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Community Paramedicine Intervention for Heart Failure Discharges: An Economic Feasibility Analysis

ABSTRACT

Community paramedicine (CP) is an emerging healthcare delivery intervention, which involves post-discharge home visits by paramedics to avoid 30-day readmission among patients with heart failure (HF). However, the economic implications of CP intervention for HF discharges are uncertain and would be useful to both health administrators and policy makers. This study aims at examining the economic feasibility of the intervention considering the implementation costs and the financial benefits due avoided Hospital Readmission Reduction Program (HRRP) penalties. A cost-benefit Monte Carlo simulation model is applied to several scenarios defined based on hospital service area size and annual number of HF discharges.

KEYWORDS: Cost-benefit analysis, heart failure, community paramedicine, readmission

INTRODUCTION

Heart failure (HF) is a serious cardiovascular disease that affects more than 5 million people in the US. Due to the increase in elderly population and life expectancy, the prevalence of HF is expected to grow in the future and reach over 8 million by 2030 (Fitch, Pelizzari, & Pyenson, 2015; Storrow et al., 2013). HF causes a major burden on the US healthcare system as it is associated with significant morbidity, death, and utilization of resources. It accounts for more than 1 million hospitalizations annually and nearly a fifth of HF patients that are discharged from a hospital are readmitted within 30 days (Blecker, Ladapo, Doran, Goldfeld, & Katz, 2014).

Over the past several years, given the substantial burden of HF, the Centers for Medicare and Medicaid Services (CMS) expressed major interest in implementing initiatives targeting the high readmission rates of HF patients. For instance, the Hospital Compare, a consumer-oriented website published by the CMS, provides 30-day HF readmission measures and allows consumers to compare multiple hospitals since 2010. In addition, in 2012 CMS initiated the Hospital Readmission Reduction Program (HRRP), which is designed as a direct financial incentive for hospitals to reduce readmissions related to five conditions including HF. In this program, hospitals with excess readmissions are penalized up to 3 percent of their Medicare diagnosis-related group (DRG) payments. In the first year of the program, around 70% of the hospitals received penalties which aggregate to approximately $280 million in Medicare payments (Fitch et al., 2015).

As a result of such incentives, hospitals have devoted substantial effort to implement various strategies to minimize readmissions among HF patients and avoid financial penalties. One potential hospital strategy to reduce HF readmission is community paramedicine (CP) which is an evolving healthcare delivery intervention that uses emergency medical service (EMS) providers in a broader role with additional training (Guy, 2014; Patterson & Skillman, 2013; Pearson, Gale, & Shaler, 2014). As a healthcare intervention, CP help fill the healthcare gaps, increase the access to the healthcare services, and lower the cost by deploying existing mobile resources out-of-hospital setting more efficiently. The provided services, targeted populations, and the goals of each CP intervention may be unique as the needs of the local communities may vary. The types of CP interventions include but not limited to: chronic disease management, hospital discharge follow-up, fall/risk prevention, immunizations, and health education and promotion (LaFrance & Coffman, 2016; Patterson, Coulthard, Garberson, Wingrove, & Larson, 2016).

CP intervention holds a great potential to reduce the HF readmissions and associated penalties by providing follow-up home visits after hospital discharge (Figure 1). CP intervention for HF discharges is intended for coordinating patient care typically from the time between the 2-days prior to discharge to the 30-days post-discharge. Prior to hospital discharge, HF patients are visited by a registered community paramedic. During this first meeting, the community paramedic explains the program and asks for participation. Post discharge, the community paramedics visit the patient at home multiple times for 30 days. During these home visits, the community paramedic performs various tasks such as educating post-discharge instructions, evaluating vital signs, reviewing medications, and assessing diet and safety. The encounters can be documented in the electronic health record (EHR) through a mobile device and thereby the visits can be viewed by a case manager, specialist, primary care and emergency department providers as appropriate. The community paramedic can also consult with patient's physicians to address any needs identified during the visit (e.g., to adjust medication).

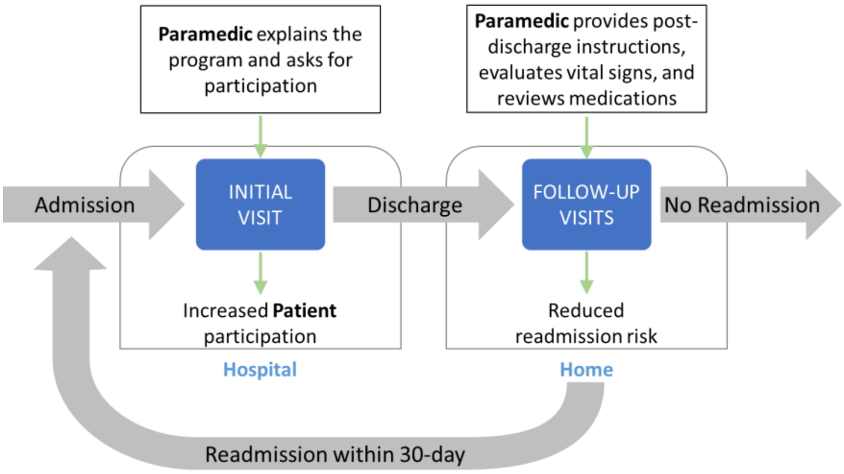

Figure 1. CP intervention for HF discharges

CP intervention for HF discharges provides health assessments and treatments for patients at home and enhances patients' self-management. Consequently, it introduces the opportunity for hospitals to reduce 30-day readmission rates for patients with HF. In fact, among other chronic diseases, HF is the leading targeted disease by CP interventions around the country (Patterson et al., 2016). Although the number of CP programs for HF discharges is growing and the anecdotal successes have been reported, the examination of economic feasibility of CP in different implementation settings is deficient (Drennan et al., 2014; Guy, 2014; Mumolie, 2015; Patterson & Skillman, 2013). The aim of this study is to present a cost-benefit simulation model to evaluate the implementation of CP intervention for HF discharges by hospitals under the CMS Hospital Readmission Reduction Program. The cost-benefit model considers the demand, costs, and the financial benefits. To consider the variations in service area size and annual number of HF discharges, several scenarios are defined.

METHOD

Many factors play a role in determining CP intervention's costs and benefits. First, the demand to this intervention should be estimated. Based on the demand, the cost elements, such as equipment and personnel costs, can be calculated. Expectations of CP financial benefits is currently limited since Medicare and most private insurers still do not reimburse EMS services performed without transport (Choi, Blumberg, & Williams, 2016). However, avoiding the HRRP penalties by decreasing the 30-day readmission rate with CP intervention can provide substantial cost savings to the hospitals.

The Cost-Benefit Model

To assess the economic feasibility of CP intervention for HF discharges, we used Monte Carlo simulation model to determine the expected net present value (NPV).

The NPV formulation considering the initial investment cost ($C_{initial}$), annual cost (C^i_{yearly}), and annual saving (B^i_{yearly}) is given as;

$$NPV = -C_{initial} + \sum_{i=1}^{t} \frac{\left(B^i_{yearly} - C^i_{yearly}\right)}{(1+r)^i}, \tag{1}$$

where *i* represents the year and *r* is the discount rate.

The initial cost of a CP intervention for HF discharges is examined in two key areas:

- Equipment cost (C_e) includes the cost of CP vehicle (non-transportation vehicle) and the medical and communication equipment allocated for it (Pearson & Shaler, 2015; WECAD, 2011).
- Prior launching a CP intervention for HF discharges, a training is required to orient paramedics to non-emergent care. Training topics may include patient navigation, interviewing techniques, home safety, and such (Pearson & Shaler, 2015; Zavadsky, 2016). Hence, training cost (C_t) is included in the initial cost.

The annual cost of a CP intervention is consisting of two parts:

- Annual operating cost (C_o) includes the gas cost based on the total driving miles
- Annual personnel cost (C_p) includes the salary and benefits of the paramedics

In the proposed economic cost-benefit model, the demand to the CP intervention is estimated in terms of the number of patient visits. This value is then converted to total paramedic full-time equivalent (FTE) needed and total driving miles to calculate the initial and annual cost items. The FTE paramedic need is calculated as

$$p = \frac{nl + nvl + {}^{nvd}/_{s}}{a}, \tag{2}$$

where *n* is the number of HF discharges, *l* is the average patient visit length, *v* is the number of CP visits per patient, *d* is the traveling distance to visit a patient in the service area, *s* is the average speed, *a* is the annual working hours of a FTE paramedic, and *p* is the number of FTE community paramedics required. The total driving miles equals to nvd.

The HRRP penalty reduction due to the CP intervention constitutes the annual saving in the economic model. The penalty reduction in the HRRP is calculated based on the excess readmission ratio which is computed as $e = r_p/r_e$, where r_p is the predicted readmission ratio and r_e is the expected readmission ratio. The predicted readmission ratio is the observed readmission ratio whereas the expected readmission ratio is the readmission rate expected based on national average hospital performance with the same case mix as the hospital in consideration (Zhang et al., 2016). If the excess readmission ratio is greater than 1, the penalty is defined as the excess readmission ratio minus 1 multiplied by the Medicare revenue for HF patients:

$$max\left(r_p/r_e - 1, 0\right)nc, \quad (3)$$

where c is the average Medicare payment per HF discharge. Thus, the annual saving in our model is found by the penalty savings with reduced readmissions due to the CP intervention.

Input Data and Assumptions

The model inputs are used to estimate the demand, the costs, and the benefits associated with CP intervention. We rely on publicly available sources and CP pilot studies for model inputs.

<u>Inputs to Estimate the Demand</u>

The demand to community health interventions depends on the scope of the intervention, the number of patients to be served, and their geographic distribution (Brooks et al., 2014; Jaskiewicz & Tulenko, 2012; Stratis Health, 2017; WECAD, 2011).

The patient visit lengths in both hospital and at home are assumed to be one hour each. HF patients receive several scheduled home visits by community paramedics for a period of 30 days after their discharge (LaFrance & Coffman, 2016). Since the number of home visits may change based on the patients' progress and health status, we assume a Triangular (6, 8, 10) distribution (Zavadsky, 2016).

To estimate the service area size of the hospitals, we combine two data sets: First, we obtain the hospital service areas (HSA) from the Dartmouth Atlas of Healthcare (The Dartmouth Atlas of Health Care, 2016). Hospital service areas are defined by assigning ZIP Codes to the hospital where the greatest proportion of their Medicare residents were hospitalized. Second, we obtain the list of nationwide ZIP Codes and boundaries from (ESRI, 2015). This shapefile allows us to compute the area size of each Zip Code in ArcGIS 10.2. After matching these two data sets by a ZIP Code to HSA crosswalk provided by (The Dartmouth Atlas of Health Care, 2014), we are able to estimate the service area size of the hospitals in square miles. The service areas are assumed to have square shapes. The patient locations are uniformly distributed throughout the service area.

Under the patient prospective payment system (IPPS), each case is classified into a diagnosis-related group (DRG). HF admissions are defined as DRGs 291, 292, and 293. DRG 291 represents a HF with major complication/comorbidity (the most severe case), DRG 292 represents a HF with complication/comorbidity (the moderate case), and DRG 293 represents HF without comorbidities or complications (the least severe case) (Fitch et al., 2015). To obtain a total of annual HF discharges for each hospital, we combine the annual number of discharges for DRGs 291, 292, and 293 from Medicare Inpatient Charge Data FY 2014 provided by (CMS, 2016b). The model includes the assumption of 100% coverage situation which means all the HF discharges receive CP intervention.

<u>Inputs to Estimate the Costs</u>

We assume that the hospitals can allocate part-time paramedics for CP intervention and a vehicle is assigned for each community paramedic staff. A non-transporting EMS vehicle is considered for CP visits since paramedics are not expected to transfer patients to the hospitals. The average vehicle speed of 40 miles per hour and the standard Internal Revenue Service (IRS) mileage reimbursement rate is used as the cost per mile (IRS, 2015). The travel distances between the patients' homes and the hospital are assumed to be Euclidean. The number of workdays in a year is 250 and the workday length for each community paramedic is eight hours. The fringe rate is 30% and the annual costs of medical equipment, non-transporting CP vehicle, and communication equipment and the training cost are estimated based on the previous pilot studies and reports (Colorado Mountain College, 2017; Dengerink, 2012; South California Office of Rural Health, 2014; WECAD, 2011; Zavadsky, 2016). The annual salary of a community paramedic is determined based on the Emergency Medical Technicians and Paramedics annual wage data provided by (Bureau of Labor Statistics, 2016). We do not consider the cost of a medical director, who is responsible for protocol and care plan development/approval (NAEMT, 2015), since the directors can "participate in program-related duties as part of their regular job responsibilities" (Zavadsky, 2016).

Inputs to Estimate the Benefits

CP intervention for HF discharges is an emerging model and there is limited published data on the effectiveness and clinical outcomes. In our model, the impact of CP intervention on reducing HF readmissions is estimated from the outcomes of pilot studies conducted by MedStar, an emergency medical service provider in Fort Worth, TX (Zavadsky & Hooten, 2016). Although these pilot studies are consistent in reporting reduction in readmissions, the reduced readmission rates with CP intervention vary (i.e. 16.3% and 19.1%) (Choi et al., 2016; Hostettler, 2016). Thus, due to the uncertainty in the outcomes of such studies, we define a uniform distribution over the range from 16.3% to 19.1%.

Excess readmission ratios and readmission rates for HF are taken from Medicare Hospital Readmissions Reduction Program data provided by (CMS, 2016a). The average hospital readmission rate is estimated as 21.90%. The average Medicare payment per HF discharge is obtained from Medicare Inpatient Charge Data FY 2014 (CMS, 2016b) and estimated as $7396. The HRRP penalties are computed based on the HRRP algorithm explained in the above section. To simplify the analyses of outcomes, it is assumed that the HRRP penalties are administered at the end of each year based on the excess ratio of that specific year. The model also assumes that the HF readmission penalty is always below the hospital's cap.

The model discounts the future costs and benefits at a 3% annual rate back to the present to adjust for the time value of the money. The time horizon is selected as five years since the equipment and vehicles are assumed to be replaced every five years. An inherent assumption of the model is that the number of HF discharges do not change during the time horizon. The model input values are listed in Table 1.

Table 1. Simulation model inputs

Parameter	Estimate
HF readmission rate with CP intervention	Uniform (16.3%, 19.1%)
Number of home visits after discharge	Triangular (6, 8, 10)
Annual paramedic salary	$31,980
Annual paramedic working hours	2,000
Paramedic fringe rate	30%
Medicare payment per HF discharge	$7,396
Paramedic visit duration (hour)	1
Training cost (per paramedic staff)	$10,000
Cost of medical equipment	$2,000
Cost of a non-transporting CP vehicle	$40,000
Cost of communication equipment	3,500
Speed (miles per hour)	40
Driving cost ($ per mile)	0.126

Scenarios

To consider the variations in service area size and annual HF discharges among hospitals, we define scenarios with the 25th, 50th, and 75th percentile values. For the base case scenario, we use the median values of service size and number of discharges. Other scenarios are created with the combination of the 25th and 75th percentile values. Thus, we have five scenarios (Table 2). The patient case mixture of the hypothetical hospitals in the scenarios are assumed to reflect the national average. The excess readmission ratio is selected as 1.051 which corresponds to the mean excess readmission ratio of the penalized hospitals having the same case mix with national average. We utilized @RISK 7 software (Palisade Corporaion, 2015) to run Monte Carlo simulations for 1,000 iterations for each defined scenario.

Table 1. Scenario setup

Scenarios	Annual HF discharges (number of patients)	Service area size (square miles)
Base case hospital	120	556
Small-sized hospital with a small service area	60	212
Small-sized hospital with a large service area	60	1280
Large-sized hospital with a small service area	215	212
Large-sized hospital with a large service area	215	1280

RESULTS

Table 3 displays the expected outputs of the simulations for each scenario. In the base case scenario, which represents an average hospital in terms of annual HF discharges and service size area, CP intervention for HF discharges can be implemented with a part-time paramedic. However, the expected NPV value is negative. The expected one-time cost and annual cost are $55,500 and $33,845, respectively. The expected HRRP penalty savings afforded from the CP intervention are not high enough for an average hospital to offset these costs. Figure 1 presents the distribution of the forecasted NPVs for the base case scenario. In five-years horizon, the NPV for this particular scenario is expected to be positive with only 5.4% certainty.

Table 2. Simulation outputs for scenarios

Scenarios	FTE CP	Expected Initial Cost	Expected Annual Cost	Expected Annual Savings	Expected NPV	Probability of NPV>0
Base case	0.760	$55,500	$33,845	$45,264	($3,205)	5.4%
Small-sized & small area	0.333	$55,500	$14,537	$22,255	($20,158)	0%
Small-sized & large area	0.428	$55,500	$19,437	$22,255	($42,595)	0%
Large-sized & small area	1.214	$111,000	$52,975	$81,097	$17,790	100%
Large-sized & large area	1.560	$111,000	$70,829	$81,097	($63,973)	0%

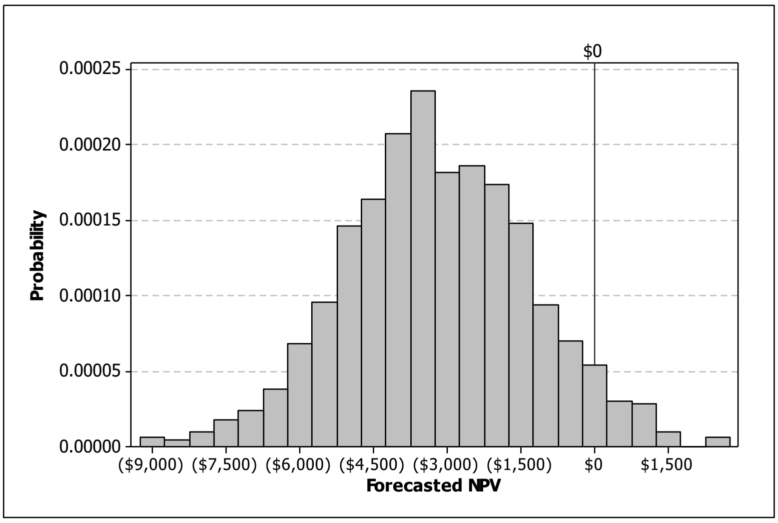

Figure 1. The simulation results for the NPV of the base case scenario

Small-sized hospitals can implement CP intervention for HF discharges with a part-time paramedic and thereby, the initial costs are similar to the base case hospital. In addition, the annual costs of the CP intervention for small-sized hospitals are lower than the base case hospitals. However, the economic benefits from the HRRP penalties avoided are not higher than the total implementation costs. Hence, under the current HRRP penalty model, it is not feasible to implement CP intervention for small-sized hospitals regardless of their service area size. The distribution of the forecasted NPVs are presented in Figure 2.

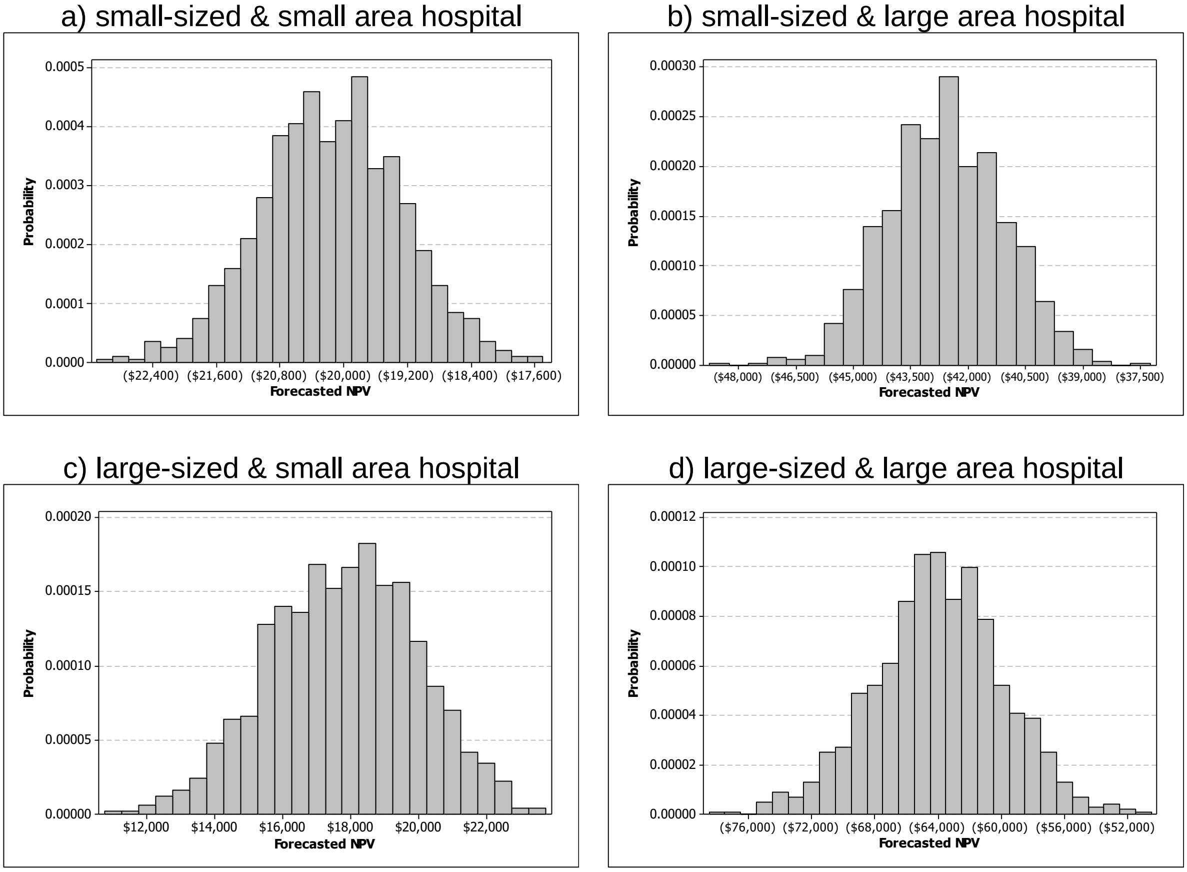

Figure 2. The simulation results for the NPV of the a) small-sized & small area, b) small-sized & large area, c) large-sized & small area, and d) large-sized & large area scenarios

Implementing a CP intervention for HF discharges requires more than one FTE paramedics for large-sized hospitals. Consequently, the initial cost is higher than other cases due to additional investment for equipment and personnel training. Large-sized hospitals in our cases can avoid approximately eighty thousand dollars of HRRP penalties annually due to their high number of HF discharges. However, the feasibility of CP intervention depends on the service size area for such hospitals. The expected annual cost for a large-sized hospital serving to a large area is nearly 34% higher than a large-sized hospital serving to a small area. This is because both the personnel and operating costs are higher due to longer travel times required for home visits. As a result, expected NPVs are always negative for a large-sized hospital serving to a large area. On the other hand, simulation results indicate that the CP intervention for HF discharges is feasible for a large-sized hospital serving to a small area. The break-even point for return on investment occurs after the fourth year.

The large-sized hospital serving to a small area case is considered in the sensitivity analysis since it is the only scenario with positive expected NPV. Ten important model inputs are used for the sensitivity analysis and are varied across defined ranges to understand the importance of each to the NPV. For number of home visits after discharge, we use expected value of the triangular distribution for the point estimate (e.g., 8). All model inputs are varied by ±20%. Figure 3 illustrates a tornado diagram which is a set of one-way sensitivity analysis of these model inputs. The wider the bar on the tornado diagram, the larger influence on the NPV. The maximum and the minimum values of the ranges for each model input are given end of the bars. The Tornado diagram shows that NPV is most sensitive to Medicare payment per HF discharge and number of home visits after discharge. Annual paramedic salary and paramedic visit duration have the larger impacts on NPV. On the other hand, NPV is relatively insensitive to training cost, driving cost, cost of communication equipment, and cost of medical equipment. An important observation from the tornado diagram is that, varying one of the top four influential model inputs (e.g., Medicare payment per HF discharge, number of home visits after discharge, annual paramedic salary, and paramedic visit duration) within the given ranges may result in negative NPVs. However, the CP intervention for HF discharges is always feasible with the variations in the remaining model inputs.

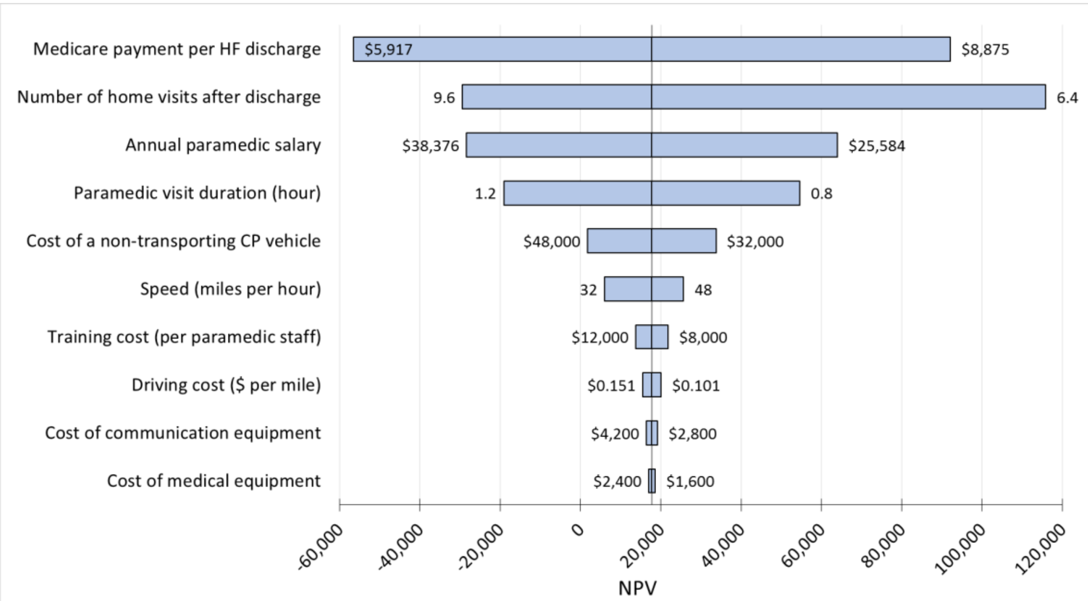

Figure 3. Tornado diagram represents the results of one-way sensitivity analyses

DISCUSSION

Heart failure (HF) imposes a tremendous burden on patients and the U.S. healthcare delivery system. Reducing the high 30-days readmission rates of HF patients is one of the main challenges for this disease. Medicare's Hospital Readmission Reduction Program (HRRP) aims to reduce preventable readmissions by penalizing hospitals with excessive readmissions rates of several diseases including HF (Gu et al., 2014).

Transitional care models have been shown to be successful in reducing HF readmission rates by ensuring effective post-discharge follow-up care which helps HF patients follow through with physicians' instructions and manage their conditions (Albert et al., 2015; Costantino, Frey, Hall, & Painter, 2013; Kansal et al., 2017; Naylor, Aiken, Kurtzman, Olds, & Hirschman, 2011). Community paramedicine (CP), which uses paramedics to provide home visits with the goals of collecting feedback for physicians, enhancing self-management, and thereby avoiding readmission, is an emerging example of such transitional care models. Paramedics are under-utilized yet highly-qualified, relatively inexpensive, and mobile resources (Drennan et al., 2014). Hence, CP intervention can support post-discharge HF management while deploying existing healthcare resources more efficiently.

Currently, the economic feasibility of CP intervention for HF discharges is not clear since paramedic services without transportation of patient are not reimbursed by Medicare and most private insurers (Choi et al., 2016; NAEMT, 2015; Pearson et al., 2014). However, avoiding HRRP penalties through CP intervention can create monetary benefits for hospitals. To demonstrate the economic feasibility of CP intervention for HF discharges, analyses that quantify the detailed costs and benefits of the intervention and account for important parameters, such as service region size, number of visits, and demand, are needed. In this sense, net present value analysis can be useful to quantitatively evaluate the economic feasibility of CP interventions for HF discharges.

In this study, economic evaluation of CP intervention for HF dischargers within hospitals is investigated by cost-benefit analysis. The purpose is to estimate the net present value (NPV) of the intervention for a hospital within a given time horizon. The cost of the intervention involves both several initial and ongoing costs. Specifically, the initial costs explicitly considered in the model are equipment and training costs whereas operating and personnel costs constitute the ongoing costs of the intervention. On the other hand, HRRP penalty reduction is the main financial benefit in the model. To our knowledge, this is the first economic study to evaluate CP interventions for HF discharges considering the implementation costs and the potential financial benefits due avoided HRRP penalties. To deal with the uncertainties in the model inputs, we use Monte Carlo simulation and one-way sensitivity analysis.

The economic feasibility of CP intervention for HF discharges is investigated by implementing our cost-benefit model to different hypothetical hospital scenarios. We organize the scenarios in terms of annual HF discharges (number of patients) and service area size (square miles). In addition to a base case which represents an average-sized hospital serving to an average area, we define four different scenarios: small-sized hospital with a small service area, small-sized hospital with a large service area, large-sized hospital with a small service area and large-sized hospital with a large service area. Hence, we investigate the NPVs of CP intervention for HF discharges for different hospital setting.

The results indicate that CP intervention for HF discharges is not economically feasible for an average hospital under the current HRRP and without any Medicare reimbursement for CP home visits. Similarly, we find the CP intervention for HF discharges is not cost-saving for most scenarios, namely small-sized & small area, small-sized & large area, and large-sized & large area. Notably, the expected annual costs for each of these cases are different to each other. CP intervention for HF discharges is appeared to be feasible only for large-sized hospital with a small service area with a 100% probability of net benefit being positive.

According to the results, the hospital implementation settings, or more precisely the number of HF patients and the size of the service region, matter in determining the economic feasibility of CP intervention for HF discharges. This finding is supporting the arguments of previous studies evaluating CP and other community health interventions (Brooks et al., 2014; Guy, 2014; Jaskiewicz & Tulenko, 2012; Patterson & Skillman, 2013; Stratis Health, 2017; WECAD, 2011).

Our study has several limitations. First, in the NPV formulation, we assume the annual HRRP penalty is determined based on the readmission rate of that that specific year and applied at the end of each year instead of 1 year delay as in the actual application. Second, we do not include medical directors and other supervisors' costs because they can participate in CP related duties as a part of their regular job responsibilities. Third, the model assumes all HF discharges would accept CP intervention and the number of HF patients to be constant during the simulation horizon. In our scenarios, however, we define several hospitals with different number of HF discharges and compare the results. Forth, as in all cost-benefit analysis, our model requires high-quality data to demonstrate accurate results. Our model relies on publicly available data extracted from case studies, official reports, and national statistics. There is currently a lack of randomized controlled trials presenting the effectiveness of CP interventions in reducing HF readmission (Drennan et al., 2014).

CONCLUSION

As an emerging transitional care model, the economic feasibility of community paramedicine (CP) for heart failure (HF) discharges is currently vague. That being the case, fair evaluation of implementation costs and savings associated with reduced Medicare penalties plays a great role in the success of CP interventions. This study aims to utilize cost-benefit analysis to examine economic feasibility of CP for HF discharges. The methodology presented includes a Monte Carlo simulation model to calculate the expected net present value. The results indicate the intervention is not appeared to be cost-saving for an average hospital whereas hospitals serving to many patients in a geographically small area can financially benefit from the intervention. Our results can provide fair evidence of economic feasibility of CP intervention for hospitals with different number of HF patients and service size area. Hence, health administrators and policy makers considering implementing CP intervention or designing reimbursement models can benefit from this study findings.

An interesting research extension involves studying the partnership of a free-standing emergency medical services (EMS) agency with multiple hospitals to implement CP intervention. The current cost-benefit model considers the hospital-based EMS services and calculates the NPV from the hospital's perspective. In a partnership situation, further research can consider cost sharing between the free-standing EMS agency and hospitals, similar to the cost sharing models applied for multiple echelon supply chains (Ustundag & Kilinc, 2013).

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