Trend Analysis of Hospital Resource Utilization for Prolonged Mechanical Ventilation Patients in Taiwan: A Population-Based Study

Tien-Chiung Hung MSc, Yung-Fa Lai MD, Ching-Wan Tseng MSc,
Yong-Han Hong PhD, and Hon-Yi Shi MPH DrPH

BACKGROUND: The aging Taiwan population is expected to require vast medical resources, including prolonged mechanical ventilation (PMV). This study determined the trends in hospital resource utilization and associated factors in PMV patients in Taiwan. METHODS: All patients who had received mechanical ventilation for > 21 days (International Classification of Diseases, 9th Revision, Clinical Modification codes 518.81–518.89) during 2004–2007 were recruited to the study. Administrative claims data obtained from the Bureau of National Health Insurance of Taiwan were analyzed. RESULTS: The study analyzed 65,181 patients who had received PMV during 2004–2007. The number of PMVs per 100,000 persons was 94.30 in 2004, and it gradually decreased to 89.38 in 2007, which was a change rate of −5.22%. During the study period, stay significantly decreased, from 35.12 days to 31.61 days, whereas hospital treatment costs significantly increased, from $7,933.17 to $8,257.52 (*P* < .001). Considerably decreased stay and increased hospital treatment costs were significantly associated with age, number of comorbidities, hospital level, hospital volume, and patient referral source (*P* < .001). CONCLUSIONS: These population-based data demonstrated a decrease in the prevalence of PMV, especially for older patients, and that stay decreased; however, hospital treatment costs increased. Moreover, healthcare providers and patients should recognize that attributes of both the patient and the hospital may affect hospital resource utilization. Additionally, these analytical results should be applicable to similar populations in other countries. *Key words: prolonged mechanical ventilation; trends; predictors; hospital resource utilization.* [Respir Care 2013;58(4):669–675.

Introduction

Patients admitted to ICUs often require mechanical ventilation.[1,2] Many critically ill patients have persistent respiratory failure that requires prolonged mechanical ventilation (PMV). PMV is commonly defined as more than 21 days of mechanical ventilation lasting at least 6 hours per day, although mechanical ventilation for a shorter duration has also been mentioned in the literature.[1-3] The Centers for Medicare and Medicaid Services in the United States define PMV as at least 21 continuous days of mechanical ventilation for at least 6 hours per day.[3] Indeed, most ventilated patients transferred to long-term acute care hospitals have received mechanical ventilation for at least 21 days.[3] Of all patients who receive mechanical ventilation, an estimated 5–13% required PMV.[3,4] Although PMV patients consume substantial medical resources, their outcomes tend to be poor, especially in the rapidly growing elderly population.[2-5]

Mr Hung is affiliated with the Department of Respiratory Therapy, E-Da Hospital; Dr Lai is affiliated with the Division of Pulmonary Medicine, Department of Internal Medicine, E-Da Hospital and with the Department of Occupational Therapy, I-Shou University; Mr Tseng is affiliated with the Department of Respiratory Therapy, Kaohsiung Chang Gung Memorial Hospital; Dr Hong is affiliated with the Department of Medical Nutrition, I-Shou University; and Dr Shi is affiliated with the Graduate Institute of Healthcare Administration, Kaohsiung Medical University, Kaohsiung City, Taiwan, Republic of China.

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Correspondence: Hon-Yi Shi MPH DrPH, Graduate Institute of Healthcare Administration, Kaohsiung Medical University, 100 Shih-Chun First Road, Kaohsiung City, Taiwan, Republic of China. E-mail: hshi@kmu.edu.tw.

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Historically, patients requiring PMV tend to be treated in ICUs, and associated discharge rates are low. However in the 1990s, changes in the medical care reimbursement regulations of the Taiwan healthcare system created incentives to transfer patients requiring PMV from ICUs of acute care hospitals to long-term assisted care facilities.[2-6] The policy for PMV patients implemented by the Taiwan Bureau of National Health Insurance (BNHI) in 2000 required the transfer of such patients to a respiratory care center after an ICU stay of 21 days, and to a respiratory care ward after a respiratory care center stay of 42 days.[7]

Although many studies have evaluated PMV outcomes, few longitudinal studies have exceeded 2 years,[1-5] and most published data are limited to United States or European populations.[1-6] Therefore, the findings of previous studies of PMV outcomes may not be generalizable to patient populations in Asian countries. Further, no studies have longitudinally evaluated temporal trends in hospital resource utilization by PMV patients, and none have systematically evaluated associations with hospital resource utilization in this patient group.[8]

Clinical decision making and policy making for PMV is challenging and requires efficient planning and effective medical care. Thus, the aim of this population-based study was to analyze trends in hospital resource utilization and associated factors in a population of patients who had received PMV.

QUICK LOOK

Current knowledge

Prolonged mechanical ventilation (PMV) is defined as $>$ 21 days of ventilatory support. The number of patients receiving PMV in North America has been rapidly increasing. The rate of PMV in other countries is not well described.

What this paper contributes to our knowledge

In Taiwan, from 2004 through 2007, the requirement for PMV fell by 5%, hospital costs increased, and hospital stay decreased.

Methods

Study Design and Data Sources

This study analyzed administrative claims data obtained from the BNHI. Because the BNHI is the sole payer in Taiwan, the data set included information for all patients discharged from all hospitals in Taiwan during the study period, and was assumedly the most comprehensive and reliable data source for the study. This study analyzed data for all patients who had received mechanical ventilation or PMV (International Classification of Diseases, 9th Revision, Clinical Modification [ICD-9-CM] disposition codes 518.81–518.89 and ICD-9-CM 96.72, respectively). After excluding data for patients younger than 17 years (351 subjects), the final data set included data for 65,181 PMV patients treated from 2004 to 2007. The study protocol was approved by the institutional review board of E-Da Hospital.

Patients and Variables

The following attributes of this Taiwan population of PMV patients were analyzed: age, sex, comorbidity, hospital level, hospital volume, and patient referral source. Age categories were $<$ 65 years, 65–74 years, and $\geq$ 75 years. Comorbidities were identified from ICD-9-CM codes for primary and secondary diagnoses, excluding cancer related codes. These ICD-9-CM codes were used to calculate the Deyo-Charlson comorbidity index.[9-12] Patient referral source was categorized by hospital department as general medicine, general surgery, cardiology, pulmonary, neurology/neurosurgery, and other. Hospital level was accredited by the Taiwan Joint Commission on Hospital Accreditation as medical center ($>$ 500 beds), regional hospital ($>$ 300 beds), or district hospital ($>$ 100 beds). The "selective referral hypothesis" postulates that the severity of PMV at admission may differ between high-volume and low-volume hospitals. Because official performance information to help PMV patients select healthcare providers is not available, patients choose hospitals with better reputations or more successful surgeries after consulting with their relatives and friends. Hospital volume was categorized as low, medium, and high if the number of patients treated at the hospital in the previous year was $\leq$ 25%, 26–74%, and $\geq$ 75%, respectively, of the total patients treated at the hospital that year. Hospital resource utilization was measured by stay and hospital treatment cost.

Statistical Analyses

Continuous variables were tested for statistical significance by one-way analysis of variance, and categorical variables were tested by chi-square analysis. Analysis of trends in the prevalence of PMV patients was assessed by Cochrane-Armitage trend test. Hospital treatment costs were analyzed by collecting data for the following medical costs, which are required data in standard administrative claims for reimbursement from the Taiwan BNHI: operating room, radiology, physical therapy, hospital room, anesthetist, pharmacy, laboratory, special materials, surgeon, and others. Multiple regression models used to predict stay and hospital treatment costs included both patient attributes and hospital attributes.

Table 1. Prevalence of Prolonged Mechanical Ventilation, 2004 Through 2007

Year	Total Population	PMV Patients	Prevalence (1/100,000 persons)	Change Rate (%)*
2004	17,281,468	16,297	94.30	Reference
2005	17,559,586	16,278	92.70	−1.70
2006	17,823,777	16,310	91.51	−2.97
2007	18,232,185	16,296	89.38	−5.22

* Change rate = (2005, 2006, 2007 prevalence–2004 prevalence)/2004 prevalence.
PMV = prolonged mechanical ventilation

Hospital treatment cost was adjusted for specific hospital levels according to their differences in BNHI reimbursements. Cost-to-charge ratios were used to derive costs from hospital charges, and costs were inflation adjusted to 2007 dollars. Furthermore, to reflect changes in real dollar value, cost data were adjusted by the consumer price index for each year of 2004–2007 (95.45, 97.65, 98.23, and 100.00, respectively). Additionally, hospital treatment costs were then converted from Taiwan dollars to United States dollars, at an exchange rate of 31.0:1, which was the average exchange rate during 2004–2007. Statistical analyses were performed using statistics software (SPSS 15.0, SPSS, Chicago, Illinois). All tests were 2-sided, and *P* values $< .05$ were considered statistically significant.

Results

The prevalence rate of PMV patients was 94.3 per 100,000 persons in 2004, and gradually declined to 89.38 per 100,000 persons by 2007. Thus, the rate of decline from 2004 to 2007 was 5.22%, which was statistically significant ($P < .001$) (Table 1).

Regarding patient attributes, the estimated mean ± SD age was 77.99 ± 13.87 years, and 37.37% of the PMV patients were female (Table 2). Furthermore, 0.56% of the PMV patients had a Charlson comorbidity index of 0; 1.49% had a Charlson comorbidity index of 1; 3.96% had a Charlson comorbidity index of 2; 9.41% had a Charlson comorbidity index of 3; and 84.59% had a Charlson comorbidity index ≥ 4. In terms of patient referral source, the referring department was general medicine in 36.94% of patients, general surgery in 4.86%, cardiology in 4.78%, pulmonary in 44.94%, neurology/neurosurgery in 5.89%, and other in 2.59%. Regarding hospital attributes, 34.65% of the PMV patients were treated in medical centers, 41.72% were treated in regional hospitals, and 25.11% were treated in district hospitals. In terms of volume, 50.71% of the PMV patients were treated in low-volume centers, 24.18% were treated in medium-volume centers, and 36.94% were treated in high-volume centers.

Table 2. Characteristics of the Study Population (n = 65,181)

Age, median (IQR) y	80 (18–91)
Age Group, no. (%)	
< 65 y	9,635 (14.78)
65–74 y	9,236 (14.17)
≥ 75 y	46,310 (71.05)
Male, no. (%)	40,823 (62.63)
Female, no. (%)	24,358 (37.37)
Charlson Comorbidity Index score, median (IQR)	4 (0–6)
Charlson Comorbidity Index score, no. (%)	
0	364 (0.56)
1	969 (1.49)
2	2,581 (3.96)
3	6,133 (9.41)
≥ 4	55,134 (84.59)
Patient referral source, no. (%)	
General medicine	24,078 (36.94)
General surgery	3,169 (4.86)
Cardiology	3,114 (4.78)
Pulmonary	29,294 (44.94)
Neurology/neurosurgery	3,836 (5.89)
Other	1,690 (2.59)
Hospital level, no. (%)	
Medical center	15,400 (23.63)
Regional hospital	22,588 (34.65)
District hospital	27,193 (41.72)
Hospital volume, median (IQR) cases/y	418 (24–1,853)
Hospital volume, no. (%)	
< 300 (low)	16,368 (25.11)
300–999 (medium)	33,052 (50.71)
≥ 1,000 (high)	15,761 (24.18)
Age, mean ± SD y	77.99 ± 13.87
Stay, mean ± SD d	33.26 ± 22.52
Hospital treatment costs, mean ± SD United States dollars	8,017.10 ± 5,877.53

Mean ± SD stay was 33.26 ± 22.52 d, and mean ± SD hospital treatment cost was $8,017.10 ± $5,877.53.

Table 3 shows the results of trend analysis of patient and hospital attributes for each year from 2004 to 2007. The percentage of PMV patients < 65 years old and 65–74 years old significantly increased, from 12.73% and 13.20% in 2004 to 16.50% and 15.22% by 2007, respectively, but that of patients ≥ 75 years old significantly decreased, from 74.06% to 68.27%, during the same period ($P < .001$). The percentage of female patients treated significantly decreased, from 37.73% in 2004 to 36.68% in 2007 ($P = .03$). During the same period the percentage of patients with Charlson comorbidity index ≤ 2 and 3 significantly decreased, from 6.86% and 10.20% to 4.54% and 8.01%, respectively, but the percentage of patients with Charlson comorbidity index of 4 and ≥ 5 significantly increased, from 58.22% and 24.72% to 61.67% and

Table 3. Temporal Trends in Study Population Demographics and Hospital Data

	2004 (*n* = 16,297)	2005 (*n* = 16,278)	2006 (*n* = 16,310)	2007 (*n* = 16,296)	*P*
Age Group, %					
< 65 y	12.73	14.76	15.13	16.50	<.001
65–74 y	13.20	13.85	14.40	15.22	
≥ 75 y	74.06	71.38	70.47	68.27	
Male, %	62.27	61.93	63.00	63.32	.03
Female, %	37.73	38.07	37.00	36.68	
Charlson Comorbidity Index, %					
≤ 2	6.86	6.77	5.85	4.54	< .001
3	10.20	10.52	8.90	8.01	
4	58.22	59.74	61.18	61.67	
≥ 5	24.72	22.97	24.07	25.78	
Patient referral source, %					
General medicine	48.41	37.30	30.94	31.11	< .001
General surgery	5.17	4.95	4.54	4.79	
Cardiology	4.54	4.95	4.91	4.71	
Pulmonary	33.65	44.48	51.69	49.95	
Neurology	5.60	5.98	5.58	6.38	
Other	2.62	2.33	2.34	3.07	
Hospital level, %					
Medical center	20.08	23.20	23.05	28.17	< .001
Regional hospital	44.56	42.92	29.55	21.59	
District hospital	35.35	33.88	47.39	50.23	
Hospital volume, %					
≤ 25 (low)	27.99	21.46	28.37	22.62	< .001
26–74 (medium)	57.69	60.95	41.85	42.36	
≥ 75 (high)	14.32	17.59	29.78	35.02	
Stay, mean ± SD d	35.12 ± 24.24	33.82 ± 23.26	32.47 ± 21.59	31.61 ± 20.64	< .001
Hospital treatment cost, mean ± SD dollars	7,933.17 ± 5,798.83	7,995.41 ± 6,208.93	7,882.41 ± 5,543.85	8,257.52 ± 5,933.02	< .001

25.78%, respectively ($P < .001$). The percentages of patients referred from general medicine and general surgery departments decreased, from 48.41% and 5.17% to 31.11% and 4.79%, respectively, but the percentages of patients referred from cardiology, pulmonary, neurology/neurosurgery, and other departments significantly increased (4.54%, 33.65%, 5.60%, and 2.62% to 4.71%, 49.95%, 6.38%, and 3.07%, respectively, $P < .001$). In terms of hospital attributes, the percentage of patients treated in medical centers and district hospitals significantly increased, from 20.08% and 35.35% to 28.17% and 50.23%, respectively, but the percentage of patients treated in regional hospitals significantly decreased from 44.56% to 21.59% ($P < .001$). Additionally, the percentage of patients treated in low-volume and medium-volume centers significantly decreased, from 27.99% and 57.69% to 22.62% and 42.36%, respectively, but the percentage of patients treated in high-volume centers significantly increased, from 14.32% to 35.02% ($P < .001$). Stay significantly decreased, from 35.12 days to 31.61 days, but hospital treatment cost significantly increased, from $7,933.17 to $8,257.52 ($P < .001$).

Table 4 shows the data obtained by multiple regression models used to evaluate the predictors of stay. These data indicated that high Charlson comorbidity index ($P < .001$), patient referral from general medicine department ($P < .001$), treatment at a regional or district hospital ($P < .001$), and treatment in a medium- or high-volume hospital ($P < .001$) were significantly associated with short stay. Compared to patient attributes and hospital attributes, stay had a significantly larger coefficient with high-volume centers compared to low- or medium-volume centers (regression coefficient −20.14 d, $P < .001$).

Table 5 shows how data obtained by multiple regression models were used to evaluate the predictors of hospital treatment costs. These data indicated that advanced age ($P < .001$), low Charlson comorbidity index ($P < .001$), patient referral from pulmonary department ($P < .001$), treatment at a regional or district hospital ($P < .001$), treatment at a high-volume hospital ($P < .001$), and short stay ($P < .001$) were associated with decreased hospital treatment costs. Compared to patient attributes and hospital attributes, hospital treatment costs had a significantly larger

Table 4. Multiple Regression Model of the Relationship Between Effective Predictors and Stay for Patients on Prolonged Mechanical Ventilation

	Coefficient	Standard Error	*P*
Constant	63.18		< .001
Year			
2004	Reference		
2005	−4.24	−0.08	< .001
2006	−8.67	−0.15	< .001
2007	−5.18	−0.09	< .001
Age	0.03	0.02	.24
Sex			
Male	Reference		
Female	0.29	0.02	.62
Charlson Comorbidity Index			
≤ 2	Reference		
3	−14.11	−0.25	< .001
4	−13.57	−0.24	< .001
≥ 5	−14.34	−0.26	< .001
Patient referral source			
General medicine	Reference		
General surgery	2.79	0.03	.14
Cardiology	2.34	0.02	.34
Pulmonary	8.89	0.18	< .001
Neurology	0.38	0.02	.57
Other	4.23	0.03	.10
Hospital level			
Medical center	Reference		
Regional hospital	−7.47	−0.15	< .001
District hospital	−6.69	−0.14	< .001
Hospital volume			
≤ 25 (low)	Reference		
26–74 (medium)	−13.54	−0.31	< .001
≥ 75 (high)	−20.14	−0.34	< .001

Table 5. Multiple Regression Model of the Relationship Between Effective Predictors and Hospital Treatment Costs for Prolonged Mechanical Ventilation Patients

Variables	Coefficient	Standard Error	*P*
Constant	6,558.17		< .001
Year			
2004	Reference		
2005	1,148.18	0.08	< .001
2006	1,023.57	0.07	< .001
2007	1,463.24	0.11	< .001
Age	−13.22	−0.04	< .001
Sex			
Male	Reference		
Female	−270.43	−0.02	0.06
Charlson Comorbidity Index			
≤ 2	Reference		
3	998.27	0.07	< .001
4	1,063.61	0.08	< .001
≥ 5	1,057.31	0.08	< .001
Patient referral source			
General medicine	Reference		
General surgery	5,018.09	0.19	< .001
Cardiology	1,422.51	0.04	.002
Pulmonary	−1,329.47	−0.12	< .001
Neurology	1,125.83	0.06	< .001
Other	1,644.30	0.04	< .001
Hospital level			
Medical center	Reference		
Regional hospital	−5,100.18	−0.39	< .001
District hospital	−6,049.78	−0.42	< .001
Hospital volume			
≤ 25 (Low)	Reference		
26–74 (Medium)	−778.57	0.09	< .001
≥ 75 (High)	−1,430.32	−0.11	< .001
Stay	124.54	0.53	< .001

coefficient with stay (regression coefficient $124.54, $P < .001$).

Discussion

This population-based study is the first to examine how patient attributes and hospital attributes reflect changing trends in the prevalence of PMV patients, and the first to identify factors that predict stay and hospital treatment costs. The present study confirmed the findings of previous studies that age < 74 years, male sex, Charlson comorbidity index of 4 and higher, patient referral from cardiology, pulmonary, or neurology/neurosurgery department, treatment in medical center or district hospital, and treatment in high-volume hospital were associated with increased likelihood of PMV. Older patients who are predominantly male and with greater Charlson comorbidity index are the most likely to have longer stay and hospital treatment costs, probably because these characteristics represent the most frail and sick patients.

National registry studies such as those performed by the BNHI in Taiwan are an excellent source of population-based data for evaluating the current practice of PMV.[13-15] Unlike single-center series studies, data from registry studies provide an overview of practices in large populations while avoiding referral bias or bias reflecting the practices of individual physicians or institutions.[13-15]

There are few females in the population of patients receiving PMV. In 2010 the average life expectancy of the Taiwanese population for males and females was 78 years and 83 years, respectively. We hypothesize that the higher rate in males results from lower Charlson comorbidity index and the tendency of diseases to be more severe in males than in females at the time of medical intervention, because males tend to delay medical treatment.[16]

The incidence and prevalence of PMV depends on the specific setting and on how PMV is defined. No multicenter studies have applied a strict definition of PMV such as 21 days or longer. However, single-site studies indicate that 3–7% of patients receiving mechanical ventilation meet such criteria.[11] Population-based studies of PMV often use the former Diagnosis-Related Group 483 to identify patients in large administrative databases.[17] An earlier analysis of a statewide North Carolina database between 1993 and 2002 revealed a 78% increase in the number of patients discharged with Diagnosis-Related Group 483 after receiving mechanical ventilation (ie, from 43.2/1,000 such patients in 1993 to 77.1/1,000 patients in 2002).[3] In our study the prevalence of PMV patients per 100,000 patients declined gradually, from 94.30 in 2004 to 89.38 in 2007. Based on the BNHI policy requiring quality of care for PMV patients, the total numbers of PMV patients has not increased, but the total population of Taiwan increased.[18] Our study also showed a significant decrease in the prevalence of PMV in older patients (ie, PMV patients age 75 years or older decreased from 74% in 2004 to 68% in 2007, but the number of comorbidities also increased from 2004 to 2007 during the same period). Duration of ventilation is reportedly associated with cause of ICU admission, age, and treatment location.[19] Most PMV patients in the current study had been referred from pulmonary departments, and the percentage of patients, from 33.65% in 2004 to 49.95% in 2007, is consistent with previous studies.[4,20]

The temporal trend showed that a higher Charlson comorbidity index was observed from 2004 to 2007, but the stay trend was reduced during the same time period. This counterintuitive association also explains that patients with greater comorbidity are dying in hospitals. This deserves a further study in the near future.

Stay also decreased, from 35.12 days in 2004 to 31.61 days in 2007. The 2000 BNHI policy for PMV patients apparently decreased the stay of PMV patients.[18] The decrease in stay was larger in regional hospitals and district hospitals, as compared to medical centers, and most patients had initiated mechanical ventilation in the ICUs of short-term acute care medical centers. Patients with underlying chronic cardiorespiratory illnesses tended to remain ventilator-dependent and tended to transition from acute illness status to chronic or critical illness status. During this transition, alternatives to ICU care in medical centers should be considered. The literature shows that patients treated in high-volume medical centers have significantly shorter stay, compared to those treated in low-volume centers.[21] The time required before resuming work or other normal activity is also reportedly longer in patients treated in low-volume centers, compared to those treated in high-volume centers, which is consistent with the observation in this study that patients treated in high-volume centers had shorter hospital stays than those treated in low-volume centers did.

An analysis by the Medicare Payment Advisory Commission indicated that the treatment costs for PMV patients can be reduced by early transfer to regional or district hospitals.[22] The data revealed that hospital treatment costs for patients receiving PMV increased from $7,933.17 in 2004 to $8,257.52 in 2007. The data also reflect changing trends of PMV. A higher Charlson comorbidity index and treatment at a medical center were positively associated with hospital treatment costs. This perhaps explains why the hospital treatment costs were going up during the study period.[5,22,23]

In the study, the rising costs, shorter stay, and a decreased temporal trend of prevalence of PMV patients, especially for an aging population with fewer older age individuals, were simultaneously observed over time. These results are the opposite of those in the United States, which show that the incidence of PMV patients being discharged to long-term acute care hospitals is increasing.[24] In Taiwan, there was an increased percentage of patients coming from high-volume medical centers during the same time period.

Efforts to slow the growth in hospital treatment costs have increased scrutiny of various patient subgroups in order to minimize unnecessary treatments and to limit life-sustaining therapies that do not benefit the patient, such as in cases of brain death. Our analyses may help to develop guidelines for timing the changes in care for PMV patients. Increasing nurse-to-patient ratios in respiratory care centers and respiratory care wards to ratios exceeding those in ICUs may also decrease hospital treatment costs.

Limitations

This study has several limitations that are inherent in any large database analysis. First, the clinical picture obtained by analyzing claims data are not as precise as that obtained by analyzing prospective clinical trial data, due to possible errors in the coding of primary diagnoses and treatment modalities. Additionally, the relationship between these factors and hospital resource utilization could not be evaluated. Second, complications associated with hospital resource utilization were not assessed, which limits the validity of the predictions. Finally, the analysis did not examine outcome data such as patient-reported quality of life and indirect costs incurred after discharge.

Conclusions

In conclusion, these population-based data demonstrated a decrease in the prevalence of PMV, especially for older patients, and it also showed that stay decreased; however, hospital treatment costs increased. Healthcare providers and patients should understand that stay and hospital treatment costs depend not only on patient attributes but also on hospital attributes.

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