant factors+ time-varying demographic factors including age, marital status, employment status, living arrangement and self-reported money sufficiency for essential daily living.
3	All time-invariant factors+ time-varying demographic factors +lifestyle and health-related factors, including current smoking status, alcohol misuse, number of chronic conditions, number of long-term medications, current nutritional status, and functional independence.

To examine the moderating effect of gender on the associations, the interaction term between gender and each social connection indicator was added to Model 3. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported for each model.

Results

Of the 606 participants, their socio-demographic factors at baseline are as follows. 57.6% were females, 84.3% were Chinese and 52.0% had no formal education or primary school qualification only. The mean age of the participants was 70.9 years old; 58.6% were married, 46.0% were economically inactive, and 19.6% were living alone. 17.7% of participants were categorized as "isolated" based on the LSNS-6 Family subscale and 47.4% were categorized as "isolated" based on the LSNS-6 Friends subscale. There were 7.3% of participants categorized as "lonely".

The results of the three fixed-effects models are presented in Table 1. Increased frequency of social participation was consistently associated with lower levels of frailty, with OR of 0.95 remaining unchanged in Model 1 and Model 2, and increasing slightly to 0.96 in Model 3. Feeling lonely was consistently associated with higher levels of frailty (Model 1: OR=2.43, Model 2: OR=2.62, Model 3: OR=2.90; all $p<0.05$), and the association strengthened slightly after adjusting for time-varying socio-demographic and health-related factors. However, no significant association between the LSNS-6 subscale scores and level of frailty was observed in any model.

After adding interaction terms between gender and each social connection measure to Model 3, feeling lonely remained significantly associated with higher levels of frailty. However, the associations between social participation and level of frailty attenuated to be non-significant. None of the interaction terms showed any association with level of frailty.

Table 2. Associations of social isolation, social participation, and loneliness with level of frailty

	Model 1		Model 2		Model 3	
	OR (95%CI)	p-value	OR (95%CI)	p-value	OR (95%CI)	p-value
LSNS-6 Family	1.04 (0.97 - 1.11)	0.255	1.04 (0.97 - 1.11)	0.250	1.05 (0.97 - 1.14)	0.231
LSNS-6 Friends	0.99 (0.93 - 1.06)	0.848	1.00 (0.94 - 1.07)	0.991	0.99 (0.92 - 1.07)	0.782
Social participation	0.95 (0.93 - 0.98)	**<0.001**	0.95 (0.93 - 0.98)	**<0.001**	0.96 (0.93 - 0.99)	**0.019**
Lonely (Ref: Not lonely)	2.43 (1.17 - 5.04)	**0.017**	2.62 (1.24 - 5.52)	**0.011**	2.90 (1.44 - 5.84)	**0.003**

Number of observations: 782; number of individuals: 282. CI: confidence interval; LSNS:Lubben Social Network Scale; OR: odds ratio.

Conclusions

This study observed that social isolation and loneliness had differential longitudinal associations with the level of frailty among community-dwelling older adults, and suggested that loneliness and frailty should be measured and addressed concurrently among community-dwelling older adults.

EVALUATING QUALITY-OF-LIFE, LENGTH OF STAY AND COST-EFFECTIVENESS OF A FRONT-DOOR GERIATRICS PROGRAMME: AN EXPLORATORY PROOF-OF-CONCEPT STUDY

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HIGHLIGHTS

- **Front-door geriatrics has greater quality-of-life and length of stay benefits, and potential cost-effectiveness.**

Introduction

The Emergency Department Interventions for Frailty (EDIFY) programme can reduce hospital admissions among older adults. The programme's ability to benefit patient-reported outcome measures and resource utilisation are unknown. We aimed to examine EDIFY's ability in improving health-related quality-of-life (HRQOL) and length of stay (LOS), and evaluate EDIFY's cost-effectiveness.

Methods

A quasi-experiment was conducted at TTSH's ED. Patients, aged ≥85 years, pending acute admissions, suitable for discharge or transfer to low-acuity care were assigned to EDIFY or standard-care. HRQOL was measured using EQ-5D-5L over 6 months. We used a crosswalk methodology to compute Singapore-specific index scores from EQ-5D-5L responses and calculated Quality-Adjusted Life-Years (QALYs) gained. LOS and hospital bills in Singapore-dollars (SGD) before subsidy from ED attendances (including subsequent admissions, if applicable) were extracted from administrative databases. Seemingly Unrelated Regressions (SURs) modelled incremental costs and QALYs gained (cost: Generalised Linear Models – Gamma family, Log link; QALYs: simple linear regressions). The impact of EDIFY on LOS was investigated using Poisson models and additionally, Negative Binomial models to account for potential over-dispersion. We performed multiple imputation (MI) for missing data and estimated average programmatic EDIFY cost. Lastly, potential uncertainties were examined.

Results

Among 100 participants (EDIFY=43; standard-care=57), 61 (EDIFY=30; standard-care=31) provided complete data and data was found to be missing at random. Unadjusted results for QALYs gained are shown in Figure 1. For complete cases, QALYs gained were significantly higher at 3 months and overall for EDIFY (3-month coefficient=0.032, p=0.004; overall coefficient=0.096, p=0.002), whilst treatment costs were similar between-groups (Table 1). For MI, we observed only overall QALYs gained for EDIFY (coefficient=0.102, p=0.001) (Table 1). EDIFY reduced LOS by 17% (Incident risk ratio=0.83, p=0.015). Mean bills were: EDIFY= SGD$4562.7; standard-care = SGD$5530.9 (Figure 1). EDIFY's average cost approximated SGD$469.30. This cost was not chargeable in an ED attendance and not accounted for in the treatment cost for EDIFY patients, as EDIFY in ED was not considered standard-care. In a deterministic sensitivity analysis, EDIFY's cost-threshold was SGD$2,500 before EDIFY-intervention patients incurred higher treatment costs (coefficient=1.30, p=0.053), exceeding the estimated EDIFY programmatic cost of $469.30 by 5.3 times. Main conclusions were consistent in other uncertainty scenarios.

Conclusions

This exploratory proof-of-concept study showed that EDIFY has greater QALY and LOS benefits, and equivalent costs as current standard-care, leading to potential cost-effectiveness. Early geriatric specialist interventions at the front-door of acute hospitals via EDIFY has now been established as standard-care for older persons attending the ED at TTSH.

Figure 1. Unadjusted results (means, standard deviations) of QALYs (A and B), hospital bills (C) and LOS (D), by intervention groups (and EDIFY disposition sub-groups)

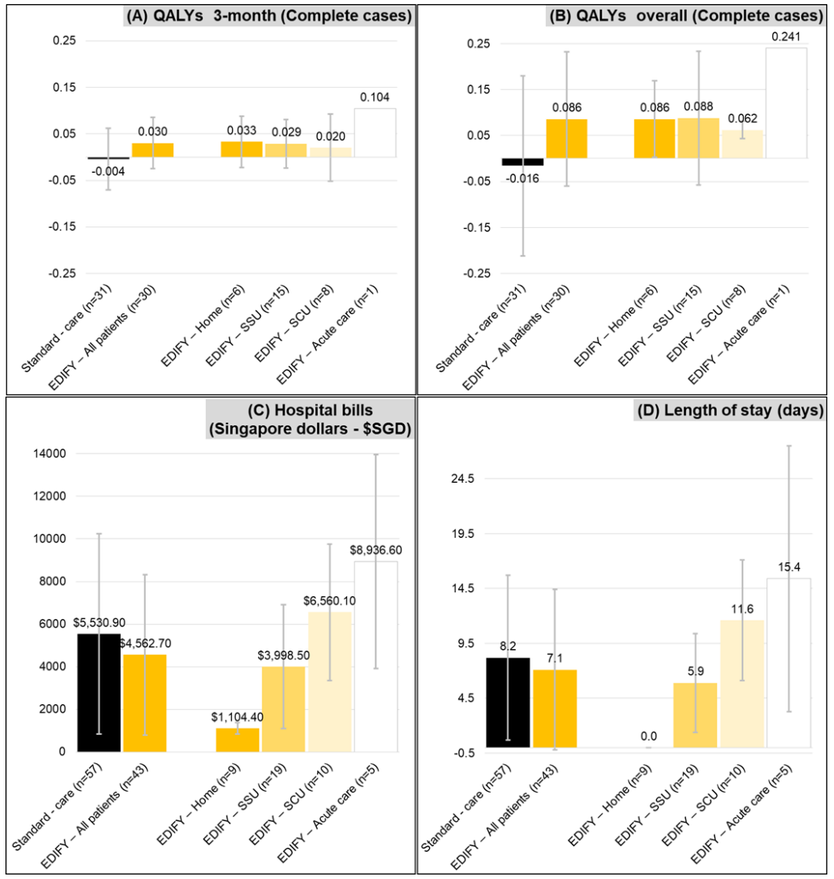

Table 1. Cost-effectiveness results from complete case and imputed data

Modelled outcomes	Analysis type	Intervention coefficients (95%CI)	p-value
QALYs 3-month	Complete case †	0.032 (0.010, 0.054)	0.004*
	Imputed data ‡	0.014 (-0.005, 0.033)	0.154
QALYs overall	Complete case †	0.096 (0.035, 0.157)	0.002*
	Imputed data ‡	0.102 (0.041, 0.162)	0.001*
Treatment cost (Hospital bills)	Complete case †	-0.079 (-0.433, 0.277)	0.665
	Imputed data ‡	-0.192 (-0.522, 0.137)	0.252

** p-value<0.05. † SUR using suest command; and ‡ SUR using mysuest command on Stata V16.0.*

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INTEGRATED MANAGEMENT AND PALLIATIVE CARE FOR TERMINALLY-ILL NON-CANCER PATIENTS (IMPACT) PART 1: AN INTERIM ANALYSIS OF HOME DEATH AND HEALTHCARE UTILISATION OUTCOMES

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HIGHLIGHTS

- **A dedicated palliative homecare programme for end-stage organ failure can potentially improve rates of home deaths, and reduce healthcare utilisation and costs.**

Introduction

Programme IMPACT (PI) aims to improve the quality of life of terminally-ill non-cancer patients, reduce unnecessary admissions to acute hospital, and enhance capabilities of community health partners to provide home palliative care services for non-complex patients. This study aimed to compare home death and acute healthcare utilisation outcomes among a cohort of deceased end-stage organ failure (ESOF) patients with and without the support of a palliative homecare programme.

Methods

A retrospective cohort study was performed. To assemble a control group, deaths recorded in Singapore's national death registry from 2016 to 2017 were first screened. Decedents of this period did not have access to a palliative homecare programme for ESOF because this timeframe preceded PI. The following inclusion criteria was then used to identify potential control patients: i. Central region of Singapore address; ii. ≥2 hospital admissions in the last year of life, with ≥1 at TTSH; and iii. A principal, final or secondary ESOF diagnosis in an admission in their final year of life. Enrolled PI patients who passed away from the last quarter of 2017 to 2019 were included as intervention patients. Any decedent who utilised day or inpatient hospice, or home palliative care during the last year of life, or who had cancer as a cause of death or co-morbidity were excluded from the study. Additionally, control patients crossed over to the intervention arm were assigned as intervention patients.

Place of death, cumulative hospitalisations, length of stay (LOS), emergency department (ED) and specialist outpatient clinic (SOC) visits during the last 6-, 3-, and 1-month of life, were extracted and compared between groups. Comparative modeling analysis was focused on patients with deaths recorded as primarily caused by chronic heart failure, chronic obstructive pulmonary disease, or end-stage renal failure. Logistic regression was used to model the probability of home deaths. Cumulative healthcare utilisation at each of the various settings were examined using zero-inflated Poisson regression models. Cumulative costs of healthcare utilisation were considered using Generalised Linear Models (Gamma family, Log link). p-values<0.05 were deemed significant and all statistical analyses were performed using Stata V.14.2 (Stata Corp, College Station, Texas, USA).

Results

60 PI and 109 control decedent patients were analysed. PI patients were enrolled on average for 93.7 days (SD=109.1) before their demise. Information on their place of death can be found in Table 1. Most PI patients passed away at their own residence (71.7%). Majority of controls died in a government hospital (78.9%). PI patients were 10 times more likely to pass away at their own home (OR=10.07; 95%CI 4.21-24.10).

In the comparative healthcare utilisation analysis (Table 2), PI patients were more likely to have fewer hospitalisations at the 6-month time-point (incidence rate ratio [IRR]=0.648). LOS for PI patients was lower across all time-points examined (IRRs: 6-month=0.697, 3-month=0.736, 1-month=0.839), compared to control patients. PI patients had fewer ED visits at 6- and 3-month time-points (6-month IRR=0.507, 3-month IRR=0.577) and fewer SOC visits at the 6-month time-point (IRR=0.795). There were no between-group differences in hospitalisations at 3- and 1-month time-points, ED visits at 1-month time-point and SOC visits at 3- and 1-month time-points. PI patients were more likely to incur lower hospitalisation costs across all time-points [Exp (b): 6-month=0.527, 3-month=0.515, 1-month=0.450], compared to ESOF controls.

Conclusions

In this interim analysis, it would appear that Programme IMPACT, a dedicated palliative homecare programme for ESOF patients, may improve rates of home deaths and reduce healthcare utilisation and costs. Another round of analysis will be performed for the final evaluation using contemporaneous controls for better between-group comparability and to ensure reproducibility of results.

Table 1. Places of death of end-stage organ failure patients examined

Places of death	Intervention n=60	Controls n=109
	n (%)	
Government Hospital	16 (26.7%)	86 (78.9%)
Residence	**43 (71.7%)**	**15 (13.8%)**
Private Hospital	1 (1.7%)	6 (5.5%)
Other locations	0 (0.0%)	0 (0.0%)
Public & Charitable Institution	0 (0.0%)	2 (13.8%)

Table 2. Modelling results of comparisons between Programme IMPACT and control patients

Outcome*	Intervention (n=60) versus controls (n=109)		
	IRR	95% CI	p-value
Hospitalisation			
6-month	0.648	(0.507 – 0.827)	<0.001*
3-month	0.791	(0.585 – 1.070)	0.128
1-month	0.991	(0.625 – 1.571)	0.968
Length of stay			
6-month	0.697	(0.649 – 0.748)	<0.001*
3-month	0.736	(0.673 – 0.805)	<0.001*
1-month	0.839	(0.710 – 0.991)	0.039*
Emergency Department visits			
6-month	0.507	(0.390 – 0.660)	<0.001*
3-month	0.577	(0.411 – 0.809)	0.001*
1-month	0.933	(0.543 – 1.603)	0.803
Specialist Outpatient Clinic visits			
6-month	0.795	(0.634 – 0.997)	0.047*
3-month	1.022	(0.715 – 1.461)	0.904
1-month	0.941	(0.445 – 1.989)	0.873
Hospitalisation costs	**MR**	**95% CI**	**p-value**
6-month	0.527	(0.380 – 0.732)	<0.001*
3-month	0.515	(0.341 – 0.777)	0.002*
1-month	0.450	(0.252 – 0.805)	0.007*

*CI: confidence interval; IRR: incidence rate ratio; MR: mean ratio; * Adjusted for organ failure type, gender, death age, race, home type.*

INTEGRATED MANAGEMENT AND PALLIATIVE CARE FOR TERMINALLY-ILL NON-CANCER PATIENTS (IMPACT) PART 2: AN INTERIM ANALYSIS OF PATIENTS' END-OF-LIFE PREFERENCES AND UNNECESSARY HEALTHCARE UTILISATION

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HIGHLIGHTS

- **Among 209 patients studied who died, 92.8% had a formal or informal advance care plan done.**
- **70.8% of patients died at home and up to 91.4% of patients had their end-of-life care preferences honoured.**

Introduction

Programme IMPACT (PI) aims to improve the quality of life of terminally-ill non-cancer patients, reduce unnecessary admissions to acute hospitals, and enhance capabilities of community health partners to provide home palliative care services for non-complex patients. PI was piloted at Tan Tock Seng Hospital (TTSH). Patients who had a non-cancer diagnosis, 6 to 12 months' prognosis, preferred palliation and home-death as care goals and resided within Central Health's catchment area were eligible. In this study arm, we preliminarily evaluated the effectiveness of Program IMPACT in (1) honouring patients' preferences and (2) reducing unnecessary healthcare utilisation.

Methods

A single-arm prospective pre-post study design was employed. End-stage organ failure patients who were enrolled into PI between 2nd October 2017 and 19th June 2020 were included in this preliminary analysis. As part of advance care planning (ACP), the Preferred Place of Care discussion was used to elicit patients' end-of-life (EoL) care preferences. Concordance between patients' preferences and actualised care outcomes were analysed for patients who passed on during the study period. As part of care coordination provided by PI, where possible, scheduled specialist outpatient clinic (SOC) appointments were cancelled upon enrolment as these services would be provided during home care visits. To assess for reduction in healthcare utilisation, we compared the number of SOC appointments at point of inpatient discharge and point of enrolment into PI.

Results

A total of 419 patients were eligible for PI. Only 320 patients consented to enrolment and were included in the analysis. Of the 99 patients not enrolled, 50% rejected the programme citing reasons due to cost or patient/family members not being ready for this programme. Table 1 describes the profile of patients included. 64% of patients were diagnosed with end-stage renal and heart failure. Nearly 70% were referred from in patient care. The mean duration spent in the programme was about 11.0 months (SD: 12.2 months) and mean time to death was about 7.6 months (SD: 9.0 months). Among the 209 patients who died, 70.8% died at home and 92.8% had an official or informal ACP done. There was up to 91.4% concordance between patient preferences and actualised outcomes (Table 2). There were 477 scheduled SOC appointments from 186 patients prior to enrolment, and this was reduced by 25.7% by the point of enrolment into PI.

Conclusions

In this preliminary analysis, most patients had their EoL care preferences honoured and unnecessary healthcare utilisation was reduced. The final evaluation will provide a complete picture on the effectiveness of PI in these aspects.

Table 1. Profile of Program IMPACT patients

Characteristics		n=320	%
End Stage Disease	Renal	135	42.2
	Heart	70	21.9
	Respiratory – COPD	49	15.3
	Respiratory – non-COPD	32	10.0
	Frail EoL	32	10.0
	Unknown	2	0.6
Referral source	TTSH Inpatient	222	69.4
	TTSH Outpatient	74	23.1
	Community/Community hospital	16	5.0
	Others	8	2.5
Discharged from Programme IMPACT		**268**	**83.8**
Reasons for discharge	Death	209	209
	Admit to hospice/nursing home	20	20
	Withdrawn from service	14	14
	Admit to community support/home palliative care programme	6	6
	Patient stabilised or seeking for active treatment	19	19
Length of stay (Months)	Mean (SD)	11.0	12.2
Time to death (Months)	Mean (SD)	7.6	9.0

COPD: chronic obstructive pulmonary disease; EoL: end-of-life; SD: standard deviation; TTSH: Tan Tock Seng Hospital

Table 2. Concordance between preferences and actual outcomes

Factors assessed for concordance		n=209	%
Place of death	Home	148	70.8
	Acute hospital	59	28.2
	Hospice/Community hospital	2	1.0
CPR concordance	Yes	188	90.0
	No	7	3.3
	Data missing*	14	6.7
Medical intervention concordance	Yes	191	91.4
	No^	2	1.0
	Data missing*	16	7.6
Place of death concordance	Yes	172	82.3
	No#	21	10.0
	Data missing*	16	7.7

*CPR: cardiopulmonary resuscitation; EoL: end-of-life; *Data for these patients was not extracted at the time of analysis and will be included in final analysis;^Reasons: family decision (n=2); administered by paramedics (n=4); sent to another hospital and staff was unaware of EoL preferences (n=1); #Reasons: died enroute to hospital (n=1); died in healthcare institution (n=15); unknown at time of analysis (n=5)*

A COMPARISON OF ONE-YEAR SURVIVORS AND DECEDENTS OF ADVANCED DEMENTIA IN AN ACUTE HOSPITAL

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HIGHLIGHTS

- **Survivors and decedents of advanced dementia at one-year after diagnosis differ in demographics, health status, functional ability, cognition and mental health and healthcare utilization.**
- **The differentiating characteristics will inform the development of a prognostic model to predict mortality in these patients at one-year.**

Introduction

Timely referral to palliative care for patients with dementia is challenging, given the complex nature of the disease. We aimed to identify patient characteristics that would differentiate survivors and decedents of advanced dementia (AD) at one-year after diagnosis, to facilitate development of a prognostic model.

Methods

Patients who were admitted to Tan Tock Seng Hospital between July 2016 and October 2017 and diagnosed with either dementia, delirium, pneumonia or were on enteral tube feeding were identified from administrative databases. Subsequently, those with characteristics consistent with Functional Assessment Staging Tool (FAST) stage 7, Mini Mental State Examination score ≤ 10, or a clinical diagnosis of AD in their medical notes were classified to have AD. Baseline characteristics at the time of AD classification were compared between survivors and decedents across five themes, namely, demographics, health status, functional ability, cognition and mental health, and health system factors. [1]Comparisons were made using t-tests and Chi-square tests for continuous and categorical data, respectively.

Results

Of 1,077 patients, 318 patients died (29.5%) within one-year of AD diagnosis. 996 patients (92.5%) were of FAST stage 7C. Alzheimer's disease constituted the largest subtype (31%), followed by vascular (25%) and mixed dementia (23%). These subtype proportions were similar between decedents and survivors. However, survivors and decedents generally differed across other baseline characteristics (Table 1). Decedents were older, and more likely to have poorer health status and lower functional ability, or experience delirium or neuropsychiatric symptoms. Decedents on average also incurred more visits in the inpatient, ED and day surgery settings compared to survivors.

Conclusions

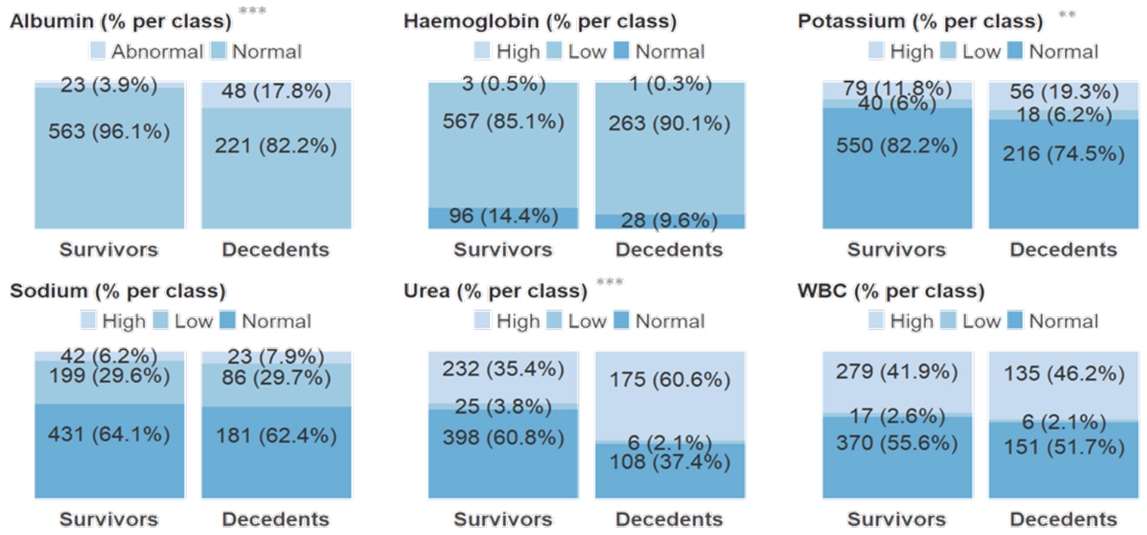
We identified characteristics differentiating survivors and decedents of AD, which will be highlighted as candidate predictors to predict mortality at one-year in a future prognostic model.

Table 1. Key findings by themes adapted from Kaur et al[1]

Themes	In comparison to survivors, decedents:
Individual factors • Demographic and social interactions	were older (mean=87.4 years vs 83.9 years***) were more likely to: • be male (40.3% vs 33.9%*) • have a caregiver (95.6% vs 90.6%**)
Health status • Measurements and conditions reflective of underlying health status	had higher Charlson comorbidity scores (9.0 vs 8.0***) were more likely to: • have pneumonia (38.1% vs 16.9%), pressure ulcers (18.8% vs 4.3%) and dysphagia (64.2% vs 42.2%) • exhibit abnormal values for albumin, potassium and urea (Figure 1)
Functional ability • Ability to perform activities of daily living	were more dependent in activities of daily living (2.9 vs 1.6***) were more likely to be bedbound (53.1% vs 29.1%***)
Cognitive and mental health • Mental conditions and/or neuropsychiatric symptoms	were more likely to experience delirium (35.5% vs 24.8%***) were as likely to experience neuropsychiatric symptoms (53.8% vs 48.2%)
Health system factors • Utilization of healthcare resources	were more likely to be referred to community services (26.4% vs 17.8%***) incurred more visits in the inpatient, ED and day surgery settings within the year prior • inpatient: mean (SD): 2.4 (1.9) vs 2 (1.5); • ED: 2.6 (2.0) vs 2.2 (1.7); • day surgery: 1.9 (2.0) vs 1.2 (0.5)

ED: Emergency department; SD: standard deviation

Figure 1. Selected biomarkers



****:p<0.001; **:p<0.01; *: p<0.05*

References

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PROGNOSTICATION IN ADVANCED DEMENTIA PATIENTS PRESENTING AT AN ACUTE HOSPITAL

Palvinder Kaur, Palvannan R.K., Sheryl Ng Hui Xian, Jermain Chu[1], Low Zhi Jun[1], Assoc Prof Ding Yew Yoong[2], Dr Tan Woan Shin, Adj Assoc Prof Allyn Hum[3]

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HIGHLIGHTS

- **This is the 1st known model to prognosticate advanced dementia patients in the acute care setting.**
- **Our model has improved predictive performance of one-year survival compared to other published models.**

Introduction

Challenges in prognosticating patients diagnosed with advanced dementia (AD) hinders timely referrals to palliative care. We aimed to develop and validate a prediction model to predict one-year mortality among patients receiving care in an acute care hospital who were diagnosed with AD.

Methods

This is a retrospective cohort study design using administrative and clinical data from Tan Tock Seng Hospital. Participants were diagnosed with AD at inpatient or outpatient settings between 2008 and 2017. Prognostic variables were identified based on a scoping review[1] conducted by the study team. The primary outcome was all-cause mortality within one-year of AD diagnosis. Models were built using logistic regression. Model variables were selected using forward selection, retaining those that were statistically significant ($p<0.05$) and based on clinical inputs. Missing data was imputed using predictive mean matching and 50 datasets were generated. Coefficients and model performance measures were pooled using Rubin's Rules. Using bootstrap validation, optimism-adjusted measures were computed. The final model was selected based on discriminative value (Area under the receiver operating curve; AUROC), sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV).

Results

Of 1077 patients, 318 (29.5%) patients died within one-year of AD diagnosis. The final model included age, gender, infections, comorbidity burden, function and mobility, and biochemicals as predictors of mortality (Figure 1). Optimism-adjusted AUROC was 0.763. Sensitivity, specificity, PPV and NPV were generated for three thresholds (Table 1) and their corresponding confusion matrix is illustrated in Figure 2A-C. Using a threshold of 0.7, only 63 patients would be referred to palliative care. 77.8% of these patients would have died within one-year (true positive) and 22.2% would survive beyond this period (false positive). Of the 1014 patients who were not referred, 73.6% would have survived (true negative) and 26.5% would have died in the following one-year (false negative). If a broader threshold of 0.3 was used, more patients would be referred to palliative care (n=404). One in two patients referred to palliative care would die in the next one year (true positive). Of the 673 patients who were not referred, 16.8% would have died within one year (false negative).

Conclusions

This is the first model in the literature that examined prognostication among AD patients presenting at an acute hospital, attaining acceptable accuracy. The current model has improved predictive accuracy in one-year survival compared to other published models based on retrospective cohorts[2,3]. Together with physicians and resource availability, we need to further deliberate on the optimal threshold (ratio of false positive and false negative) that can be operationalized in the clinical setting. In Singapore, where dementia caregiving occurs primarily at home, early identification can support proactive planning and the initiation of palliative care for AD patients at high-risk of one-year mortality.

Figure 1. Predictors of mortality in AD patients

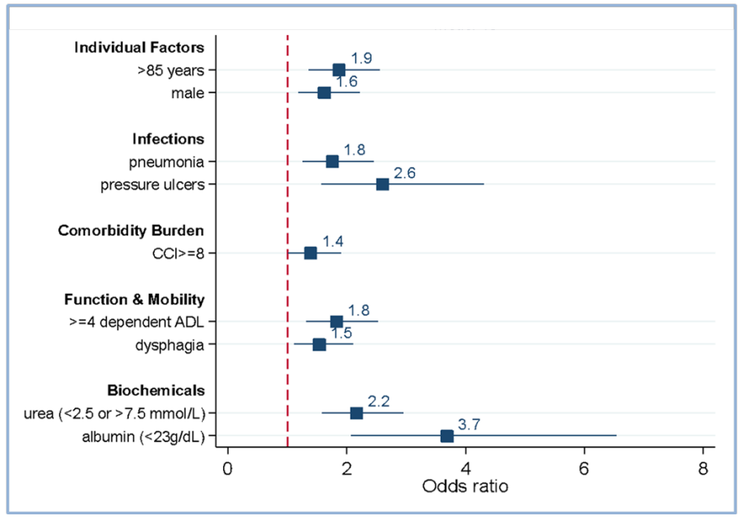

Table 1. Model performance based on different thresholds*

Threshold	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
0.7	15.4	98.1	77.8	73.5
0.5	36.8	92.6	67.6	77.8
0.3	64.5	73.8	50.7	83.2

**Estimates were pooled from 50 imputed datasets.*

Figure 2A-C: Confusion matrix for thresholds 0.7, 0.5 and 0.3^

2A

0.7	Died+	Died-	Total
Model +	49	14	63
Model -	269	745	1014
Total	318	759	1077

2B

0.5	Died+	Died-	Total
Model +	117	56	173
Model -	201	703	904
Total	318	759	1077

2C

0.3	Died+	Died-	Total
Model +	205	199	404
Model -	113	560	673
Total	318	759	1077

^Estimates were pooled from 1 imputed dataset.

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PROGNOSTIC FACTORS OF PATIENTS WITH END-STAGE LUNG DISEASE: A SCOPING REVIEW

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HIGHLIGHTS

- **Of the 55 studies identified, most were conducted on patients with interstitial lung disease, with only two other studies on bronchiectasis.**
- **Pulmonary function and disease, as well as comorbidity, were thecategories of prognostic factors most commonly modelled, while older age, lower forced vital capacity and lower carbon monoxide diffusing capacity were the most investigated factors.**

Introduction

The progression of chronic lung disease to end-stage lung disease (ESLD) is characterized by a gradual decline over many years, interspersed with recurrent episodes of exacerbations and recovery, and eventual death. While there is no standardization of the conditions under the umbrella term of ESLD, conditions mentioned across multiple studies include chronic obstructive pulmonary disorder (COPD), interstitial lung disease (ILD), pulmonary hypertension (PH) and bronchiectasis. Heterogeneity in symptoms and disease staging in ESLD renders accurate prognostication challenging, which in turns inhibits timely referral to palliative care. To develop a prognostic model for ESLD patients, the identification and definition of the likely prognostic factors applicable across all included conditions would be the starting point. As multiple reviews on prognostic factors and models for COPD patients have already been established, a targeted approach towards understanding the factors for the other ESLD conditions would be an invaluable addition to prognostic literature. Hence, we conducted a scoping review to identify non-COPD and non-malignant lung conditions that would be classified as ESLD, and subsequently summarized the prognostic factors associated with these conditions.

Methods

We conducted a scoping review following frameworks by Arksey and O'Malley and Riley et al[1,2]. We searched MEDLINE, Embase, PubMed, CINAHL, Cochrane Library and Web of Science for studies published between 2000 and 2020 that described ESLD populations with an all-cause mortality risk period of up to 3 years. These included populations with ILD, connective tissue disease-associated ILD (CTD-ILD), PH associated with chronic lung disease and bronchiectasis. Only primary studies which reported associations adjusted through multivariable analysis were included. We summarized characteristics of the included studies and provided an overview of the categories of prognostic factors documented in literature. Additionally, to provide an overview of the quality of evidence synthesized, an appraisal of these studies was conducted using the Quality In Prognosis Studies (QUIPS) tool[3]. The QUIPS tool assessed the risk of bias of a study across six domains: Study Participation, Study Attrition, Prognostic Factor Measurement, Outcome Measurement, Study Confounding, and Statistical Analysis and Reporting.

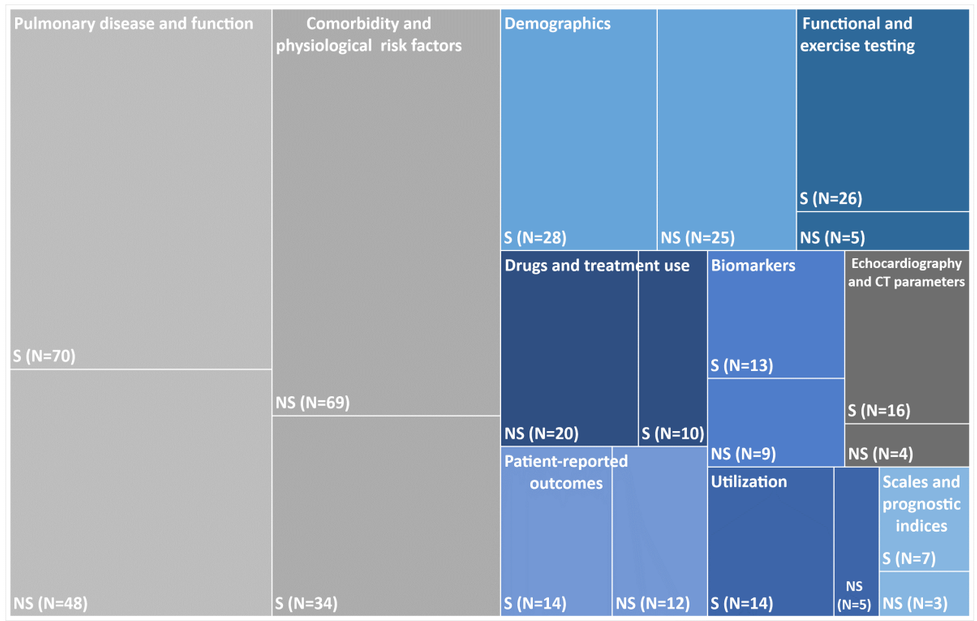
Results

A total of 126 models across 55 studies assessed prognostic factors associated with mortality. Of the 55 studies reviewed, 53 (96%) were based on ILD or CTD-ILD populations and 2 were on bronchiectasis populations. Half of the studies looked at mortality risk periods up to 1 year. Pulmonary function and disease, as well as comorbidity, were the categories of factors most commonly modelled, with the associations between mortality and pulmonary function being statistically significant more often than that of comorbidity (Figure 1). Comparing the number of models in which each individual prognostic factor appeared in, older age, lower forced vital capacity (FVC) and lower carbon monoxide diffusing capacity (DLCO) were most investigated. These factors were also frequently associated with increased mortality risk in more than 60% of the models they appeared in. Using the QUIPS tool, 51 studies (93%) were deemed to be at a low-to-moderate risk of bias. Of these, only 5 studies (9%) exhibited a low risk of bias across all domains, and 32 studies (58%) were deemed to be at moderate or high risk in the domain of Statistical Analysis and Reporting.

Conclusions

The review provides a thorough map of prognostic factors in ESLD, and would prioritize the inclusion of age, FVC and DLCO in a model to predict short-term mortality in ESLD patients. Future prognostic studies on ESLD should aim to report their results in accordance with reporting guidelines to facilitate easier quality appraisal of their conduct and statistical methods used.

Figure 1. Distribution of models included by prognostic factor domain



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2. Hum A, **George PP**, Tay RY, Wu HY, Ali NB, Leong I, Chin JJ, Lee A, Tan L, Koh M. Prognostication in Home-Dwelling Patients with Advanced Dementia: The Palliative Support DEMentia Model (PalS-DEM). J Am Med Dir Assoc. 2021 Feb;22(2):312-319.e3.

3. **Ge L, Yap CW, Kaur P, Ong R, Heng BH.** Psychometric evaluation of the 8-item Altarum Consumer Engagement (ACE) Measure™ in community-dwelling adults in Singapore. BMC Health Serv Res 2021 Dec 16; 21, 1347 (2021).

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6. **Meng F**, Jonklaas J, Leow MK. Interconversion of Plasma Free Thyroxine Values from Assay Platforms with Different Reference Intervals Using Linear Transformation Methods. Biology (Basel). 2021 Jan 11;10(1):45.

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11. **Tan AL, Tan WS.** Potentially avoidable readmissions: Understanding drivers and technology-enabled solutions. Ann Acad Med Singap. 2021 Oct; 50(10)739–741.

12. **Tan AL, Ng SHX, Pereira MJ.** Singapore's COVID-19 "circuit breaker" interventions: A description of individual-level adoptions of precautionary behaviours. Ann Acad Med Singap. 2021 Aug;50(8):613-618.

13. Lall P, Dutta O, **Tan WS**, Patinadan PV, Kang NQY, Low CK, Car J, Ho AHY. "I decide myself"- A qualitative exploration of end of life decision making processes of patients and caregivers through Advance Care Planning. PLoS One. 2021 Jun 18;16(6):e0252598.

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GRANTS & TRAINING AWARDS

GERI COVID-19 GRANT CALL — $99,800

Bridging distances in times of Covid-19: Does communication technology acceptance and use combat loss of Socio-emotional well-being in older adults?

Serene Nai (PI)
Tan Woan Shin (Co-I/Mentor)
William Tov (SMU)

MOE TIER 1 — $97,000

Understanding and Strengthening University Students' Psycho-Socio-Emotional Wellness and Preparedness for COVID-19 and Future Pandemics: A Cross-Sectional Mixed-Methods Study.

Andy Ho (PI)
Tan Woan Shin (Co-I)
Ram Bajpai (Co-I)

NMRC HSRG — $496,910

Improvement of screening and identifying vulnerable and frail patients in a tertiary cancer centre. Optimising care and improving quality of life through early detection

Melissa Ooi (PI)
Tan Woan Shin (Collab)

GERI INTRAMURAL PROJECT FUNDING — $149,851

Help Optimise and Mobilise Elders (H.O.M.E)

Dr Tan Mei Ying Melanie (PI)
Dr Lau Lay Khoon (Site-PI)
Dr Lydia Au (Co-I)
Dr Lim Seok Mei (Co-I)
Dr Tou Nien Xiang (Co-I)
Dr Michelle Jessica Pereira (Co-I)
A/Prof Ding Yew Yoong (Co-I)
Collaborators: Dr Dina Ee; Mr Russell Yoong Kuok Leong; Ms Amanda Lim; Ms Jane Ho; Ms Audrey Chia; Mr Lai Weng Kin; Ms Cheng Jing Wen; Ms Serene Tay; Ms Marian Lee

MOH TRADITIONAL CHINESE MEDICINE RESEARCH GRANT — $265,980

Heat and Acupuncture Randomised Controlled Trial to Manage Osteoarthritis of the Knee (HarmoKNEE): An Effectiveness-Implementation Hybrid Study

Dr Bryan Tan (PI)
Dr Tan Tong Leng (Site PI)
Dr Su-Yin Yang (Co-I)
Dr Michelle Jessica Pereira (Co-I)
Dr Kong Keng He (Co-I)
Ms Chua Yu Chun (Co-I)
Ms Tan Siang Ing (Co-I)
Mr Yan Yew Wai (Co-I)

CONFERENCE PRESENTATIONS & AWARDS

SINGAPORE HEALTH & BIOMEDICAL CONGRESS 2021 — OCT 2021

Singapore Young Investigator Award - Gold (Health Services Research) Oral

Prognostication in Advanced Dementia Patients Presenting at an Acute Hospital

Palvinder Kaur, Palvannan R.K., Sheryl Ng Hui Xian, Tan Woan Shin, Ding Yew Yoong, Allyn Hum

Presenter - Palvinder Kaur

Singapore Young Investigator Award - Bronze (Health Services Research) Oral

Cost-effectiveness of EDIFY: Emergency Department Interventions for Frailty

Michelle Jessica Pereira, Edward Chong, Joseph Antonio D Molina, Sheryl Ng Hui Xian, Eileen Fabia Goh, Zhu Birong, Mark Chan, and Lim Wee Shiong

Presenter - Dr Michelle Jessica Pereira

Singapore Young Investigator Award - Merit (Health Services Research) Oral

Examining health resilience of community-dwelling individuals: A preliminary qualitative analysis

Yip Wan Fen, Ge Lixia, Chieh Pann Pei, Eric Chua Siang Seng, Ringo Ho Moon-Ho, Evon Chua Yiwen, Tham Sinma, Ian Leong Yi Onn, Andy Ho Hau Yan, Tan Woan Shin

Presenter - Dr Yip Wan Fen

Singapore Young Investigator Award - Merit (Health Services Research) Oral

Social isolation and loneliness are associated with frailty in older adults: Findings from a longitudinal study

Ge Lixia, Yap Chun Wei, Heng Bee Hoon

Presenter - Ge Lixia

15TH SINGAPORE PUBLIC HEALTH & OCCUPATIONAL MEDICINE CONFERENCE — NOV 2021

Merit Oral

Using qualitative methods to explore multiple perspectives on individual resilience in health among community-dwelling adults in Singapore

Tan Woan Shin, Ge LIxia, Yip Wan Fen, Chieh Pann Peu, Eric Chua, Rongo Ho Moon-Ho, Evon Chua Yiwen, Tham Sinma, Ian Leong Yi Oon, Andy Ho Hau Yan, Heng Bee Hoon

Presenter - Dr Tan Woan Shin

Merit Oral

Social isolation and loneliness are associated with frailty in older adults: Findings from a longitudinal study

Ge Lixia, Yap Chun Wei, Heng Bee Hoon

Presenter - Ge Lixia

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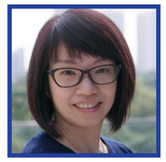

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