Mortality, Health Care Use, and Costs of Weaning Center Survivors and Matched Prolonged ICU Stay Controls

Louise Rose, Erind Dvorani, Esha Homenauth, Laura Istanboulian, and Ian Fraser

BACKGROUND: Quantification of long-term survival, health care utilization, and costs of prolonged ventilator dependence informs patient/family decision-making, health care policy, and understanding of specialized weaning centers (SWCs) as alternate care models. Our objective was to compare survival trajectory, health care utilization, and costs of SWC survivors with a matched cohort of ≥ 21-d-stay ICU patients. METHODS: This was a retrospective longitudinal (12 y) case-control study linking to health administrative databases with matching on age, sex, Charlson comorbidity index, income quintiles, and days in ICU and hospital in preceding 12 months. RESULTS: We matched 201 SWC subjects to 201 prolonged ICU survivors (402-subject cohort); 42% had a Charlson score of > 4. Risk of death at 12 months was lower in SWC subjects (hazard ratio [HR] 0.70 [95% CI 0.54–0.91]) adjusting for length of hospital admission (HR 1.02 [95% CI 1.00–1.04]) and number of care location transfers (HR 0.84 [95% CI 0.75–0.93]). By follow-up end, more SWC subjects died, 149 (73%) versus 127 (62%). We found no difference in discharge to home. At 12 months, acute health care utilization was comparable for the entire cohort, except hospital readmission rates (median interquartile range [IQR] 2 [1–3) vs 1 [1–2] d). Median (IQR) cost 12 months after unit discharge was CAD $68,165 ($19,894–$153,475). 12-month costs were higher in the SWC survivors (CAD $82,874 [$29,942–$224,965] vs CAD $55,574 [$6,572–$128,962], $P < .001$). SWC survivors had higher community health care utilization. Regression modeling demonstrated cost was associated with stay and care transfers but not SWC admission. Over 12-y follow-up, health care utilization and costs were higher in SWC survivors. CONCLUSIONS: SWC admission may confer some medium-term survival advantage; however, this may be influenced by selection bias associated with admission criteria. *Key words: Prolonged mechanical ventilation; ventilator weaning; long-term outcomes; administrative database.* [Respir Care 2022;67(3):291–300. © 2022 Daedalus Enterprises]

Introduction

The anticipated increase in numbers of critically ill patients with prolonged dependence on a mechanical ventilator due to an aging and increasingly comorbid population[1] and more recently the SARS-CoV-2 virus pandemic[2] poses a substantial burden on limited public health care resources.[3] Approximately 5–10% of critically ill ventilated adults will require prolonged mechanical ventilation (PMV), using a definition of invasive ventilation for ≥ 21 d.[4-6] Specialized weaning centers (SWCs) provide an alternate model of care for these patients to ICUs. These alternate care models offer a partial solution to the burden of PMV patients due to acute health care cost savings primarily from lower staff-to-patient ratios.[7] Furthermore, SWCs may improve weaning outcomes and short-term survival.[8,9] This many lead to more patients discharged home and fewer patients with ongoing ventilator dependence requiring residential care.[10]

Multiple studies from many countries published over 3 decades report outcomes of PMV subjects managed in various care locations including SWCs.[10,11] However, comparative data on longitudinal outcomes including mortality, health care utilization, and costs after discharge of SWC subjects with a control group of subjects requiring PMV who remain in an ICU setting without transfer to an SWC are lacking. Therefore, it is challenging to quantify the contribution to long-term outcomes of patient transition to an SWC compared to remaining in an ICU setting. Quantification of longer-term outcomes such as post-discharge health care utilization and associated costs helps to inform understanding of use of SWCs as a viable and cost-effective alternate model of care to patients remaining in the ICU. These data will inform policy regarding public health care spending as well as patient and family decision making regarding a transition in care location. Although SWCs in either an acute or post-acute setting are a relatively common component of some

health care systems such as the United States[12] and Italy,[13] many other countries have limited or no access to SWCs.[6] Furthermore, no data describe the proportion of critically ill patients requiring PMV that are admitted to an SWC within these various jurisdictions.

SEE THE RELATED EDITORIAL ON PAGE 375

Few studies of PMV subjects report mortality beyond one year or consider a comparator group. A recent cohort study conducted in a German SWC reported a 5-y survival rate of 37%, with duration of ventilation identified as a predictor of survival.[14] In a retrospective population-based Canadian cohort study, we previously identified estimated 5-y mortality was higher for subjects who received ventilation in an ICU for > 21 d compared to subjects ventilated for fewer days.[15]

Our objectives in this study were to compare survival trajectory (minimum follow-up 1 y, maximum 11 y), home discharge, health care utilization (acute care and community based), and health care costs of patients discharged from an SWC in Toronto, Canada, compared to a matched cohort of patients with a minimum ICU stay (length of stay [LOS]) of 21 d without SWC transfer.

QUICK LOOK

Current knowledge

Patients experiencing prolonged ICU stays experience worse short-term outcomes compared to short-stay ICU patients including poor survival to one year. These patients require a shift in priorities of care to a more rehabilitative focus. Specialized weaning centers (SWCs) are one care model that provides this rehabilitative focus and might influence longer-term patient outcomes.

What this paper contributes to our knowledge

We found that 12 months after unit discharge SWC subjects had lower risk of death when controlling for length of hospital stay and number of care location transfers. Longer-term follow-up found more SWC subjects had died. Patterns of health care utilization differed, with SWC survivors using more community and specialist clinic-based services. Given the limitations of case-control studies, to truly understand the effect on long-term outcomes of an SWC admission compared to remaining in an ICU, a carefully designed randomized controlled trial is needed.

Methods

Study Design, Setting, and Sample

We conducted a retrospective longitudinal matched cohort study linking the clinical and quality database of the prolonged-ventilation weaning center (PWC), Toronto, Canada, to health administrative databases for the province of Ontario, held at Institute for Clinical Evaluative Sciences (ICES). The health administrative databases contain anonymized data for all Ontario residents and have been shown to be both valid and reliable.[16] Using the PWC database, we identified a cohort of patients discharged alive from January 2004–April 2016 (12 y). Controls had a minimum ICU stay of 21 d, no SWC admission, and were discharged alive from ICU. Controls were identified considering all mechanically ventilated ICU admissions in the health administrative databases. We performed 1:1 matching using the following characteristics: age category, sex, income quintile (high vs low), and Charlson comorbidity index category. To further match in terms of illness prior to

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the index admission, we matched on number of days in ICU and days in hospital prior to the index admission. Controls had their ICU admission in the same 12-month period as cases.

SWC subjects were admitted following an ICU admission in the greater Toronto area and southern Ontario with an estimated population 6.7 million and approximately 720 ICU beds. SWC admission criteria include medical stability, ventilation for a minimum of $\geq$ 21 d, and considered by the referring and SWC clinical teams following medical review "weanable" within 90 d. Reasons for not admitting to the SWC include hemodialysis, recent high spinal cord injury, and patient inability to be involved in directing their care. These criteria are similar to those used in other SWCs in Canada and other countries.[17,18] The decision to refer a patient to the SWC is at the discretion on the ICU clinical team. The SWC team reviews all referred patients to confirm admission criteria are met. Due to limitations on bed availability (the SWC has a bed capacity of 4–6 weaning patients), patients may remain in ICU on a waiting list; within the greater Toronto area, there are no other SWCs or step-down units in which an ICU patient is weaned. On SWC admission, all patients have a tracheostomy in situ. The 90-d interprofessional program has been described in detail previously[7] and comprises individualized weaning and mobilization treatment plans; speech language pathologist, occupational therapy, dietetic, psychiatric, and social work management; and, if required, palliative, pain, and wound care consultation. When weaned, or completion of the 90-d program if not weaned, patients are repatriated to the referring institution, which for some weaned and all nonweaned patients required ICU readmission. For the prolonged ICU stay matched cohort, subjects would only be readmitted to an ICU if clinical deterioration or new complications occurred within the same episode of care or for an entirely new episode of care.

Data Sources

We linked our SWC cohort using unique encoded identifiers to health administrative databases to identify (1) hospitalizations and in-hospital death from the Discharge Abstract Database, (2) emergency department (ED) presentations from the National Ambulatory Care Reporting System, (3) physician billings including procedures from the Ontario Health Insurance Plan database,[19] (4) drug costs from the Ontario Drug Benefit claims (costs for prescriptions to individuals eligible for provincial coverage), (5) in-patient rehabilitation from the National Rehabilitation Reporting System, (6) facility-based continuing (residential) and long-term care services from the Continuing Care Reporting System and the Client Profile Database, (7) same-day surgeries from the Same Day Surgery Database, (8) in-patient mental health stays from the Ontario Mental Health Reporting System, (9) home care services from the Home Care Database, and (10) deaths outside of hospital from the Registered Persons Database. Following well-established methods, both neighborhood income and urban/rural place of residence were ascertained using postal codes and linking to Statistics Canada census data.[20]

Outcomes

We determined outcomes to April 31, 2017, with a minimum follow-up of 1 y, maximum follow-up of 11 y. We measured mortality at 6 months, annually to 5 y, and over the maximum follow-up period. Overall survival among cases and controls was calculated. We determined time-to-home discharge from unit discharge in SWC and ICU survivors.

We determined health care utilization including number of admissions to hospital and ICU, presentations to the ED, number of d admitted to hospital and to the ICU, general practitioner (GP)/nurse practitioner and specialist physician visits, in-patient rehabilitation unit stays, same-day surgeries, in-patient mental health stays, home care services used, days in complex continuing or long-term care, and publicly funded drug claims. We compared health care utilization and costs in the 12 months before the index hospital admission and after SWC/ICU discharge at 6 months, 1 y, and overall duration of follow-up (11 y).

We calculated health care utilization costs in 2017 Canadian dollars using established patient-level costing methodology (USD 1: CAD $1.25).[21] We calculated overall costs as well as costs associated with acute care hospital admissions, ED and ambulatory clinic visits, same-day surgery, rehabilitation, complex and continuing care, in-patient mental health, residential long-term care, home care, physician and nonphysician billings, and out-of-hospital publicly funded drug costs.[22]

Ethical Considerations

The use of data held at ICES was authorized under section 45 of Ontario's Personal Health Information Protection Act according to privacy regulations of ICES. The collection of data for the PWC clinical and quality database is approved by the Research Ethics Board of the Michael Garron Hospital.

Statistical Analyses

We compared baseline characteristics of cases and controls using descriptive statistics including chi-square tests for categorial data, Cochran-Armitage tests for

Table 1. Baseline Characteristics

	SWC $n = 201$	Prolonged ICU $n = 201$	P
Female	113 (49.6)	94 (46.8)	> .99
Age, y			
Mean (SD)	66.1 (14.0)	66.5 (13.3)	.77
18–34	9 (3.9)	6 (3.0)	> .99
35–49	17 (7.5)	14 (7.0)	
50–64	62 (27.2)	58 (28.9)	
65–79	98 (43.0)	88 (43.8)	
≥ 80	42 (18.4)	35 (17.4)	
Income quartiles 1, 2 (lowest)	124 (54.4)	110 (54.7)	> .99
Income quartiles 3, 4, 5 (highest)	104 (45.6)	91 (45.3)	
Charlson comorbidity index			
0	12 (5.3)	9 (4.5)	> .99
1–2	61 (26.8)	53 (26.4)	
3–4	60 (26.3)	54 (26.9)	
> 4	95 (41.7)	85 (42.3)	
Mean (SD) days in ICU prior to index admission	1.3 (5.6)	1.2 (5.5)	.9
Mean (SD) days in hospital prior to index admission	7.2 (15.8)	7.1 (15.4)	.97

Data are shown as *n* (%) unless otherwise noted.
SWC = specialized weaning center

ordinal data, and *t* tests for continuous data. We created Kaplan-Meier curves with 95% Hall-Wellner bands to describe survival after unit discharge and ability to return home stratified by case/control status with individuals censored at follow-up end (March 31, 2017). Time zero for these models was ICU discharge for the prolonged ICU stay survivors and SWC discharge for those subjects experiencing an ICU and SWC admission in the same episode of care. We used multivariable Cox proportional hazard modeling of survival and time to return to home. Variables a priori considered for inclusion in these models were age, sex, income quintile, Charlson comorbidity index, stay of index hospital admission, and number of transfers in locations of care.

We reported mean (SD) and median (interquartile range [IQR]) rates and duration (hospital and ICU LOS) of health care utilization and health care costs and compared those incurred before admission and after discharge using one-way ANOVA for means and the Kruskal-Wallis tests for medians. We created multivariable linear regression models with a log link and gamma distribution function to examine variables associated with costs. A P value $< .05$ was taken to indicate differences between cases and controls. We conducted analyses in SAS Enterprise Guide 7.15 (SAS Institute, Cary, North Carolina).

Results

We identified 261 survivors in the PWC database; 33 were excluded (13 as unable to be linked or duplicate records or without an ICU admission prior to PWC admission; these subjects were admitted for noninvasive ventilation titration not PMV) and 20 admitted after study period end, resulting in 228 subjects. We were able to match 201 SWC subjects to 201 prolonged ICU stay survivors (402-subject cohort) using our full-matching criteria with an additional 27 subjects by removing number of ICU and hospital days in the year prior to the index admission. We provide demographic and outcomes data on this 456-patient matched cohort in the supplementary material for comparison (see the supplemental materials at http://www.rc.rcjournal.com). Baseline matching characteristics for the 402-subject cohort are shown in Table 1. Forty-two percent of subjects had a Charlson comorbidity index of > 4, indicating substantial existing comorbidity in these subjects.

Overall median (IQR) hospital stay for the entire episode of care that included the SWC/ICU admission was 82 (39–154) d. Hospital length of stay was longer for subjects with an SWC admission, 134 (89–237) versus 41 (24–76) d. SWC subjects experienced more transfers across care locations following unit discharge than the prolonged ICU stay group, (mean SD) of 1.6 (1.5) (maximum 9) transfers versus 0.8 (1.0) (maximum 5).

Mortality and Discharge Disposition

Fewer hospital deaths in the period following unit discharge occurred in SWC group, 52 (26%) versus 79 (39%). One-to-three year survival was higher in the SWC group (Fig. 1) with fewer deaths at 1 y, 84 (42%) versus 116

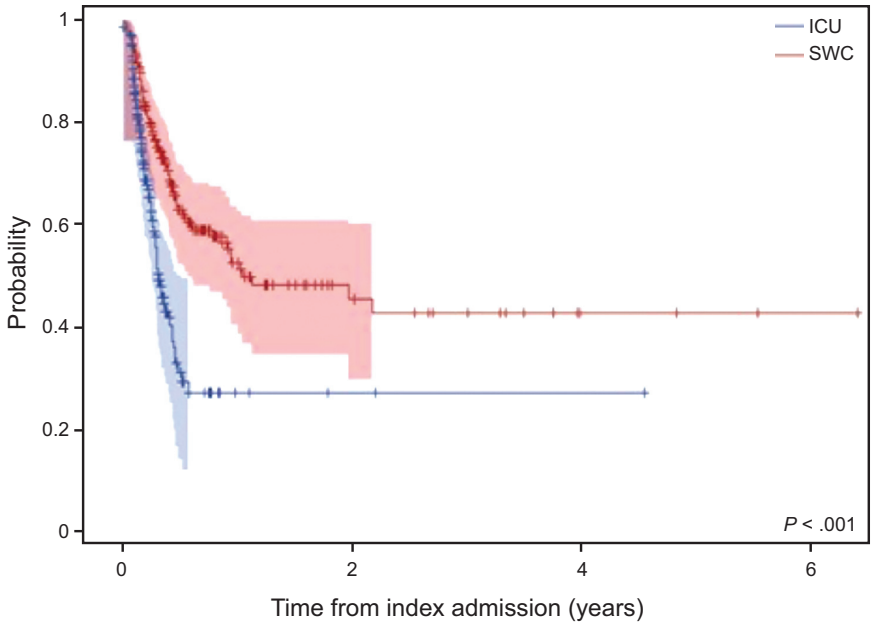

Fig. 1. Probability of discharge home. Shaded areas represent 95% Hall-Wellner bands. SWC = specialized weaning center.

(58%); 2 y, 103 (51%) vs 120 (60%); and at 3 y, 118 (59%) versus 123 (61%). By year 4, the number of deaths was the same, 125 (61%), in each group. By the end of follow-up, more SWC subjects had died than the prolonged ICU cohort, 149 (73%) versus 127 (62%). Of the 402-subject cohort, 121 (30%) were discharged home (with or without home support services), 131 (33%) died in hospital, and 83 (21%) were transferred to long-term or complex continuing care; 67 (17%) were lost to follow-up within the administrative databases due to multiple transitions.

In our multivariable Cox proportional hazard model adjusting for index hospital stay and number of transfers in locations of care and risk of death in our matched cohort was lower in SWC subjects (HR 0.70, [95% CI 0.54–0.91). Increasing length of index hospital admission (HR 1.02 [95% CI 1.00–1.04]) (per month increase) was associated with decreased survival, whereas fewer care location transfers were associated with increased survival (HR 0.84 [95% CI 0.75–0.93]) (per transfer) (see the supplemental materials at http://www.rc.rcjournal.com).

Although the proportion of subjects in each group discharged home was similar, 62 (31%) versus 59 (29%), as shown in the Kaplan-Meier curve, SWC subjects remained in a hospital or long-term care setting for longer (Fig. 2). There was no difference in the ability to return home between groups (HR 1.33 [95% CI 0.92–1.93], $P = .12$). Increasing duration of index hospital stay (HR 0.59 [95% CI 0.53–0.67]) (per month increase) and number of care transfers (HR 0.58 [95% CI 0.48–0.71]) (per 1 transfer increase) were associated with decreased likelihood of return to home.

Health Care Utilization

In the 6 months and 12 months following unit discharge, the use of acute care was similar between the matched cohort. There were no differences in the proportion of subjects presenting to ED or the rate of ED visits, the proportion of subjects requiring hospital readmission, number of days in hospital, number of in-patient rehabilitation stays, or same-day surgeries. However, the rate of hospital readmissions at 12 months was higher in SWC subjects (median [IQR] 2 [1–3] vs 1 [1–2] d). A higher proportion of SWC subjects required ICU readmission at 6 months (26% vs 11%, $P < .001$); however, this difference had lessened at 12 months (31% vs 24%, $P = .12$). The profile of community health care utilization was different in the matched cohort, with SWC subjects having more median (IQR) physician billing claims (144 [66–237) vs 102 [8–208], $P < .001$), more GP visits (16 [2–39] vs 10 [0–27], $P = .02$), and more specialist physician visits (64 [23–130] vs 41 [1–97], $P < .001$) at 12 months (Table 2).

When considering the entire 12-y follow-up period health care utilization, nearly all forms of acute and community health care utilization were higher in the SWC group. Median (IQR) d in long-term care and publicly funded drug claims were similar.

Health Care Costs

In the 6 months, 12 months, and over the entire follow-up period following unit discharge, the overall median

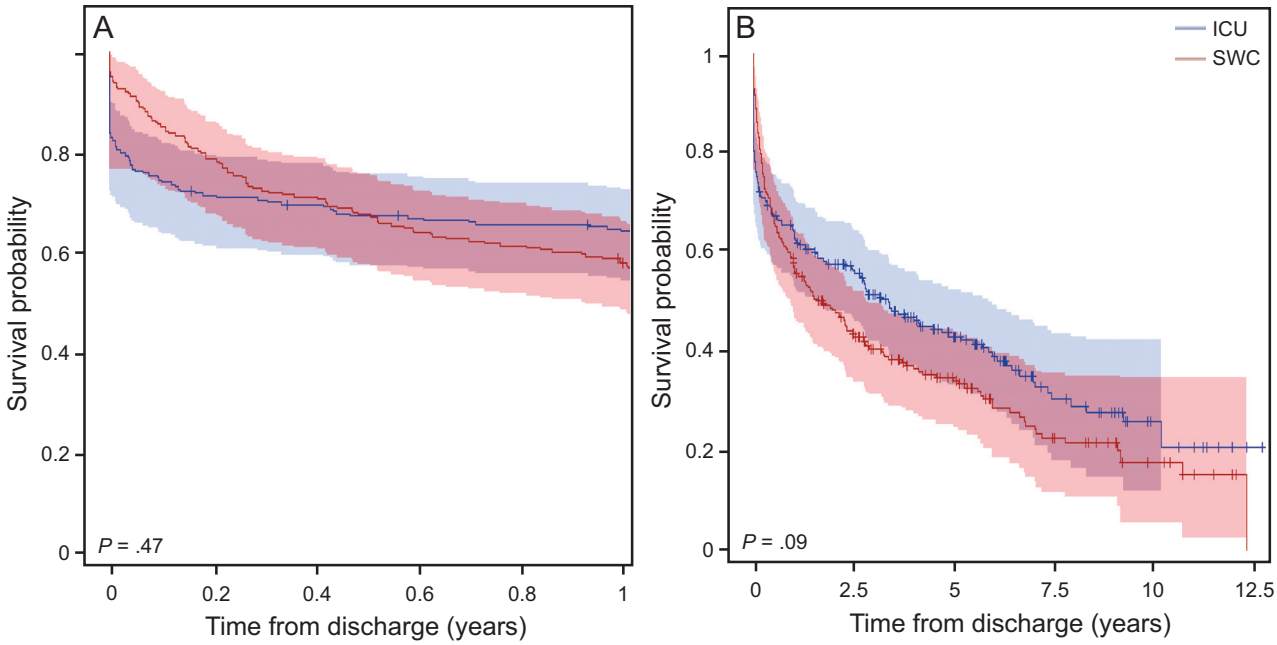

Fig. 2. Probability of survival at A: 1 y and B: 12 y. Shaded areas represent 95% Hall-Wellner bands. SWC = specialized weaning center.

(IQR) cost per patient of the overall cohort to the public health care system was CAD $50,439 ($9,486–$118,570), CAD $68,165 ($19,894–$153,475), and CAD $99,858 ($30,601–$198,741), respectively. Highest-cost categories are shown in (Table 3), with SWC subjects incurring higher costs in all high-cost categories. SWC subjects had higher in-patient rehabilitation median costs at 6 months (P = .01); prolonged ICU stay subjects had higher long-term care costs at 12 months (P = .03). There were no differences in 6- and 12-month costs for ED visits, same-day surgery, publicly funded drugs, and home care services.

Multivariable linear regression modeling demonstrated no difference in costs at 6 and 12 months by care location (ie, SWC vs ICU) in the matched cohort when adjusting for length of hospital admission and care location transfers (ie, to another acute care facility, rehabilitation, and/or complex continuing care) during the index admission. Both these variables were associated with increased costs (Table 4).

Discussion

To address gaps in knowledge, we conducted this study to compare long-term outcomes in terms of survival, ability to return home, health care utilization, and costs of a matched cohort of subjects surviving SWC admission to those of subjects surviving a prolonged (≥ 21 d) ICU stay without SWC admission. At 12 months after unit discharge, we found that SWC subjects had lower risk of death when controlling for length of hospital stay and number of care location transfers. However, by the end of follow-up, more SWC subjects had died. In the 12 months after discharge, patterns of health care utilization differed, with SWC survivors using more community and specialist clinic-based services. Overall cost per subject to the health care system within these 12 months was substantial (CAD $68,165) and associated with length of hospital admission and number of care location transfers but not care location (ie, SWC vs ICU). For the entire 12-y follow-up, health care utilization and costs were higher in SWC survivors.

In this matched cohort, we found increased mortality in subjects with prolonged ICU stay compared to SWC subjects despite SWC subjects requiring a longer hospital stay. As with other studies,[15,23] increased mortality was associated with increasing hospital stay. We hypothesize this excess mortality might be explained in part by a decision to withdraw life-supporting treatment in the prolonged ICU stay group as demonstrated in the sharp early decline in survival in the Kaplan-Meier curve and significantly higher hospital mortality.

SWCs, including the center contributing data in this study, generally have reasonably stringent admission criteria that include an expectation that the patient is potentially weanable.[24] This introduces selection bias that is challenging to address in observational research despite best efforts at cohort matching. As shown in our supplementary material (see the supplemental materials at http://www.rc.rcjournal.com), survival was not different in the matched cohort that did not include matching on acute health care

Table 2. Health Care Utilization of Subjects 6 and 12 Months After Unit Discharge

	6 Months			12 Months		
	SWC *n* (%)	ICU *n* (%)	*P*	SWC *n* (%)	ICU *n* (%)	*P*
ED visits	67 (31.3)	74 (36.8)	.46	95 (47)	100 (50)	.62
Median (IQR)	0 (0–1)	0 (0–1)	.44	0 (0–2)	0 (0–2)	.31
Hospital admissions	200 (99.5)	184 (91.5)	< .001	201 (100)	201 (100)	
Median (IQR)	2 (1–2)	1 (1–2)	< .001	2 (1–3)	1 (1–2)	< .001
Hospital d						
Median (IQR)	0 (0–11)	0 (0–4)	.10	2 (0–19)	1 (0–22)	.26
ICU admissions	52 (25.9)	22 (10.9)	< .001	62 (31)	48 (24)	.12
Median (IQR)	0 (0–1)	0	< .001	0 (0–1)	0	.18
ICU d						
Median (IQR)	0 (0–2)	0	< .001	0 (0–4)	0	.18
In-patient rehab stays	39 (19.4)	21 (10.4)	.01	44 (19)	54 (24)	.25
Median (IQR)	0	0	.01	0	0	.08
Same-day surgeries	15 (7.5)	23 (11.4)	.17	25 (12)	31 (15)	.39
Median (IQR)	0 (0–0)	0 (0–0)	.18	0 (0–0)	0 (0–0)	.38
Complex continuing care	55 (27.4)	27 (13.4)	< .001	57 (28)	37 (18)	.02
Median (IQR) d	0 (0–2)	0	< .001	0 (0–2)	0	.007
Long-term care	7 (3.5)	12 (6.0)	.24	8 (4)	19 (10)	.03
Median (IQR) d	0	0	.22	0	0	.02
OHIP claims	201 (100.0)	196 (97.5)	.02	201 (100)	198 (99)	.08
Median (IQR)	103 (45–186)	55 (7–131)	< .001	144 (66–237)	102 (8–208)	< .001
GP/NP visits	159 (79.1)	139 (69.2)	.02	162 (81)	144 (72)	.04
Median (IQR)	10 (1–28)	5 (0–18)	.003	16 (2–39)	10 (0–27)	.02
Specialist visits	194 (96.5)	150 (74.6)	< .001	194 (97)	152 (76)	< .001
Median (IQR)	43 (15–109)	22 (0–55)	< .001	64 (23–130)	41 (1–97)	< .001
Drug benefit claims	98 (48.8)	111 (55.2)	.19	106 (53)	118 (59)	.23
Median (IQR)	0 (0–32)	4 (0–30)	.31	3 (0–57)	14 (0–70)	.24
Home care services	100 (49.8)	94 (46.8)	.55	111 (55)	104 (52)	.48
Median (IQR)	0 (0–12)	0 (0–7)	.54	1 (0–24)	1 (0–32)	.72

SWC = specialized weaning center
ED = emergency department
IQR = interquartile range
OHIP = Ontario Health Insurance Plan
GP = general practitioner
NP = nurse practitioner

Table 3. Median Health Care Costs (2017 CAD$) of Subjects Following Unit Discharge

	SWC	Prolonged ICU	*P*
Total 6-mo costs	$71,422 ($25,448–$136,951)	$27,052 ($3,915–$76,599)	< .001
Total 12-mo costs	$82,874 ($29,942–$224,965)	$55,574 ($6,572–$128,962)	< .001
Total overall costs	$134,664 ($67,904–$298,323)	$68,425 ($6,572–$140,927)	< .001
6-mo hospitalization	$33,100 ($3,434–$107,650)	$11,039 ($2,660–$46,622)	< .001
12-mo hospitalization	$38,560 ($5,922–$132,309)	$29,052 ($3,697–$71,527)	.03
Overall hospitalization costs	$58,272 ($19,547–$162,075)	$30,848 ($4,114–$78,650)	< .001
6-mo physician billing	$5,685 ($2,406–$11,807)	$2,197 ($345–$5,530)	< .001
12-mo physician billing	$7,722 ($3,550–$14,211)	$4,427 ($481–$10,862)	< .001
Overall physician billing	$15,382 ($7,140–$27,154)	$6,425 ($492–$15,931)	< .001

utilization in the one year prior to the index admission. In this cohort, we concluded the SWC cohort was more medically fragile due to higher rates of ICU and hospital admission in the 12 months preceding the index admission, leading to rematching. One conclusion from our data is that to truly understand the effect on long-term outcomes of an

Table 4. Multivariable Analyses of Variables Associated With 6- and 12-Month Costs

	Estimate	Wald 95% CI		*P*
6-Month Costs				
Intercept	10.35	10.16	10.53	< .001
SWC (reference = prolonged ICU stay)	−0.02	−0.27	0.22	.87
In-hospital transfer (per 1 transfer increase)	0.24	0.14	0.34	< .001
LOS in hospital (per mo increase)	0.10	0.07	0.14	< .001
12-Month Costs				
Intercept	10.77	10.60	10.94	< .001
SWC (reference = prolonged ICU stay)	−0.20	−0.44	0.04	.10
In-hospital transfer (per 1 transfer increase)	0.27	0.17	0.37	< .001
LOS in hospital (per mo increase)	0.10	0.07	0.13	< .001

Cohort is already matched on age, sex, income, Charlson comorbidity index, number of d in ICU, and days in hospital prior to the index admission.
SWC = specialized weaning center
LOS = length of stay

SWC admission compared to remaining in an ICU a carefully designed randomized controlled trial is needed. However, given the limited availability of SWC beds compared to ICU beds, conduct of such a trial would be challenging.

Interestingly, despite the aforementioned concerns about selection bias, acute health care utilization in the 12 months following discharge was relatively similar. SWC subjects experienced more ICU readmissions at 6 months; however, patterns of ICU readmission at 12 months were similar. This may be reflective of the SWC repatriation policy. This requires readmission to the transferring ICU for nonweaned patients and in some cases for weaned patients while a bed in an alternate setting is secured. ICU readmission rates and days in ICU were similar between the groups. Although SWC subjects experienced more hospital readmissions, ED presentations, hospital, and ICU days were comparable. SWC subjects did require more community and specialist out-patient clinic-based services. Understanding the burden of these patients on these services is essential for supporting their provision as the number of individuals with prolonged dependence on a mechanical ventilator continues to increase.[25,26]

Public health care costs were substantial at 2017 CAD $68,165 per patient at 12 months, higher for SWC subjects. Using similar database and costing methods, we previously reported 12-month costs of 11,594 subjects who received PMV (> 21 d) at 2013 CAD $32,526, with costs of subjects ventilated for ≤ 21 d at 2013 CAD $13,657.[15] High costs are likely due to the sequalae of critical illness as well as preexisting comorbidity.[27] Finding comparable recent data in similar populations from other countries is challenging as few studies consider nonhospital costs or subjects experiencing protracted index admissions. A 2010 study of PMV survivors conducted in 5 US centers reported mean 12-month costs per subjects as USD $306,135,[28] which is substantially higher than our Canadian costs and likely due to differences in funding models. Studies reporting costs of ICU survivors with shorter ICU stays consistently report much lower costs [29,30] than ours, confirming that survivors of protracted ICU admission with or without an SWC admission incur substantially higher public health care costs than most ICU survivors. These data that demonstrate high costs following unit discharge emphasize the need from a health systems perspective to prioritize strategies that may prevent prolonged ventilator dependence.[31]

In this study, we used cohort matching based on a number of variables available in the health administrative databases including patterns of acute health care utilization in the 12 months prior to the index admission. However, limitations of using health administrative databases mean that we were unable to match on other clinical parameters such as severity of illness or reasons for PMV. Also, associations between location of care and long-term outcomes may be due to residual confounding from unmeasured factors. Data on clinical decision-making are unavailable, which may have resulted in selection bias influencing our outcomes of interest. Although we hypothesize that the increased mortality in the prolonged ICU stay group was due to withdrawal of care, we cannot confirm this hypothesis in our data. Finally, generalizability to other health care contexts may be limited due to differences in SWC admission criteria.

Conclusions

Compared to a matched cohort of ≥ 21-d-stay ICU subjects, SWC survivors had improved medium-term survival but no difference in return to home. Patterns of

health care utilization differed in the first 12 months following unit discharge, with SWC survivors using more community-based services. Health care costs after discharge were substantial and higher in SWC survivors. We hypothesize the demonstrated survival benefit may be influenced by selection bias associated with SWC admission criteria. Given the challenges of observational data sets, to truly understand the effect on long-term outcomes of an SWC admission compared to remaining in an ICU, a carefully designed randomized controlled trial is needed; however, conduct of such as trial would not be without challenges.

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