


Using Cost-Effectiveness Analysis in Mixed Methods Research: An Evaluation of an Integrated Care Program for Frequently Hospitalized Older Adults in Singapore

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Abstract

Traditional evaluation techniques are often not suitable for studying health interventions operating in real-world settings, particularly when interventions operate through complex causal pathways. We describe a mixed methods design for evaluating an integrated home care and social support service targeting mature and older adults (55+ years) in Singapore. Here, nurses and community health workers visit patients' homes to address health and social needs while facilitating linkages to community-based services and providing caregiver support. Our mixed methods evaluation plan is composed of three components: quantitative comparison of hospital-based service utilization, cost-effectiveness analysis, and qualitative investigation into the experiences of patients, caregivers, and individuals who declined services. This article contributes a description of how cost-effectiveness analysis adds value when incorporated into mixed methods studies.

Keywords

evaluation, integrated care, older adults, cost-effectiveness analysis, Singapore

Introduction

Although randomized controlled trials are the gold standard in clinical research, randomization is often not appropriate when evaluating complex community-based interventions, and innovative

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evaluation designs are in high demand (Victora, Habicht, & Bryce, 2004). Traditional evaluation techniques typically focus on identifying what happened in response to an intervention while leaving behind questions of why such a change came about or if the amount of money needed to create the change is a worthwhile investment compared with alternative approaches.

In this case example, we describe an applied mixed methods protocol used to evaluate an integrated home care program, Aging-In-Place (AIP), directed at mitigating unplanned hospital admissions for mature and older adults (55 years and older) in Singapore. We outline a multi-component evaluation that addresses gaps common in previous evaluations of integrated care programs. The first component employs a difference-in-differences design, a quasi-experimental technique that uses longitudinal data to compare an intervention group with a similar control group over the same time period (Dimick & Ryan, 2014). Here, we compared hospital-based service utilization patterns for participants in the intervention group with service utilization patterns for a control group of older adults. For the second component, we conducted a cost-effectiveness analysis (CEA) to determine the incremental cost associated with any improvements in health status that were experienced by the program participants (Stufflebeam & Shinkfield, 2007). The third component considers qualitative data collected from patients, their caregivers, and individuals who were offered a place in the program but declined services. This qualitative component allowed for patients' and caregivers' firsthand experiences to be integrated with the quantitative data from the two other evaluation streams in order to identify the mechanisms behind any observed quantitative changes. Data from individuals who declined the AIP services also provided information into why some patients decided not to participate in the program, which will ultimately help managers identify potential methods for increasing service uptake among patients who encounter barriers when attempting to access home-based care.

The goal of this article is twofold. First, we aim to introduce the application of CEA to mixed methods researchers who may not have previously considered including CEA techniques within their studies. CEA is a staple tool for health economists (Weinstein & Stason, 1977), yet it has only recently been applied in concert with other evaluation techniques (i.e., impact and process). Incorporating CEA into a mixed methods evaluation enables researchers to also comment on the financial trade-offs associated with the program outcomes (Tan-Torres Edejer et al., 2003). For example, Littlewood and Ashton (2012) incorporated CEA into their evaluation comparing self-managed physiotherapy for shoulder surgery with clinical-based care. In addition to quantitatively assessing the effectiveness of the alternative form of therapy and qualitatively exploring patients' experiences, the CEA enabled the research team to determine the monetary cost associated with patients' changes in health status (i.e., pain, function, quality of life). More recently, Blanchet et al. (2016) included a CEA component in their mixed methods study evaluating the impact of incorporating digital technology into the treatment of early childhood illnesses in Burkina Faso. Here, the authors note the added challenge of integrating CEA results into other evaluation components. Yet these integration challenges are likely outweighed by the thorough analysis achieved when including multiple sources of data. Fruitful discussions of how to address such complexities will likely take place in the future as CEA continues to gain popularity among mixed methods researchers.

The second goal of this article is to provide a practical guide to be followed and adapted by other researchers aiming to evaluate complex health interventions operating in real-world settings. We present the procedures we followed for selecting adequate comparison groups, collecting and analyzing data, and integrating the results from each evaluation component. As our aim is to present a template that can be modified to evaluate a diversity of programs, we chose to focus on describing our evaluation methodology and have not included the full results of our specific study here. For readers who are interested, portions of the study findings are presented elsewhere (see Penkunas et al., 2018).

Study Context

Minimizing unplanned hospital admissions and use of emergency services by older adults is a priority for health care providers and policymakers worldwide. Despite efforts to reduce older adults' reliance on these services, rates of acute care use for people older than 65 years remain high (Jencks, Williams, & Coleman, 2009; Parker, 2005). Older patients transitioning from inpatient settings back into the community often encounter fragmented services and difficulties in maintaining continuous care (Coleman, 2003), elevating the risk of rapid readmission. High usage of expensive inpatient and nursing home services drives up the proportion of health care costs dedicated to older populations (Anderson & Hussey, 2000; Yang, Norton, & Stearns, 2003).

Well-integrated health systems must foster an outpatient landscape that is easy for patients to navigate and obtain both medical and social services (Mur-Veeman, Hardy, Steenbergen, & Wistow, 2003). More typically, care for older adults is characterized by siloed treatments and providers who do not communicate with one another (Bergman et al., 1997; Callahan, Thomas, Goldhirsch, & Leipzig, 2002). Integrated service delivery models attempt to increase the coordination of services, first, between levels of care and, second, across different providers in order to improve patient outcomes (Gröne & Garcia-Barbero, 2001).

Program Description

Singapore is one of the most rapidly aging countries in the world with approximately 30% of the population projected to be older than 60 years by 2050 (United Nations, 2013). In 2011, Khoo Teck Puat Hospital in northern Singapore implemented the AIP program, an integrated home care intervention that targets frequently hospitalized mature and older adults and their caretakers. Patients who are hospitalized three or more times within a 6-month period are offered a place in the program at no cost; services are offered to patients regardless of age, diagnosis, or comorbidities. A team of home care nurses and community health workers engage older patients shortly after hospital discharge to provide person-centric, home-based care and individualized linkage to community-based services. Nurses and community health workers typically visit patients twice per month, adjusting their level of contact to match the current medical and social needs of each patient.

Caregivers are provided with both active and passive education opportunities to improve their symptom management skills and reduce caregiver-related stress. For example, caregivers are not only given one-on-one training in how to measure patients' blood pressure but also provided with information on support resources within the community. AIP program staff also assess patients' home environment in areas where physical improvements are needed (e.g., installation of grab bars in the shower) to decrease risks posed to the patients within their homes. AIP staff supplement their home visits with telephone consultations, and patients and their caregivers are encouraged to contact AIP staff if an issue arises. Through addressing the medical and social needs of patients, supporting caregivers in the home, and providing referrals to community-based services, patients' utilization of hospital-based services is hypothesized to decrease, resulting in lower total health care-related expenditures and a higher quality of life among patients and caregivers.

A pilot of the AIP program began in September of 2011 and was scaled up through 2012 as funding was acquired from the Singapore Ministry of Health. Data considered for this evaluation spanned from August 2012 to December 2014. The evaluation itself was conducted throughout 2015. The AIP program was active and enrolling patients at the time of writing.

Method

Study Design

The aim of this mixed methods evaluation was to determine the impact of the AIP program on hospital-based service utilization, compare the CEA results for the AIP program with alternative interventions in Singapore (e.g., home-based medical care without integrated social services), and investigate the processes through which service utilization patterns and health care spending patterns were influenced (Tashakkori & Creswell, 2007). This evaluation followed a concurrent design in that service utilization data, cost estimates, and data from face-to-face interviews were collected simultaneously along three parallel tracks. The parallel data collection phases allowed for a shorter overall study period and more rapid production of results than would have been possible if each phase was conducted sequentially (see Figure 1). The quantitative and qualitative findings were integrated by bringing together the three evaluation components during analysis and comparison (Fetters, Curry, & Creswell, 2013).

Following the intention-to-treat principle, patients meeting inclusion criteria who lived within 10 political districts were identified as the intervention group and were analyzed together regardless of individuals' uptake of the program, generating conservative estimates of the treatment effect (Gupta, 2011; Montori & Guyatt, 2001). Patients who resided within the hospital's catchment zone, but outside these 10 political districts, were defined as the control group. These patients were selected as the most appropriate control group since they resided in a similar geographic area as intervention patients, also received inpatient services from the study hospital, and did not actively self-select or choose not to participate in the AIP program. Because of the real-world nature of this study, patients could not be randomly assigned to a treatment group, yet the quasi-experimental design allowed for the estimation of difference-in-differences statistical models (Lechner, 2011) and enabled robust cost-effectiveness calculations (Murray, Evans, Acharya, & Baltussen, 2000).

Primary quantitative outcomes for our study included the following: (1) differences in hospitalization patterns between intervention and control patients at 180 days follow-up, (2) differences in emergency department utilization between intervention and control patients at 180 days follow-up, and (3) differences in inpatient length of stay between intervention and control patients at 180 days follow-up. Length of stay was calculated by summing the number of inpatient days accrued for all hospitalizations with an admission date falling within the follow-up period. Secondary outcomes included 30- and 90-day measures of inpatient and emergency department service utilization, as well as differences in mortality between the two groups. CEA was conducted by comparing the differences between intervention patients and control individuals in accrued health care costs and changes in their self-reported health status. The sources and definitions of these outcomes are listed in Table 1. The quantitative evaluation components were designed to compare outcomes between patients who had access to the intervention and a group of control patients who did not, allowing the control group to act as a counterfactual in the difference-in-differences analysis (Shadish & Cook, 1999).

Qualitative data were collected from AIP participants, their caregivers, and a sample of individuals who were offered AIP services but did not enroll in the program. By considering data from patients who met the inclusion criteria of being hospitalized three times within a 6-month period yet declined the AIP services, we were able to gain a firsthand understanding of why patients who required rapid rehospitalization opted not to join the program. This provided information to AIP managers wishing to refine their linkage or service provision strategies to better engage patients. We then integrated the quantitative and the qualitative results to develop a comprehensive understanding of the connection between participation in the AIP program and

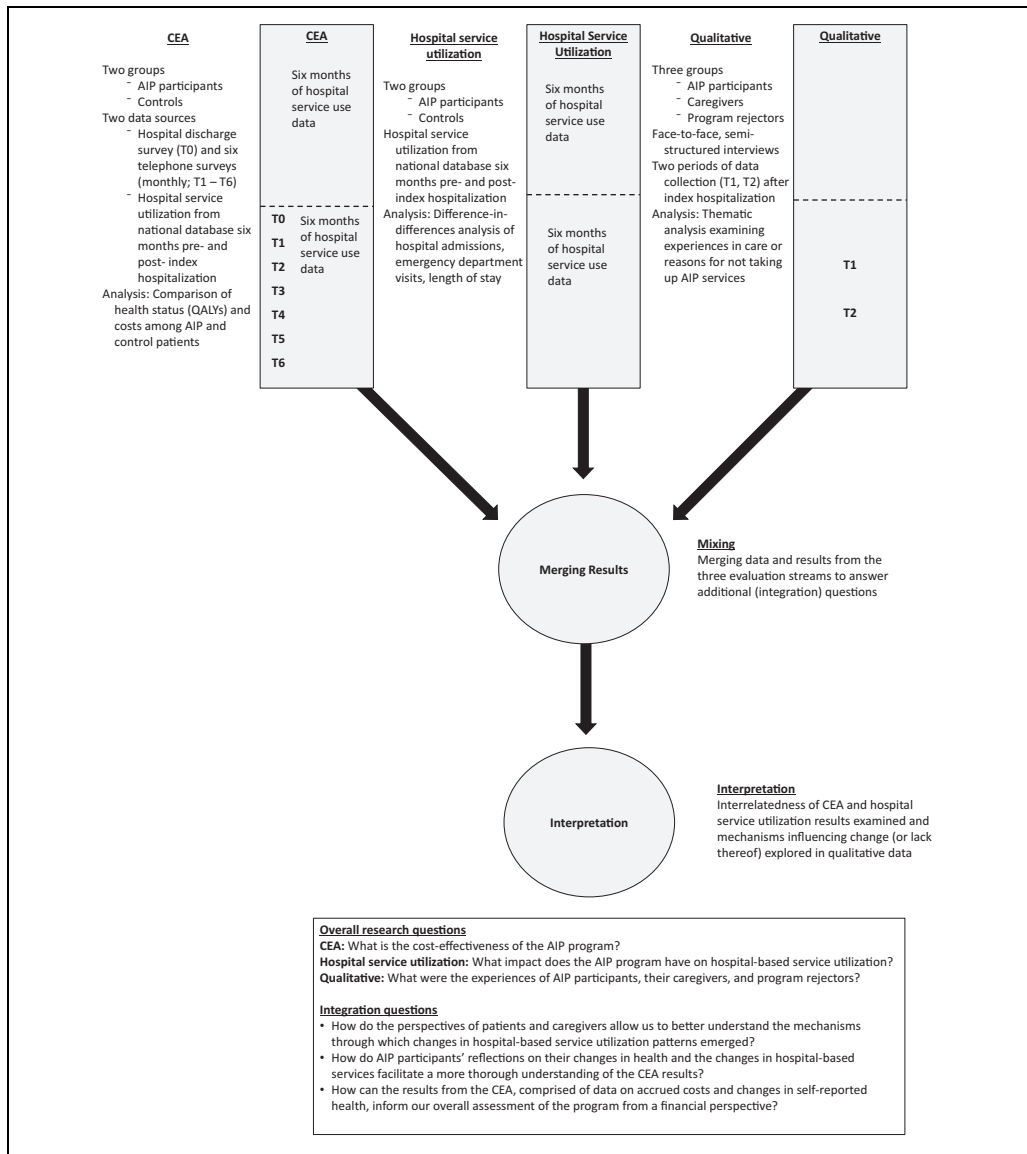


Figure 1. Visualization of study design and integration.

changes in health service utilization, including an analysis of the mechanisms through which these changes may have occurred. Ethical approval for this evaluation was granted by the National Healthcare Group’s Domain Specific Research Board (reference number: 2013/01116).

Descriptions of the Evaluation of Hospital-Based Service Utilization

For the evaluation of hospital-based service utilization, we used retrospective hospital administrative data to identify intervention and control patients admitted for inpatient treatment three

Table 1. Definitions of Outcome Variables.

Outcome variable	Type	Definition
Cumulative number of hospital admissions during the follow-up period	Count	Total number of inpatient hospital episodes accrued by AIP and control group patients during the follow-up period
Cumulative number of emergency department visits during the follow-up period	Count	Total number of emergency department visits accrued by AIP and control group patients during the follow-up period
One or more hospitalizations during the follow-up period	Binary	Yes/no variable indicating whether the patient experienced an inpatient episode during the follow-up period
One or more emergency department visits during the follow-up period	Binary	Yes/no variable indicating whether the patient used any emergency department services during the follow-up period
Length of stay	Count	The cumulative number of inpatient days accrued for admissions within the baseline and follow-up periods. For episodes where admission and discharge occurred on the same day, the length of stay is considered 1
Death during the follow-up period	Binary	Yes/no variable indicating whether the patient died during the follow-up period as indicated by the death registry provided by the Ministry of Health
Self-reported health status	Continuous	As measured through the EQ-5D-5L survey instrument

Note. AIP = Aging-In-Place.

or more times at the study hospital during the 6 months directly preceding the study period. We included data for all patients who experienced three or more hospitalizations during the 6 months prior to 1 August 2012 to fully capture the effect of the AIP program at the community level. Patients were excluded from the sample if they died during the index hospitalization, died within 2 weeks of discharge from the index hospitalization, were referred to an alternative home-medical program, or were admitted to the study hospital from a nursing home (Figure 2). The entire study period lasted 30 months to allow for 6 months of post-enrollment data to be collected for all patients.

Data Sources for the Evaluation of Hospital-Based Service Utilization

We extracted demographic data from the hospital's electronic medical records (see Table 2), including age, ethnicity, sex, Singaporean citizenship status, and Charlson comorbidity index score (Charlson, Pompei, Ales, & Mackenzie, 1987). Data pertaining to inpatient and emergency department episodes were obtained from the Ministry of Health's nationwide database, allowing us to include service utilization data for all public hospitals in Singapore. Administrative data from 1,509 individuals (Intervention = 1,242; Control = 267) were included in this component of the evaluation.

Evaluation of Hospital-Based Service Utilization Data Analysis

We analyzed hospital administrative data using multivariate logistic regression models and difference-in-differences estimation models. Group differences in binary variables, such as whether or not patients died during the follow-up period, were assessed using logistic

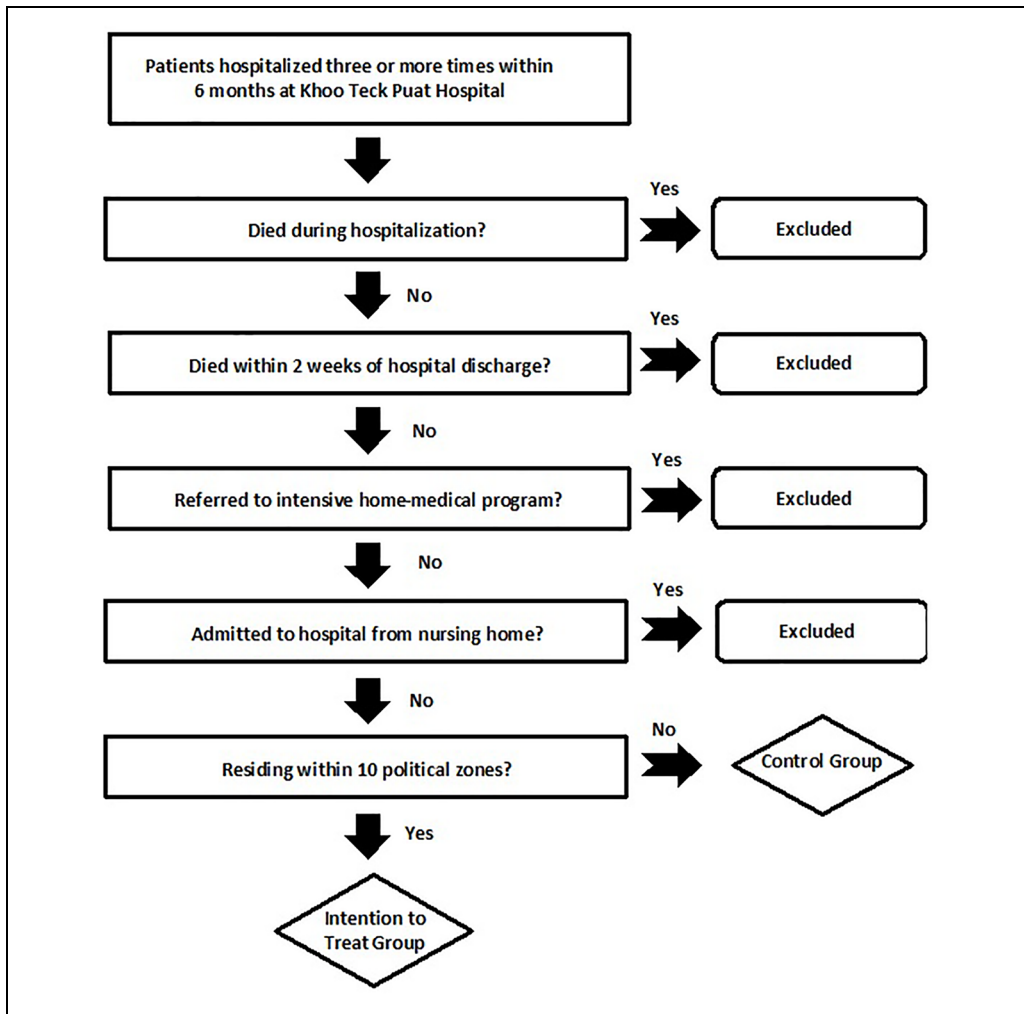


Figure 2. Flow diagram for determining study group assignment.

regression models. We employed difference-in-differences estimation models for continuous variables, such as cumulative length of stay during the follow-up period. Difference-in-differences designs account for temporal trends present when measuring changes over time, a confounder that could lead to erroneous interpretations of results when comparing groups longitudinally.

From both patient groups, we compared the amount of hospital-based services used during the 180-day baseline period with the amount of services used during the 180-day follow-up period. Comparing the difference between baseline and follow-up service utilization for the two groups illustrated the effect of the program while controlling for background changes in utilization that could not be attributed to the AIP program (Ryan, Burgess, & Dimick, 2014).

Cost-Effectiveness Analysis Description

We recruited a convenience sample of patients for the CEA evaluation component as patients were discharged from their third consecutive inpatient episode at the study hospital during the

Table 2. Comparison of Demographic and Clinical Characteristics for Patients Included in the Hospital-Based Service Utilization Evaluation Component.

	Intervention (N = 1,242)	Control (N = 267)	p
Age, years, <i>M</i> (<i>SD</i>)	67.8 (14.6)	69.6 (14.8)	.061
Ethnicity, <i>n</i> (%)			
Chinese	689 (55.5)	178 (66.7)	.001
Malay	316 (25.4)	40 (15.0)	
Indian	170 (13.7)	32 (12.0)	
Others	67 (5.4)	17 (6.4)	
Female, <i>n</i> (%)	576 (46.4)	124 (46.4)	.985
Singaporean citizen, <i>n</i> (%)	1,200 (96.6)	260 (97.4)	.525
Length of stay of index admission, days, <i>M</i> (<i>SD</i>)	7.0 (11.4)	8.1 (9.0)	.122
Charlson Comorbidity Index score, <i>M</i> (<i>SD</i>)	2.4 (2.3)	2.1 (2.1)	.075

Note. Chi-square used to test for statistical significance between groups.

6 months prior to February 28, 2014. Patients completed a survey at discharge and then participated in 6 months of telephone surveys in order to collect the data necessary to carry out the CEA calculations. Individuals who resided within the 10 political zones of the study hospital catchment area were again considered intervention patients, while those residing outside these zones acted as control individuals. The exclusion criteria described above for the hospital-based service utilization sample was applied to the CEA cohort as well. In total, 249 AIP participants and 56 control patients were recruited for the CEA component of the evaluation. We experienced an attrition rate of approximately 33% (101 out of 305) over the 6-month follow-up period. We also collected hospital administrative data for these patients and included it in our evaluation of patients' hospital-based service utilization component.

CEA Data Sources

Information captured by the discharge survey included age, sex, ethnicity, marital status, number of children, relationship to the primary caregiver, housing type, number of household members, perceived income adequacy, medical financial scheme coverage, Medifund assistance, number of medication types, EQ-5D-5L, activities of daily living independence, and instrumental activities of daily living independence. Chi-square tests conducted on the baseline data revealed that intervention group and control group participants were similar in terms of socio-demographic characteristics (see Table 3).

Telephone surveys with intervention and control patients took place monthly to collect data on health care service utilization and out-of-pocket costs associated with medical treatments. Participants were asked to report all outpatient (i.e., primary care, pharmaceutical, rehabilitation) and hospital-based services they engaged in over the prior month as well as all out-of-pocket health care costs they accrued. Health status was measured each month using the EQ-5D-5L, a self-report survey that measures health on five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression (Herdman et al., 2011). The EQ-5D-5L is designed to measure the level of health experienced by the respondent, and the tool has been used in Singapore successfully by others (Luo, Wang, Thumboo, Lim, & Vrijhoef, 2014).

The health decrement data collected through the EQ-5D-5L allowed for the calculation of quality-adjusted life-years (QALYs). QALYs are a standard measure of disease burden that characterize both the quality and quantity of an individual's life (Drummond et al., 2005;

Table 3. Comparison of Demographic Characteristics for Patients Participating in the Cost-Effectiveness Component of the Evaluation.

	Intervention group, n (%)	Control group, n (%)	<i>p</i>
Sex	(<i>N</i> = 249)	(<i>N</i> = 56)	
Female	111 (44.6)	30 (53.6)	.223
Male	138 (55.4)	26 (46.4)	
Ethnicity	(<i>N</i> = 249)	(<i>N</i> = 56)	
Chinese	132 (53.0)	29 (51.8)	.183
Malay	62 (24.9)	19 (33.9)	
Indian	31 (12.4)	7 (12.5)	
Other	24 (0.10)	1 (0.02)	
Marital status	(<i>N</i> = 237)	(<i>N</i> = 54)	
Married	103 (43.5)	22 (40.7)	.716
Other	134 (56.5)	32 (59.3)	
Primary caregiver	(<i>N</i> = 230)	(<i>N</i> = 52)	
Self	87 (37.8)	13 (25.0)	.081
Other	143 (62.2)	39 (75.0)	
Housing type	(<i>N</i> = 237)	(<i>N</i> = 54)	
1-3 rooms apartment	58 (24.5)	15 (27.8)	.613
4+ rooms apartment/condominium/ private flat, etc.	179 (75.5)	39 (72.2)	
Health coverage	(<i>N</i> = 237)	(<i>N</i> = 54)	
Yes	220 (92.8)	50 (92.6)	.571
No	17 (7.2)	4 (7.4)	
Medifund assistance	(<i>N</i> = 237)	(<i>N</i> = 54)	
Yes	52 (21.9)	5 (9.3)	.022
No	185 (78.1)	49 (90.7)	

Note. Total *N* may vary by characteristic due to missing data. Chi-square used to test for statistical significance between groups.

Weinstein, Torrance, & McGuire, 2009). Typically, one QALY represents a full year lived in perfect health, while a year lived in a state of health that is less than perfect is associated with a QALY value below one. When combined with out-of-pocket costs, hospital-based service costs, and program implementation costs, QALY scores allow for the creation of an incremental cost-effectiveness ratio (ICER). ICER calculations are commonly used by health economists as a representation of the cost-effectiveness of the intervention or program under study. After calculating the ICER for the AIP program, we then benchmarked it against other interventions in Singapore (Eichler, Kong, Gerth, Mavros, & Jönsson, 2004) and the average yearly income of Singaporean citizens.

CEA Data Analysis

Monetary costs included those associated with hospital-based services, as well as outpatient services, that were reported during the monthly telephone surveys. They also included costs for implementing the AIP program for intervention patients. Effectiveness was determined by calculating QALYs using EQ-5D-5L responses for both groups, adjusting for baseline differences. Dividing the difference in cost by the difference in effect for the two groups resulted in the ICER, as expressed by

$$\hat{R} = \frac{\bar{C}_T - \bar{C}_C}{\bar{E}_T - \bar{E}_C} = \frac{\Delta\bar{C}}{\Delta\bar{E}} \quad (1)$$

where \bar{C}_C and \bar{E}_C are the mean cost and effect for the control group and \bar{C}_T and \bar{E}_T are the mean cost and effect for the treatment group (AIP patients). Within the denominator, subtracting the effect measured for the control group (\bar{E}_C) from the effect for the treatment group (\bar{E}_T) represents the difference in QALYs between AIP patients and patients in the control group. Bootstrapping techniques (a process where subsamples of the data are repeatedly analyzed separately) were used to develop a cost-effectiveness acceptability curve (CEAC) (Briggs, Wonderling, & Mooney, 1997; Fenwick, Claxton, & Sculpher, 2001). Constructing a CEAC from bootstrapped data helps researchers quantify and visualize the degree of uncertainty present in economic evaluations of health interventions (Fenwick, O'Brien, & Briggs, 2004). CEACs developed with bootstrapped data are often used to determine the proportion of simulated ICERs that are cost-effective. The degree of uncertainty represented through the CEAC can be considered by evaluators and policymakers when creating recommendations based on a CEA, and, in some cases, it may be advised to undertake additional studies to reduce uncertainty prior to enacting a decision.

Specific to the CEA evaluation component, calculating the ICER point estimate allowed for the results of this study to be easily compared with either the ICER point estimates found for other interventions or with a fixed cutoff representing the threshold for willingness to pay for a QALY gained (Drummond et al., 2005). Although we chose QALYs as the most appropriate measure of effectiveness for the AIP program, researchers incorporating CEA components into their evaluation must consider carefully what indicator will best capture the effectiveness for their specific program (i.e., pain free days, lives saved) (Robinson, 1993). Researchers must also be aware of the drawbacks of CEA and the limitations inherent to this methodological approach. For example, the interpretation of results can change drastically with modifications to the costs included in the equation, the specific intention of the intervention, and the reference intervention with which the study program is being compared. Additionally, the quality of CEA evidence can change depending on the type of study being conducted (e.g., randomized controlled trial, case-control study, etc.) and with the level of variability present in the data going into CEA calculations. Therefore, researchers should not rely solely on point estimates when comparing CEA results (Jamison et al., 2006).

Qualitative Evaluation Description

The qualitative sample was composed of three groups that differed in their experiences with the AIP program: care recipients, caregivers, and program rejectors. Combining these views allowed for a comprehensive appraisal of how the AIP program influenced care recipients' patterns of hospital-based service utilization, the degree of support caregivers received, and the reasons why some individuals choose not to participate in the program. Care recipients and caregivers were required to have participated in the program for at least 3 months in order to be included in the qualitative portion of the evaluation. Program rejectors recruited for the study must have explicitly declined the AIP services. Respondent groups were recruited using patients' contact information maintained by the study hospital.

Qualitative Data Sources

A team of local interviewers with backgrounds in health research were trained on interview techniques through didactic methods and role-play exercises. As Singapore is a multilingual

society, the interview team was composed of individuals proficient in the primary local languages (i.e., English, Mandarin, Malay). Interpreters were used as necessary (i.e., Tamil-English). Potential participants were selected based on mutually agreed on eligibility criteria established by the study team. Patients with active psychiatric disorders and patients who were not discharged from the hospital into the community, including patients who were admitted into a long-term care facility, were excluded. Caregivers for these excluded patients were also deemed ineligible. The contact details for individuals who met the eligibility requirements were extracted from the hospital's records.

A member of the study team or a hospital staff member contacted potential participants over the telephone to explain the purpose of the study, how they would be involved in the study if they chose to participate, and their right to refuse participation without fear of repercussions. Individuals making the recruitment calls were conversant in English, Mandarin, Chinese dialects, Malay, and Tamil and conducted the recruitment in the preferred language of the potential participant. A maximum of four telephone calls were made to each potential participant.

Semistructured interviews were conducted in participants' homes or at a convenient location in the community using standardized interview guides, tailored for each of the three respondent groups. Discussions were audio recorded. The interview guides were designed to elicit different yet interrelated appraisals of the AIP program from care recipients, caregivers, and program rejectors. We developed the framework for the interview questions in a way that allowed the topics of health and health care to be considered within the context of the AIP program.

The interviewers presented a series of topics they wished to explore with the participants, but the conversations were not limited to only the topics outlined in the guides. Semistructured interviewing methods allowed participants to freely expand on their answers and the ideas brought up throughout the interview, resulting in rich descriptive data covering a range of experiences and topics. The open-ended nature of the interviews allowed for discussions to progress into areas that were particularly meaningful to the participant.

Questions for AIP patients explored their opinions of the services they received, their expectations surrounding the home health services, and how the program affected their ability to manage their symptoms. Caregivers were asked about their interactions with the AIP staff, how they approached their caregiving duties, and issues surrounding stress management. Program rejectors were asked why they decided not to take up the AIP services, about their approach for managing their health, and about their ability to function independently.

Two separate periods of data collection occurred with the first round of interviews taking place between May and July of 2014 and the second round between October and December 2014. In accordance with local ethics board guidelines, patients with substantial cognitive impairment were not interviewed, and, if available, a proxy was interviewed in their place. Seven proxies completed the interview due to the patient's degree of cognitive impairment: six for care recipients and one for a program rejector. In total, 111 interviews were conducted: 65 care recipients, 32 caregivers, and 14 program rejectors (see Table 4). Sample sizes for the qualitative component were not based on statistical assumptions but rather were in line with theoretical data saturation principles (Morse, 1994). Audio recordings were translated into English as necessary and then transcribed verbatim for thematic analysis.

Qualitative Data Analysis

Thematic analysis was conducted by two independent coders who were not involved in participant recruitment or in data collection. Coders began with a period of open, inductive coding (Hsieh & Shannon, 2005) employing a constant comparative approach to the data while building a thematic taxonomy of codes (Bradley, Curry, & Devers, 2007). Coding took place in a

Table 4. Demographic Characteristics of Individuals Participating in the Qualitative Component of the Evaluation.

	No. interviewed	Average age, years	Age range, years	Male, n (%)	Female, n (%)
Care recipient	65	65	27-95	35 (54)	30 (46)
Caregiver	32	57	26-83	11 (34)	21 (66)
Program rejector	13	61	48-80	11 (85)	2 (15)

Note. Information for one program rejector was not collected as the interview was completed by a proxy.

stepwise fashion, with each coder reading a selection of the interview transcripts and then meeting to refine the coding framework. The two coders read and systematically coded the entire catalogue of transcripts, and disagreements in coding were rectified through thorough discussion with reference to the original transcripts.

The thematic analysis focused on characterizing whether the AIP program assisted patients in delaying inpatient and emergency department service use, how AIP staff interacted with patients and their caregivers, the implementation of the home health component of the program, and whether adjustments to recruitment procedures could enable more patients to take up services. To increase the credibility of the qualitative data analysis, the two coders met regularly to examine and refine the coding schemes applied to the transcripts and consulted with the larger study team to review the emerging themes. Tabulations of codes within the thematic framework were produced to identify recurring concepts and to aid in the application of the coding scheme to theoretical models.

Integration of Quantitative and Qualitative Results

The analyses conducted for the three evaluation components each demonstrated a result specific to the type of data considered. Analysis of the hospital-based service data compared the change in service utilization patterns among patients in the AIP program with the change measured for patients within the control group. The CEA compared the differences between AIP patients and patients in the control group in health status and monetary costs allowing for the estimation of unit costs per QALY gained among the AIP participants. Analysis of the qualitative data illustrated patients' appraisals of the AIP services, caregiver's perceptions of the program, and the reasons why some frequently hospitalized older adults chose not to take up AIP services.

We then proceeded with integrating the results from the three evaluation components in an attempt to produce a more complete understanding of the effectiveness of the AIP program (Howe, 2012; Mertens & Hesse-Biber, 2012). Our integration efforts were guided by the three following questions, each of which required two or more evaluation components to answer:

1. How do the perspectives of patients and caregivers allow us to better understand the mechanisms through which changes in hospital-based service utilization patterns emerged?
2. How do AIP participants' reflections on their changes in health and the changes in hospital-based services facilitate a more thorough understanding of the CEA results?
3. How can the results from the CEA, composed of data on accrued costs and changes in self-reported health, inform our overall assessment of the program from a financial perspective?

These guiding questions were designed to help capitalize on the value added to the evaluation by collecting both quantitative and qualitative data (Fetters & Freshwater, 2015).

Researchers considering a methodology similar to ours should ask themselves early in the design phase what additional answers—over and above those that are possible from either data source in isolation—can be provided by combining the quantitative and qualitative components (O’Cathain, Murphy, & Nicholl, 2010; Wisdom, Cavaleri, Onwuegbuzie, & Green, 2012). Importantly, researchers adapting our method must realize that the results from each component are not collected for the sole purpose of “confirming” one another. Instead, the results from the different data sources may contradict one another, and the integration process is critical to clarifying the action of the program under study (Fetters & Molina-Azorin, 2017).

Our integration efforts were somewhat different from those described for other mixed methods studies since the CEA portion of our evaluation provided information specific to financial costs. Results from the CEA are particularly important to policymakers and program managers tasked with deciding how to allocate a limited pool of financial resources between interventions (Russell, Gold, Siegel, Daniels, & Weinstein, 1996). For example, the ICER point estimate obtained through the CEA indicated that each QALY gained was associated with a cost of approximately 79,000 Singapore dollars. This ICER can be compared with the per capita national income for Singapore and/or the ICER calculated for alternative interventions to help inform decision making. Here, the ICER 79,000 Singapore dollars was slightly higher than the average yearly income in Singapore suggesting that the AIP program represented relatively good value for money. Yet when taking into consideration the variability of our data by creating the CEAC, we found that the distribution of the modeled values was relatively wide and about 50% of the modeled values were above or below the average yearly income threshold. The insights gained through the CEA component were pertinent to program managers who must consider how much money is necessary to achieve a particular outcome.

The financial trade-off associated with the AIP program (just over 1-year-income per QALY) can be compared with those for other inventions addressing similar issues in comparable settings to help policymakers make decisions about how to use a finite amount of money. Information in the qualitative dataset also informed the program of how to potentially increase patients’ self-rated health (i.e., faster linkage to home health services after hospital discharge), which, in turn, could influence patterns of hospital-based service utilization and reduce the overall ICER estimate.

Interpreting the CEA findings in light of the results from the hospital-based service utilization analysis provided greater insight into which specific elements of the total costs for patients were influenced among patients in the AIP program. Examination of the hospital service utilization results indicated that patients enrolled in the AIP program were less likely to be hospitalized within the first 30 days after discharge compared with those not receiving home-based AIP services. This reduction in costly inpatient care informs our interpretation of the CEA results: Patients remaining out of the hospital during the first 30 days postdischarge will likely accrue fewer health care–related costs than those who were admitted to the hospital for inpatient treatment. Comparisons of emergency department and inpatient service use at 90 and 180 days after discharge showed no significant difference between AIP and non-AIP patients, suggesting that the effect of the program is most prominent during the first 30 days postdischarge. If the AIP services had supplanted a greater portion of the high-cost hospital-based services, we likely would see a reduction in the ICER point estimate, which would increase the overall cost-effectiveness of the AIP program as long as self-reported health status did not also decrease drastically.

Combining information on the financial costs associated with an increase in QALYs with the first-hand experiences of patients collected through the qualitative component provided a narrative describing the specific ways in which self-rated health was influenced. For example, care recipients often cited their appreciation for the social contact that the home visits afforded them:

- Interviewer: So, do the monthly visits from nurses affect you in any way?
 Care recipient: I feel happier after chatting with the nurse.
 Interviewer: In better spirits?
 Care recipient: Yes.
 (Care recipient, 61 years old, female, Chinese, married)
 Interviewer: When the nurses come, how do you feel?
 Care recipient: When the nurses come, I feel happy.
 Interviewer: Ah.
 Care recipient: That's it, chat happily, feel happier.
 Interviewer: Ah, so do you feel better when the nurse comes to check on your health? Do you feel better?
 Care recipient: Feel better, just like, [when I] stay alone, [I] will feel lonely.
 (Care recipient, 76 years old, female, Chinese, widowed)

These quotations highlight the importance of the home visits in decreasing patients' loneliness, an important contributor to depression in older adults (Cacioppo, Hughes, Waite, Hawkley, & Thisted, 2006), which is measured on the EQ-5D-5L for the calculation of QALYs. These personal perspectives were useful to the study team when considering how to interpret cost per QALY gained, information that is typically not available to health economists conducting CEA studies.

Merging the results of the quantitative and qualitative components allowed for a more detailed understanding of changes in hospital-based service utilization and the processes through which the AIP program influenced patients' health care seeking behavior. For example, the home visits afforded an opportunity for nurses to provide additional medical care to AIP patients, monitor their medication and dietary habits, and reinforce healthy lifestyle changes, all of which likely contributed to a reduction in hospital-based service utilization during the immediate postdischarge period:

- Interviewer: Okay, when the nurse mentioned that they would be coming to visit you, what were your hopes for the program?
 Care recipient: I think it's good. Because we get to know about our illness, and they will give advice so that we can avoid always having to be admitted to the hospital. So we can better care for our own selves, like taking our medicine like this.
 . . .
 Interviewer: Hmm. Okay. From where do you get all these information?
 Care recipient: From the nurses and their advice, we took their advice.
 Interviewer: Ah. Okay. So all from the nurses.
 Care recipient: Yes, from the nurses. If not, we do not know anything.
 . . .
 Interviewer: Hmm. Okay. What do you feel are the areas we can modify to improve this program? In your opinion, there is no right or wrong answer, just your opinion.
 Care recipient: In my opinion, this method is good where the nurse comes to see you before you go and see the doctor. If you are unwell, the nurse can give advice. If she cannot, then we can see the doctor.
 [Care recipient, 75 years old, male, Malay, married]

This above quote points to specific processes—such as medication adherence, increased access to information surrounding their health conditions, and rapid linkage to outpatient care

when symptoms begin to worsen—facilitated by the AIP program that are important for helping older adults avoid hospitalization. Not all comments received by care recipients were positive, such as some caregivers stating that the lack of after-hours or weekend support was an impediment to patients remaining out of the hospital. Contradictions were also present in the data, with some patients requesting more frequent home visits, while others stating that the current schedule was adequate. These negative and contradictory responses allowed further insights into why the effect of the program was not reflected in the quantitative data beyond the 30-day follow-up time point.

The synergistic nature of integration efforts is a hallmark of mixed methods research. Researchers aiming to use mixed methods techniques to evaluate complex interventions can take advantage of these features to produce results that more thoroughly describe the outcomes from innovative health care programs than if a single source of data were used (Craig et al., 2008). Mixed methods results can also be conveyed through a visual joint display to aid in connecting the findings from each evaluation component and apply these findings to theoretical models or specific recommendations. Table 5 presents a model joint display we developed for this case example using the Pillar Integration Process as conceptualized by Johnson, Grove, and Clarke (2017). We began with the outside columns and completed the joint display moving inward as the data were integrated through a four-stage process of listing, matching, checking, and pillar building.

The Pillar Integration Process is one technique for integrating multiple data sources, and it provides great flexibility to evaluators in the types of data that can be displayed. The recent review of joint displays used in mixed methods studies published by Guetterman, Fetters, and Creswell (2015) presents several additional high-quality examples. In all, integrating the results from the three components of the evaluation increased the credibility of the current study and was used to generate explanations for unexpected findings (Barbour, 1999).

Discussion

We present a case example describing a practical yet robust methodology employed to evaluate an integrated home care program for older adults in Singapore. Our goal was to gain a comprehensive understanding of the outcomes produced by this integrated care program and to use the results gained from this evaluation to inform future iterations of the service while assessing cost-effectiveness. This mixed methods evaluation design was informed by health services research, health economics, and social sciences literature and contributes a methodological framework that can be adapted by others in search of practical designs for evaluating programs with complex causal pathways (Victoria et al., 2004).

Our integration efforts focused on mixing the results obtained through three different evaluation methods that are often carried out separately. In addition, the AIP program operated in a real-world setting that lacks the controls of a clinical trial, and the program affects patients' health through circuitous causal pathways that are difficult to measure. The complex nature of patients' medical conditions, the personalized care delivered by staff, and the fact that the program being evaluated was already integrated into the standard system of care presented real difficulties to evaluators tasked with developing an objective and nuanced appraisal useful to program implementers. Each of the evaluation components we utilized offered strengths and weaknesses of their own, but by combining the three approaches, we were able to build an understanding of the program from multiple, complementary perspectives. For example, evaluating multifaceted community-based health programs using only health service utilization data leaves out crucial information related to program implementation and patient/caregiver experiences. Similarly, an evaluation that focused solely on CEA would miss out on the insights

Table 5. Model Joint Display Developed Using the Pillar Integration Process (Johnson et al., 2017).

Case: Evaluation of the AIP program				
QUANT data	QUANT categories	Pillar building themes	QUAL categories	QUAL codes
Average Charlson Comorbidity Index score of AIP participants = 2.4 (SD = 2.3)	Moderate to high degree of medical comorbidities among AIP participants	Demand for information on medical conditions	Need for professional monitoring	Care recipient: "Okay, er, for me personally I like when they actually come here to take the [blood] pressure and then from that reading from that result, ah, that is where they start telling you, okay, you need to cut down on this. I know many people don't like to be told off." Caregiver: "The nurses help me to monitor my mother's condition. They also help cater to her medical needs and give suggestions on how I can take care of her." Caregiver: "Ah, if [the nurse doesn't tell him], he won't listen to what we say. He, look he, there's one more person to tell him, ah, see if he listens to it."
Average of 3.35 hospital admissions and 3.51 emergency department visits for AIP during 6-month pre-intervention period	Frequent hospitalization and emergency department use indicative of poor self-management in the community	Willingness of patients to adhere to doctors' orders and change behavior	Follow-up from AIP nurses can increase adherence	
20.8% of AIP patients visited at home within 2 weeks of discharge. 50% of simulations were not cost-effective using annual earning threshold.	Variation in timing of first home visit and variation in cost-effectiveness analysis results using bootstrapped data	Meeting the needs of patients in community rather than hospital settings	Demand for community-based assistance from caregivers	Caregiver: "Maybe, I think second [hospitalization] already, the red flag should be out already. And no doubt, second time already, all the family caregiver should be given a chance to know what's going on." Care recipient: "The hospital or that body in charge, must also understand the patient's need before discharging the person ... Now, a lot patient they don't know [how to manage at home]. In the first stage when I was the first, when I had my first operation, I didn't know. I came back, I fell four times, it was hell in my house. Actually this is home sweet home, became hell."

Note. AIP = Aging-In-Place.

gained by looking into how major drivers in health care costs, such as service utilization patterns, were changed through the program. It is through the mixing of the results that we were able to comment meaningfully on a multicomponent program that treats patients with complex care needs operating outside a controlled trial.

The process of mixing the results from the individual evaluation components presents challenges to evaluators that require careful consideration. For us, drawing connections across the three evaluation streams necessitated that we examine closely how the data fit together, such as understanding how QALYs could be affected by changes in hospital-based service utilization and how caregivers' experiences might offer insights into patients' self-reported well-being. Open communication and regular study team meetings were required to ensure that the expertise of study team members was applied while interpreting the findings of each evaluation component and integrating the results of the three evaluation work streams. Others adapting our approach need to plan ample time during the study design phase in order to become familiar with the various methodologies and must be ready to work collaboratively with others who can help uncover the value-added results made possible by the mixed methods approach.

In the end, our experiences in conducting this study exemplified the utility of mixed methods approaches in evaluating complex health programs where the findings are not clear cut and where a single data source would have left concealed important yet difficult to measure factors. The use of multiple data sources empowers evaluators to answer questions that arise through the analysis phase of a study, and we advocate for the inclusion of CEA in mixed methods designs to provide an additional informational facet to be considered by both evaluators and policymakers.

This practical, quasi-experimental methodology was designed to facilitate causal inference when randomization was neither appropriate nor feasible. Yet a number of issues and limitations must be considered when employing an evaluation plan such as this one. First, researchers must be careful when selecting a comparison group and provide evidence that the group chosen for comparison is appropriately similar to that exposed to the intervention in terms of sociodemographic and clinical features. Propensity score matching is one option for overcoming the analytical challenges presented when the characteristics of the intervention and control groups are dissimilar (Caliendo & Kopeinig, 2008). Second, much of the data included in the CEA component were reported from the study participants themselves, which could be influenced by recall bias (Schmier & Halpern, 2004). Researchers should consider the best schedule for collecting these data (e.g., weekly, monthly) and could choose to implement a diary system where participants record the data themselves as the events happen (Tribe et al., 2005). Last, for the qualitative component, individuals volunteered to participate in the interviews, which could lead to a biased sample. Including perspectives from multiple stakeholder groups helps ensure that a range of experiences are captured in the data. Furthermore, offering incentives and being flexible with the timing and location of the interviews could prompt some individuals to participate who otherwise may not have volunteered.

For this evaluation in particular, the results were intended to inform program managers of the performance of the AIP program, identify best practices to promote and areas where further developments were needed, and to notify policymakers of the cost-effectiveness of the program. The overall results were intended to inform policy dialogue at the national level as Singapore continues to design and implement innovative care models aimed at meeting the needs of its rapidly aging population.

Contribution to the Field of Mixed Methods: Introducing CEA to Mixed Method Researchers and Presenting a Practical Guide

Our first goal was to present CEA as a viable and meaningful analytical approach to be considered by others planning mixed methods evaluations. We outlined the process for carrying out a

CEA in parallel with more traditional mixed methods approaches and highlighted areas in need of special attention when incorporating CEA into a multicomponent evaluation. Although we provided a worked example of how CEA results can be integrated with findings from other quantitative and qualitative methodologies, additional discussions around how CEA results can be used to more fully understand a program's impact could further promote the utility of CEA within the mixed methods research community.

Second, we aimed to present an easy to follow guide so that researchers with limited exposure to CEA could design, execute, and interpret the results of a mixed methods evaluation with a CEA component. The methods presented in this article are not specific to evaluating interventions for older adults or integrated care initiatives, but instead, they can be adapted to fit a wide range of programs. In preparing this guide, we have drawn attention to potential pitfalls that could be encountered while executing a methodology similar to ours and outlined techniques to mitigate such drawbacks. We also emphasized the benefits of drawing on methods from a range of disciplines and creating a multidisciplinary study team during the integration process in particular.

Conclusions

We have described our approach for evaluating a complex, community-based intervention aimed at improving the health and quality of life of older adults in Singapore and reducing patients' reliance on hospital-based services. During this evaluation, the AIP program operated in a real-world setting that precluded the use of randomization. Hence, we employed quasi-experimental techniques comparing the AIP patients with a similar group of individuals who were not offered the program services. The three components of the evaluation each provided insights into the performance of the program individually. Integrating the results from these three evaluation components presented a more complete appraisal of the intervention than any single source of data considered alone.

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