



ORIGINAL ARTICLE

Outcomes of the patients in the respiratory care center are not associated with the seniority of the caring resident

Ming-Ju Tsai ^{a,c}, Ju-Yin Huang ^b, Po-Ju Wei ^a, Cheng-Yuan Wang ^a, Chih-Jen Yang ^{a,c,d},
Tung-Heng Wang ^{a,b,e}, Jhi-Jhu Hwang ^{a,b,e,*}

^a Division of Pulmonary and Critical Care Medicine, Department of Internal Medicine, Kaohsiung Medical University Hospital, Kaohsiung Medical University, Kaohsiung, Taiwan

^b Respiratory Therapy Team, Division of Pulmonary and Critical Care Medicine, Department of Internal Medicine, Kaohsiung Medical University Hospital, Kaohsiung Medical University, Kaohsiung, Taiwan

^c Graduate Institute of Medicine, College of Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan

^d Department of Internal Medicine, School of Medicine, College of Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan

^e Department of Respiratory Therapy, College of Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan

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Abstract Although many studies show that the experience level of physicians is significantly associated with the outcomes of their patients, little evidence exists to show whether junior residents provide worse care than senior residents. This study was conducted to analyze whether the experience level of residents may affect the outcomes of patients cared for in a well-organized setting. We conducted a 7-year retrospective study utilizing statistical data from a respiratory care center (RCC) in a medical center between October 2004 and September 2011. In addition to the two medical residents who had been trained in the intensive care unit (ICU), the RCC team also included attending physicians in charge, a nurse practitioner, a case manager, a dietitian, a pharmacist, a social worker, registered respiratory therapists, and nursing staff. Weaning from mechanical ventilation was done according to an established weaning protocol. The 84 months analyzed were classified into five groups according to the levels of the two residents working in the RCC: R2 + R1, R2 + R2, R3 + R1, R3 + R2, and R3 + R3. The monthly weaning rate and mortality rate were the major outcomes, while the mean ventilator days, rate of return to the ICU, and nosocomial infection incidence rate were the minor outcomes. The groups did not differ significantly in the monthly weaning rate,

* Corresponding author. Division of Pulmonary and Critical Care Medicine, Department of Internal Medicine, Kaohsiung Medical University Hospital, Kaohsiung Medical University, Number 100, Tzyou 1st Road, Kaohsiung 807, Taiwan.

E-mail address: jjhwang@ms4.hinet.net (J.-J. Hwang).

mortality rate, mean ventilator days, rate of return to the ICU, or nosocomial infection incidence rate ($p > 0.1$). Further analysis showed no significant difference in the monthly weaning rate and mortality rate between months with a first-year resident (R1) and those with two senior residents ($p > 0.2$). Although the weaning rate in the RCC gradually improved over time ($p < 0.001$), there was no significant difference in the monthly weaning rate between the groups after adjusting for time and disease severity ($p > 0.7$). Thus, we concluded that in a well-organized setting, the levels (experiences) of residents did not significantly affect patient outcomes. This result may be attributed to the well-developed weaning protocol and teamwork processes in place, which avoid a large effect from any single factor and provide stable and high-quality care to the patients.

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Introduction

In Taiwan, an integrated delivery system (IDS) has been developed for patients who depend on mechanical ventilator support for more than 21 days. Information on all patients enrolled in this system is reported to the National Health Insurance Bureau (NHIB). The patients with stabilized clinical conditions but having difficulty in weaning from the ventilator are transferred from an intensive care unit (ICU) to a respiratory care center (RCC) within 21 days after starting mechanical ventilation. Therefore, an RCC is set as a step-down unit for caring for patients transferred from an ICU and for weaning them from mechanical ventilator support. Such patients may be treated in an RCC for a maximum of 42 days, after which they are transferred to an extended care facility such as a respiratory care ward (RCW). However, they may return to an acute care facility as clinically indicated, especially when their clinical condition deteriorates. Although their disease severity is theoretically lower than those in the ICU, patients in the RCC are still considered to be critically ill [1].

Results of many studies to date have shown that physician experience is significantly associated with patient outcomes [2–6]. However, it is to be noted that these studies did not include medical residents under training and little evidence exists to show whether junior residents provide worse care to their patients. Because residents in teaching hospitals care for patients under the supervision of an experienced attending physician, the association between residents' experience and patient outcomes may be very weak.

A rule for hospital accreditation has required that the residents caring for patients in the RCC should be senior residents (i.e., those more senior than first-year residents). This rule may have been set under the assumption that senior residents provide better care to these critically ill patients in the RCC, but no evidence to date supports this idea. This study was therefore conducted to demonstrate whether the seniority of caring residents affects patient outcomes in the RCC.

Materials and methods

Study design

This is a 7-year retrospective observational study conducted in the RCC of a medical center in southern Taiwan.

Upon implementation of the IDS for respiratory care as mandated by the NHIB in Taiwan, this 16-bed facility functioned as a step-down unit for respiratory care. Adult patients were referred to the facility from various ICUs (medical ICUs, coronary care unit, surgical ICU, cardiovascular surgical ICU, neurological ICU, neurosurgical ICU, and the burn center). For admission to the RCC, the patients must be hemodynamically stable without the use of vasoactive drugs and must have adequate gas exchange under mechanical ventilator support with inspired oxygen fraction levels less than 60% and positive end-expiratory pressures less than 10 cmH₂O.

Two medical residents rotate into the RCC each month. Both have received previous training in medical ICU for at least 1 month. The two residents work in 24-hour shifts. In addition to the two residents, the RCC team also includes attending physicians in charge, a nurse practitioner, a case manager, a dietitian, a pharmacist, a social worker, registered respiratory therapists, and nursing staff. Besides, medical chief residents provide 24-hour backup support for clinical consultation and bedside procedures. All the attending physicians are certified specialists in both pulmonary and critical care. Weaning from mechanical ventilation was done according to the recommendations in an established weaning protocol.

As a part of quality-control measure in the RCC, data are collected every month and reported to the NHIB. The monthly average acute physiology and chronic health evaluation II (APACHE-II) score is calculated from the data when the patients are admitted to the RCC. The monthly weaning rate is defined as the number of patients who are successfully weaned for ≥ 5 days divided by the number of patients who leave the RCC (including those who are transferred to the ward or RCW, returned to the ICU, or expire). The monthly mortality rate is determined by the number of expired patients (including those discharged in dying condition) divided by the total number of patients. The monthly mean ventilator days is defined as the total number of days on the ventilator for all patients who leave the RCC divided by the number of patients who leave the RCC in the month. The rate of return to the ICU is calculated as the number of patients returned to the ICU divided by the total number of patients for the month. The nosocomial infection incidence rate is defined as all events of nosocomial infection divided by the cumulative patient days of the month, expressed per thousand (‰).

The monthly statistical data in the RCC between October 2004 and September 2011 were retrieved from the records maintained. The levels of the two residents [first-year resident (R1), second-year resident (R2), or third-year resident (R3)] caring for patients in the month were also recorded as the designation for the experiences of residents. The 84 months analyzed were classified into five groups according to the levels of the two residents: R2 + R1 (a second-year resident and a first-year resident), R2 + R2 (two second-year residents), R3 + R1 (a third-year and a first-year resident), R3 + R2 (a third-year and a second-year resident), and R3 + R3 (two third-year residents). The monthly weaning rate and mortality rate were the major outcomes, while mean ventilator days, rate of return to the ICU, and nosocomial infection incidence rate were minor outcomes.

The study protocol was approved by the Institutional Review Board of Kaohsiung Medical University Hospital (KMUH-IRB-20110387), which waived the requirement for patient consent.

Statistical analysis

Data were entered and analyzed using JMP statistical software (version 8.0, SAS Institute Inc., Cary, NC, USA). All the study results are presented as mean values with standard deviations (means \pm SD) or percentages unless elsewhere indicated, with least square means with standard errors (adjusted means \pm SE) presented for adjusted results. A simple linear regression model with correlation coefficient was used to show the changes in continuous variables over time. One-way analysis of variance was used to compare continuous variables between groups. Analysis of covariance was used to determine the effects of groups, while controlling for the effects of some covariates, on continuous variables. All comparisons were two-tailed, and $p < 0.05$ were considered to be statistically significant.

Results

Of the 84 months analyzed, the mean (\pm SD) of average APACHE-II score was 16.76 (\pm 1.45); the mean mortality rate and weaning rate were 10.74% (\pm 4.98%) and 46.16% (\pm 10.79%), respectively; the mean ventilator days, rate of return to the ICU, and nosocomial infection incidence rate were 17.71 (\pm 3.15) days, 6.77% (\pm 4.87%), and 14.70% (\pm 7.06%), respectively. There were 36 months (43%) in the R2 + R2 group, 25 months (30%) in the R3 + R2 group, 10 months (12%) in the R3 + R3 group, 8 months (10%) in the R3 + R1 group, and 5 months (6%) in the R2 + R1 group.

Although no significant differences in APACHE-II score and mortality rate were noted between years, the weaning rate significantly differed in years (Table 1). A simple linear regression analysis revealed that APACHE-II score did not change significantly with time ($r = -0.0287$; $p = 0.7952$), whereas the mortality rate slightly decreased with borderline significance ($r = -0.2141$; $p = 0.0505$) and the weaning rate significantly increased with time ($r = 0.3666$; $p = 0.0006$) (Fig. 1). None of the minor outcomes (mean

Table 1 Comparison of APACHE-II score and the outcomes in different years.^a

Variables (n)	Year (n)					P		
	2004 and 2005 (15)	2006 (12)	2007 (12)	2008 (12)	2009 (12)		2010 (12)	2011 (9)
APACHE-II score	17.07 \pm 1.41	16.06 \pm 1.16	16.75 \pm 1.96	17.16 \pm 0.60	16.67 \pm 1.79	16.68 \pm 1.25	16.86 \pm 1.70	0.6119
Mortality rate (%)	11.84 \pm 5.34	12.28 \pm 5.18	11.31 \pm 4.91	11.54 \pm 4.56	8.32 \pm 4.84	9.23 \pm 5.26	10.29 \pm 4.27	0.3884
Weaning rate (%)	44.3 \pm 5.78	41.29 \pm 9.88	42.23 \pm 11.02	45.00 \pm 10.93	45.03 \pm 12.79	54.40 \pm 8.62	53.01 \pm 11.53	0.0128 ^b
Mean ventilator days (d)	16.83 \pm 2.09	18.94 \pm 3.07	17.10 \pm 2.85	16.92 \pm 2.77	20.31 \pm 3.63	17.35 \pm 2.92	16.41 \pm 3.66	0.0229 ^c
Rate of return to the ICU (%)	6.95 \pm 3.60	7.43 \pm 4.90	7.60 \pm 5.72	7.20 \pm 4.53	6.49 \pm 6.23	6.02 \pm 5.02	5.26 \pm 4.85	0.9371
Nosocomial infection incidence rate (% ₁₀₀)	10.45 \pm 7.93	16.45 \pm 5.45	20.78 \pm 8.09	12.98 \pm 4.50	18.43 \pm 6.20	11.10 \pm 4.59	13.52 \pm 5.16	0.0003 ^d

APACHE-II = acute physiology and chronic health evaluation II; ICU = intensive care unit.

^a Data are presented as mean \pm standard deviation.

^b Significant pairs from Tukey–Kramer honestly significant difference (HSD) pairwise comparison: 2010 > 2006 ($p = 0.0336$).

^c Borderline significant pairs from Tukey–Kramer HSD pairwise comparison: 2009 > 2011 ($p = 0.0582$) and 2009 > 2004 and 2005 ($p = 0.0516$).

^d Significant pairs from Tukey–Kramer HSD pairwise comparison: 2007 > 2004 and 2005 ($p = 0.0011$), 2007 > 2010 ($p = 0.0054$), 2009 > 2004 and 2005 ($p = 0.0243$), and 2007 > 2008 ($p = 0.0468$).

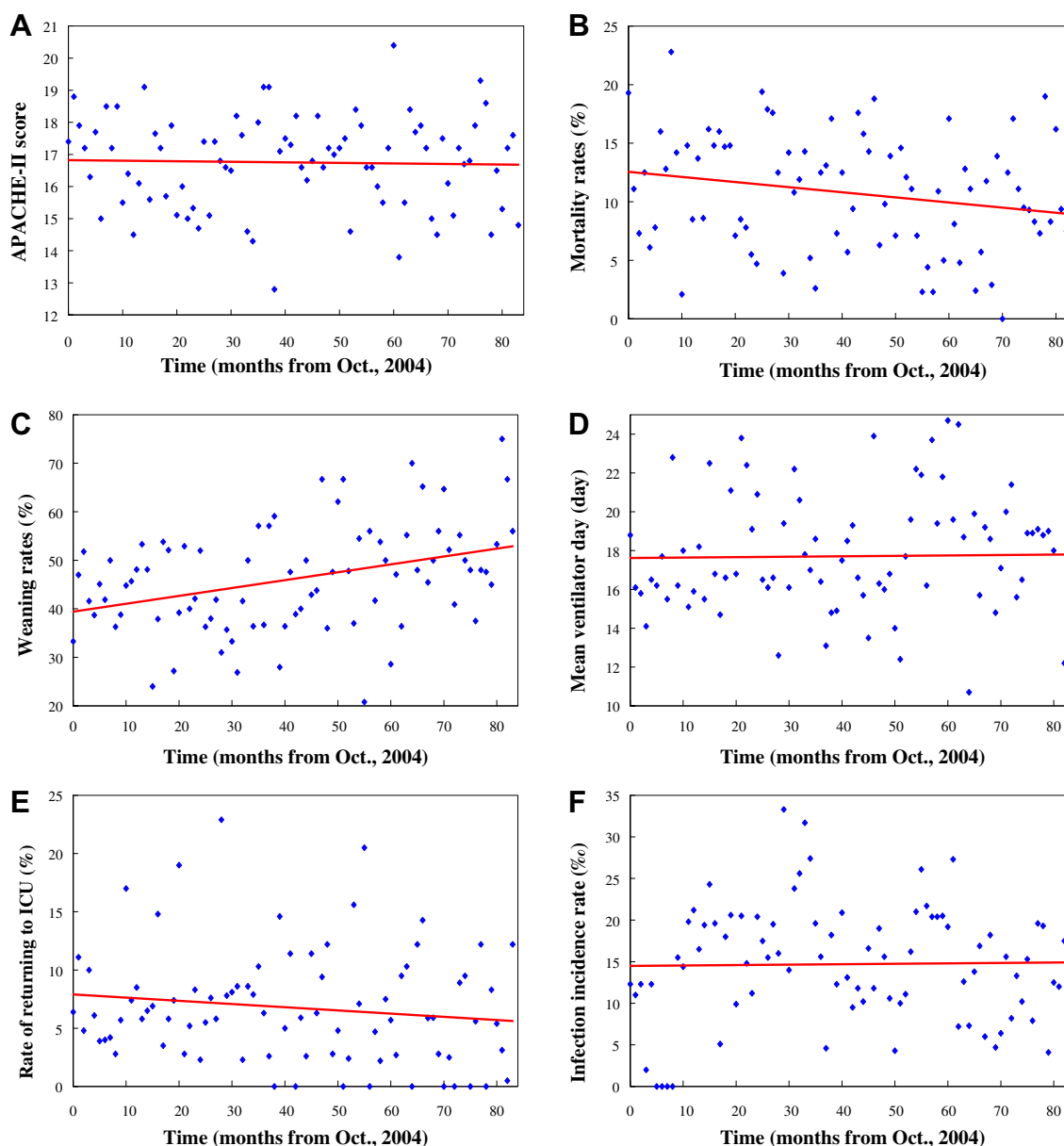


Figure 1. Changes in the (A) acute physiology and chronic health evaluation II (APACHE-II) score, (B) mortality rate, (C) weaning rate, (D) mean ventilator days, (E) rate of return to the intensive care unit (ICU), and (F) nosocomial infection incidence rate over the 84 months of study. Simple linear regression revealed the following: APACHE-II score = $16.8265 - 0.0017 \times \text{time}$ ($r = -0.0287$; $p = 0.7952$); Mortality rate = $12.554 - 0.0437 \times \text{time}$ ($r = -0.2141$; $p = 0.0505$); Weaning rate = $39.4265 + 0.1622 \times \text{time}$ ($r = 0.3666$; $p = 0.0006$); Mean ventilator days = $17.6162 + 0.0022 \times \text{time}$ ($r = 0.3666$; $p = 0.8774$); Rate of return to the ICU = $7.9038 - 0.0274 \times \text{time}$ ($r = 0.3666$; $p = 0.2129$); Nosocomial infection incidence rate = $14.4945 + 0.0050 \times \text{time}$ ($r = 0.3666$; $p = 0.8751$). The time was expressed in months from October 2004.

ventilator days, rate of return to the ICU, and nosocomial infection incidence rate) changed significantly with time ($p > 0.2$) (Fig. 1).

There were no significant differences in the average APACHE-II score ($p = 0.7185$), mortality rate ($p = 0.4323$), weaning rate ($p = 0.5852$), mean ventilator days ($p = 0.6444$), rate of return to the ICU ($p = 0.1160$), and nosocomial infection incidence rate ($p = 0.6712$) between the groups of months as classified by the levels of residents (Table 2). Further analysis showed no significant difference in these statistical data between months with an R1 and

those with two senior residents, and similar results were obtained while the months were classified by the presence or absence of an R3 (data not shown). After adjusting for time (months from October 2004) and average APACHE-II score, there were no significant differences in the mortality rate, weaning rate, mean ventilator days, rate of return to the ICU, and nosocomial infection incidence rate between the groups of months classified by the levels of residents (Table 3). Similar findings were noted when the months were classified by the presence or absence of an R1 or R3 (data not shown).

Table 2 Comparison of APACHE-II score and the outcomes in different groups of months.^a

Variables (n)	Group (n)					p
	R2 + R1	R2 + R2	R3 + R1	R3 + R2	R3 + R3	
	(5)	(36)	(8)	(25)	(10)	
APACHE-II score	17.02 ± 0.90	16.52 ± 1.39	16.86 ± 1.19	17.04 ± 1.65	16.70 ± 1.60	0.7185
Mortality rate (%)	10.20 ± 4.82	9.78 ± 4.65	13.29 ± 2.99	11.11 ± 5.47	11.51 ± 6.02	0.4323
Weaning rate (%)	51.56 ± 12.8	47.24 ± 10.54	44.23 ± 8.61	43.99 ± 10.81	46.52 ± 12.72	0.5852
Mean ventilator days (d)	17.32 ± 4.78	17.91 ± 2.99	16.08 ± 2.35	17.96 ± 3.14	17.84 ± 3.63	0.6444
Rate of return to the ICU (%)	1.74 ± 2.62	6.76 ± 5.09	8.85 ± 5.28	7.36 ± 4.66	6.14 ± 3.96	0.1160
Nosocomial infection incidence rate(‰)	14.16 ± 6.55	14.75 ± 6.00	11.68 ± 6.40	15.98 ± 7.21	14.05 ± 10.82	0.6712

APACHE-II = acute physiology and chronic health evaluation II; ICU = intensive care unit.

^a Values are presented as mean ± standard deviation. The p values are calculated using analysis of variance. The months are categorized by the level of two residents working in the unit that month. "R2 + R1" denotes a second-year resident and a first-year resident, "R2 + R2" denotes two second-year residents, and so on.

Discussion

In this retrospective study, we found that the outcomes of patients in our RCC seemed to improve progressively during the study period. Although the disease severity, as measured by monthly average APACHE-II score on RCC admission, did not change with time, the monthly mortality slightly decreased with borderline significance and the monthly weaning rate significantly improved. These findings suggested the improving quality of care in our RCC during these 7 years. We could not identify major changes in our RCC during this period (in terms of general setting, facilities, staffing, application of clinical protocols, etc.) which could explain the improvement. We believe that the cumulative experience of caring for patients in the RCC may be the most important factor contributing to the improving quality of care.

Many studies have demonstrated the beneficial effect of physician experience on patient outcomes [2–6]. An observational study showed that patients cared for by hospitalists had shorter hospital stays, lower medical costs, and lower short-term mortality, as compared with patients cared for by nonhospitalists; the differences become significant only in the second year of the program, suggesting the importance of cumulative experience [2]. Another study showed that the experience of primary care

physicians in managing patients with acquired immunodeficiency syndrome has been significantly associated with the survival of their patients [3]. Similarly, another study reported that the survival of patients with hepatocellular carcinoma depends on the level of experience of the physicians overseeing them [4]. An association of physician experience with tuberculosis and survival in patients with active tuberculosis has also been reported [5]. Many studies demonstrate the relationship between the caseload volume of the hospital and patient outcomes [7,8], whereas others show that experience of the physician significantly modifies this relationship or is even more crucial in determining outcomes than the hospital caseload volume [8–12]. Although many studies report the positive experience–outcome relationship, some do not. A recent study found that inpatient care by physicians with more years in clinical practice was associated with longer lengths of hospital stays and higher risk of mortality [13].

Although many studies discuss the impact of physician experience on patients outcomes as mentioned above, these studies compared experienced and inexperienced attending physicians. Through literature review, very few studies discussed this issue in residents, and most of them addressed the learning curve of surgical residents [14,15]. Some studies suggested that inexperienced surgical residents may be associated with worse surgical outcomes [15–17]. However,

Table 3 Comparison of the adjusted outcomes in different groups of months.^a

Variables (n)	Group (n)					p
	R2 + R1	R2 + R2	R3 + R1	R3 + R2	R3 + R3	
	(5)	(36)	(8)	(25)	(10)	
Mortality rate (%)	10.25 ± 2.23	10.26 ± 0.90	12.60 ± 1.84	10.69 ± 1.04	11.36 ± 1.58	0.8428
Weaning rate (%)	51.08 ± 4.59	44.75 ± 1.86	48.00 ± 3.79	46.11 ± 2.14	47.38 ± 3.25	0.7265
Mean ventilator days (d)	17.35 ± 1.44	17.96 ± 0.58	15.99 ± 1.19	17.93 ± 0.67	17.81 ± 1.02	0.6497
Rate of return to the ICU (%)	1.76 ± 2.15	7.10 ± 0.87	8.37 ± 1.77	7.06 ± 1.00	6.04 ± 1.52	0.1584
Nosocomial infection incidence rate(‰)	14.41 ± 3.17	14.45 ± 1.28	11.88 ± 2.61	16.31 ± 1.48	14.02 ± 2.24	0.6094

ICU = intensive care unit.

^a The values are adjusted with time (months from October 2004) and acute physiology and chronic health evaluation II score, and are presented as least-square means ± standard error. The p values are calculated using analysis of covariance. The months are categorized by the level of two residents working in the unit that month. "R2 + R1" denotes a second-year resident and a first-year resident, "R2 + R2" denotes two second-year residents, and so on.

the so-called July phenomenon (worsening of outcomes in teaching-hospital patients with the arrival of new, inexperienced housestaff) cannot be found consistently [18–20], suggesting the complexity of this issue. To our knowledge, no available evidence to date shows the impact of medical residents' experiences on patient outcomes.

Our study found no significant differences in the monthly weaning rate and mortality rates between months with different levels of residents, suggesting that experiences (levels) of residents did not significantly affect the outcomes of patients in the RCC. These findings may be attributed to the high level of organization of our RCC, especially the well-organized multidisciplinary team with attending physicians in charge, a nurse practitioner, a case manager, a dietitian, a pharmacist, a social worker, registered respiratory therapists, and nursing staff, as well as a good support system. The clinical practice supervised by experienced attending physicians is also likely to have contributed to the stable outcomes in our patients.

Application of the weaning protocol may also be a key in the stable quality of care our patients received. Many studies have demonstrated the benefits of protocol-directed weaning from mechanical ventilation, including shorter duration of mechanical ventilation, shorter length of stay, and fewer complications [21–25]. Weaning protocol directed by respiratory therapist has also been proven safe and efficient [21,25]. Many randomized, controlled trials demonstrate that protocol-guided ventilator weaning, as performed by nurses and respiratory therapists, may lead to more rapid extubation than physician-directed weaning [22,26]. Other studies, however, found that protocol-directed weaning may be unnecessary in a closed ICU with generous physician staffing and structured rounds [27] or in special populations, such as pediatric [28] and neurosurgical patients [29]. Although controversy continues to surround the effect of protocol-driven ventilator weaning [30], we believe that the use of a weaning protocol contributes to the stable, and even progressively improving, weaning rate in our RCC. Furthermore, the protocol-guided weaning performed by respiratory therapists in our RCC was supervised by experienced pulmonologists and intensivists. Therefore, the level of residents was an unimportant factor.

Some limitations of this study must be addressed. First, this study used statistical data retrieved from the record as the outcomes. Compared with studies using outcomes from individual patients, this method may result in indirect evaluation of the effect of residents' level on the outcomes. However, it is not quite necessary to obtain data from individual patients because the overall effect of the experience of residents attending during a particular month was the outcomes of concern. Monthly mortality rate and weaning rate were therefore chosen as the outcomes in this study. Another limitation of the study was its retrospective design, because the statistical data retrieved from the record lacks many relevant factors. For example, we were unable to assess the impact of important factors significantly associated with the outcomes, such as the do not resuscitate status, tracheostomy, length of stay in the ICU before RCC admission, total length of stay in the hospital before RCC admission, ventilator day, presence of cancer, source of the patient, presence of organ failures, and presence of palliative care plan.

Another limiting factor was the low sample sizes in some groups of months (groups R2 + R1 and the group R3 + R1), which may have reduced the power of our analyses. Therefore, we performed analyses after combining the groups to achieve acceptable sample sizes. Analyses with the months re-classified by the presence or absence of R1 or R3 showed consistent results.

Third, other covariates that were not included in our study model may have influenced the results. For example, the impact of the attending physician in charge was not included as a covariate. Because all of the attending physicians in charge were experienced and qualified pulmonologists and intensivists, we did not consider this factor relevant. Furthermore, the statistical analyses of this study revealed that the outcomes in groups of months were nearly the same (with high *p* values, all >0.1). We, therefore, did not believe that the conclusions would change after adjusting for other covariates.

Fourth, based on the settings and rules of RCC, many patients stayed in the RCC for months, thus receiving care from more than one group of residents. In other words, the quality of care from one group of residents may have resulted in outcomes attributed to another group of residents. This limitation, however, was unavoidable in studies of the effect of rotating residents, especially in the patient population with long hospital stays. Therefore, the arbitrary definitions used in this study, attributing the outcomes to the group of residents of the month, were considered acceptable. Similarly, the average APACHE-II score of the month, based on the data of each patient admitted in the month, was used as a covariate to adjust for disease severity. The average APACHE-II score for each month did not change significantly with time or differ significantly between the groups of months classified by different levels of residents. We, therefore, considered this imperfection acceptable. Further prospective studies with fixed residents may be needed to validate our findings.

Fifth, this study was conducted in a single RCC in a medical center, so the results may not be generalized to the RCC in other institutions or even other settings such as ICUs and general wards. Finally, the evaluation of outcomes was limited to short-term outcomes in the hospital, and the long-term prognosis was not assessed. Despite these limitations, the data presented in our study still provide evidence that the level of residents may not be important in the care received by patients in a well-organized RCC setting.

In conclusion, a well-organized setting may provide stable quality of care to patients, irrespective of the experiences (levels) of the residents. Although further prospective studies may still be needed to confirm our findings, we believe that the requirement to use senior residents to care for patients in the RCC is unnecessary as long as the rotating residents have previously received critical care training in the ICU.

References

- [1] Su J, Lin CY, Chen PJ, Lin FJ, Chen SK, Kuo HT. Experience with a step-down respiratory care center at a tertiary referral medical center in Taiwan. *J Crit Care* 2006;21:156–61.

- [2] Meltzer D, Manning WG, Morrison J, Shah MN, Jin L, Guth T, et al. Effects of physician experience on costs and outcomes on an academic general medicine service: results of a trial of hospitalists. *Ann Intern Med* 2002;137:866–74.
- [3] Kitahata MM, Koepsell TD, Deyo RA, Maxwell CL, Dodge WT, Wagner EH. Physicians' experience with the acquired immunodeficiency syndrome as a factor in patients' survival. *N Engl J Med* 1996;334:701–6.
- [4] Chen TM, Chang TM, Huang PT, Tsai MH, Lin LF, Liu CC, et al. Management and patient survival in hepatocellular carcinoma: does the physician's level of experience matter? *J Gastroenterol Hepatol* 2008;23:e179–88.
- [5] Khan K, Campbell A, Wallington T, Gardam M. The impact of physician training and experience on the survival of patients with active tuberculosis. *CMAJ* 2006;175:749–53.
- [6] Chang WC, Li TC, Lin CC. The effect of physician experience on costs and clinical outcomes of laparoscopic-assisted vaginal hysterectomy: a multivariate analysis. *J Am Assoc Gynecol Laparosc* 2003;10:356–9.
- [7] Holt PJ, Poloniecki JD, Khalid U, Hinchliffe RJ, Loftus IM, Thompson MM. Effect of endovascular aneurysm repair on the volume-outcome relationship in aneurysm repair. *Circ Cardiovasc Qual Outcomes* 2009;2:624–32.
- [8] Nugent E, Neary P. Rectal cancer surgery: volume-outcome analysis. *Int J Colorectal Dis* 2010;25:1389–96.
- [9] Srinivas VS, Hailpern SM, Koss E, Monrad ES, Alderman MH. Effect of physician volume on the relationship between hospital volume and mortality during primary angioplasty. *J Am Coll Cardiol* 2009;53:574–9.
- [10] Wang TF, Lin HC. Relationship between caseload volume and outcome for systemic lupus erythematosus treatment: the experience of Taiwan. *J Rheumatol* 2008;35:1795–800.
- [11] Lin HC, Xirasagar S, Chen CH, Hwang YT. Physician's case volume of intensive care unit pneumonia admissions and in-hospital mortality. *Am J Respir Crit Care Med* 2008;177:989–94.
- [12] Lee CC, Huang TT, Lee MS, Su YC, Chou P, Hsiao SH, et al. Survival rate in nasopharyngeal carcinoma improved by high caseload volume: a nationwide population-based study in Taiwan. *Radiat Oncol* 2011;6:92.
- [13] Southern WN, Bellin EY, Arnsten JH. Longer lengths of stay and higher risk of mortality among inpatients of physicians with more years in practice. *Am J Med* 2011;124:868–74.
- [14] Ascher-Walsh CJ, Capes T. An evaluation of the resident learning curve in performing laparoscopic supracervical hysterectomies as compared with patient outcome: five-year experience. *J Minim Invasive Gynecol* 2007;14:719–23.
- [15] Shuhaiber JH, Goldsmith K, Nashef SA. Impact of cardiothoracic resident turnover on mortality after cardiac surgery: a dynamic human factor. *Ann Thorac Surg* 2008;86:123–30. discussion 130–1.
- [16] Englesbe MJ, Pelletier SJ, Magee JC, Gauger P, Schifftner T, Henderson WG, et al. Seasonal variation in surgical outcomes as measured by the American College of Surgeons-National Surgical Quality Improvement Program (ACS-NSQIP). *Ann Surg* 2007;246:456–62. discussion 63–5.
- [17] Kestle JR, Cochrane DD, Drake JM. Shunt insertion in the summer: is it safe? *J Neurosurg* 2006;105:165–8.
- [18] van Walraven C, Jennings A, Wong J, Forster AJ. Influence of house-staff experience on teaching-hospital mortality: the "July Phenomenon" revisited. *J Hosp Med* 2011;6:389–94.
- [19] Smith ER, Butler WE, Barker 2nd FG. Is there a "July phenomenon" in pediatric neurosurgery at teaching hospitals? *J Neurosurg* 2006;105:169–76.
- [20] Claridge JA, Schulman AM, Sawyer RG, Ghezel-Ayagh A, Young JS. The "July phenomenon" and the care of the severely injured patient: fact or fiction? *Surgery* 2001;130:346–53.
- [21] Wood G, MacLeod B, Moffatt S. Weaning from mechanical ventilation: physician-directed vs a respiratory-therapist-directed protocol. *Respir Care* 1995;40:219–24.
- [22] Ely EW, Baker AM, Dunagan DP, Burke HL, Smith AC, Kelly PT, et al. Effect on the duration of mechanical ventilation of identifying patients capable of breathing spontaneously. *N Engl J Med* 1996;335:1864–9.
- [23] Chaiwat O, Sarima N, Niyompanitpattana K, Komoltri C, Udomphorn Y, Kongsayreepong S. Protocol-directed vs. physician-directed weaning from ventilator in intra-abdominal surgical patients. *J Med Assoc Thai* 2010;93:930–6.
- [24] Ramachandran V, Grap MJ, Sessler CN. Protocol-directed weaning: a process of continuous performance improvement. *Crit Care* 2005;9:138–40.
- [25] Marelich GP, Murin S, Battistella F, Inciardi J, Vierra T, Roby M. Protocol weaning of mechanical ventilation in medical and surgical patients by respiratory care practitioners and nurses: effect on weaning time and incidence of ventilator-associated pneumonia. *Chest* 2000;118:459–67.
- [26] Kollef MH, Shapiro SD, Silver P, St John RE, Prentice D, Sauer S, et al. A randomized, controlled trial of protocol-directed versus physician-directed weaning from mechanical ventilation. *Crit Care Med* 1997;25:567–74.
- [27] Krishnan JA, Moore D, Robeson C, Rand CS, Fessler HE. A prospective, controlled trial of a protocol-based strategy to discontinue mechanical ventilation. *Am J Respir Crit Care Med* 2004;169:673–8.
- [28] Randolph AG, Wypij D, Venkataraman ST, Hanson JH, Gedeit RG, Meert KL, et al. Effect of mechanical ventilator weaning protocols on respiratory outcomes in infants and children: a randomized controlled trial. *JAMA* 2002;288:2561–8.
- [29] Namen AM, Ely EW, Tatter SB, Case LD, Lucia MA, Smith A, et al. Predictors of successful extubation in neurosurgical patients. *Am J Respir Crit Care Med* 2001;163:658–64.
- [30] Girard TD, Ely EW. Protocol-driven ventilator weaning: reviewing the evidence. *Clin Chest Med* 2008;29:241–52.