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Economic Burden of Diabetes Mellitus on Patients with Respiratory Failure Requiring Mechanical Ventilation during Hospitalizations

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ABSTRACT

Objectives: To examine the economic burden of diabetes mellitus (DM) on medical expenditure among patients with respiratory failure (RF) requiring mechanical ventilation during hospitalization. **Methods:** We extracted the data from Taiwan National Health Research Insurance Database for those adult patients on their first hospitalization for RF requiring mechanical ventilation between 2004 and 2010. We examined associations between medical expenditure and the presence of comorbid DM. We performed independent t tests, chi-square tests, and multivariate linear regression analysis to identify factors associated with excess medical expenditure. **Results:** Of 347,961 patients hospitalized with first occurrence of RF requiring mechanical ventilation, 123,023 (35.36%) patients were documented to have a previous diagnosis of DM. Patients with RF and DM were sicker and consumed more health care resources than did patients with RF without DM. After adjusting for the specified covariates, mechanically

ventilated patients with RF and DM consumed at least US \$618 more of total inpatient medical expenditure than did patients with RF without DM. There were statistically significant interactions between age and DM on their total inpatient medical expenditure regardless of discharge status. **Conclusions:** DM was associated with more severe disease status and higher consumption of medical expenditure during hospitalizations among mechanically ventilated patients due to first occurrence of RF in Taiwan. These findings provide scientific evidence to facilitate appropriate resource allocation and formulate programs for higher quality of care in the future in Taiwan and other countries. **Keywords:** diabetes mellitus, economic burden, hospitalization, respiratory failure.

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Introduction

Mechanical ventilation (MV) in patients with respiratory failure (RF) is associated with an incremental cost of up to US \$1500 per day in the United States [1,2]. Based on the National Health Insurance (NHI) report in Taiwan, the cost associated with MV-dependent patients with RF was approximately US \$22,530 per year [3]. The MV utilization increased by approximately 180% from 1997 to 2004 in Taiwan [4]. Thus, the greater use of MV among patients with RF accounts for the large economic burden on limited resources of the health care system in Taiwan and other countries.

It is estimated that 15% to 25% of the patients with RF require prolonged MV because of difficult weaning [5,6]. Factors associated with difficult weaning in patients with RF included increasing blood urea nitrogen levels and lower comatose scores [7]. Furthermore, the increasing incidence of MV dependence was associated with the burden of comorbidities [8]. In particular, the increased incidence of MV among younger patients was associated with a higher burden of obesity, diabetes, or renal failure [8]. While diabetes mellitus (DM) was documented to be one of the most frequent complications for ventilator-dependent patients who were treated at long-term care hospitals [9], Cheng et al.'s study [4] indicated that DM was

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one of the leading diagnoses among patients with RF requiring MV.

Patients with DM consumed 4.3 times more health care costs than did patients without DM, and it accounted for 11.5% of the total health care cost in Taiwan [10]. Although those critically ill patients with DM were prone to develop more complications [11], these diabetic, critically ill patients had equal or even decreased mortality compared with those without DM [12,13]. As a result, decreasing mortality among critically ill patients might incur longer hospitalization and add on more economic burden either on the perspectives of health care providers and/or the Bureau of National Health Insurance (BNHI) in Taiwan. The aim of this study was to examine the economic burden due to DM among patients with RF requiring MV during hospitalization.

Methods

Data Sources

In Taiwan, the BNHI has contracted with 97% of hospitals since 1996 to ensure sufficient access to health care. Currently, the coverage of both population and hospitals is as high as 99%. The BNHI has proposed and implemented many strategies to ensure appropriate use of NHI resources in the hope of controlling the rapid growth of health care utilization and expenditures. For instance, the Integrated Delivery System (IDS) has encouraged hospitals to set up respiratory care centers and/or respiratory care wards. These step-down units provide high-quality, integrated care for patients with prolonged MV use and help with cost containment. Moreover, those sicker patients who consume more medical expenditure because of comorbid diseases and need long-term care (including RF with MV for 21 days or more) were qualified to be assigned with the catastrophic illness certificate (CIC). The co-payments for these patients are waived in accordance with NHI policy in Taiwan. Those patients with RF involved in the IDS programs or assigned with CIC were also evaluated for their excess medical expenditure.

This study used data from inpatient claims of the National Health Research Insurance Database, which covered all inpatient claims of the sampling insured Taiwanese population, during the study period of 2004 to 2010. The variables that were examined and evaluated included patients' demographic characteristics, disease status (e.g., primary and secondary admission diagnosis), and health care utilization (e.g., dates of admission and discharge, IDS, CIC, and hospital expenditure). The components of medical expenditure included all NHI-covered fees for diagnosis, laboratory tests, radiography services, therapeutic treatment, surgery, rehabilitation, blood products, hemodialysis, special medical supply, prescribed medications, and other services incurred during hospitalization. This study was exempt from the Institutional Review Board because the National Health Research Insurance Database contains only de-identified patient information and is publicly available through the proper application process.

Study Population

We evaluated beneficiaries aged 18 years or older who were hospitalized because of the first occurrence of RF during the years 2004 to 2010 on the NHI inpatient claim data. To minimize concern for data skewness, we excluded 7100 cases (2%) that were considered outliers because of extreme inpatient medical expenditure incurred during hospitalization.

Study Design

We conducted a population-based retrospective data analysis. For those included beneficiaries, the first occurrences of RF during hospitalizations in the years 2004 to 2010 were evaluated. We

defined those patients with in-patient diagnoses *International Classification of Diseases, Ninth Revision, Clinical Modification* codes of 518.81, 518.82, 518.83, and 518.84 as patients with RF and those who had the *International Classification of Diseases, Ninth Revision, Clinical Modification* code of 250 as patients with DM. In our study, all patients with RF, either with DM or without DM, were ever mechanically ventilated during hospitalizations. We also evaluated the disease records regarding their dysfunctional organ systems during hospitalizations and grouped the systems into six categories (e.g., circulatory collapse, renal failure, hepatic failure, and coagulation defects). These categories were adapted from the results of expert panel discussions and modified definitions obtained from Marshall et al.'s and Gall et al.'s studies [14,15].

Those beneficiaries who lived in areas belonging to the first and fourth quartiles of population density in Taiwan were grouped into low and high urbanization, respectively. We used Charlson's comorbidity index to estimate disease burden and as a controlling variable for potential confounding [16]. We summed all claimed reimbursement expenditures that were associated with RF for total hospital expenditure during hospitalizations. We calculated the durations between admission and discharge dates during hospitalization as "length of stay (LOS)" and categorized the LOS into three levels. The medical expenditures were expressed in US dollars (US \$1 = 31.64 New Taiwan Dollar in 2010). All the aforementioned variables were assumed to be related to medical expenditure that occurred in hospitals.

Specifically, discharge status in the NHRID was categorized as "recovered," "transferred to outpatients care," "deceased," "against-advice discharge," "critical against-advice discharge," "transferred to another hospital," and others. In Taiwan, the majority of citizens prefer to receive end-of-life care at home and so hospitals usually allow patients to be discharged under critical condition on the request of the patients' family. Therefore, we classified discharge status into two groups: alive and dead (including critical against-advice discharge).

Statistical Analysis

We used independent t tests and chi-square tests to analyze patients' sociodemographic characteristics, disease characteristics, their health utilization, and corresponding hospital characteristics among patients with first occurred RF with DM and without DM during hospitalization. As for the medical expenditure, it is expected to have some extreme values. Therefore, the truncated mean and the corresponding simple and multiple linear regression models were performed to assess the excess medical expenditure between patients with RF and DM and patients with RF without DM, stratified by their death status, after excluding 2% of the cases. Sensitivity analyses to include all cases were performed to confirm the robustness of all findings. The aforementioned variables of interest, including patients' characteristics, disease status, hospital settings, involvement of catastrophic illness status, and/or IDS, were expected to correlate with the consumption of medical expenditure through the consensus of focus group discussions. Thus, these variables were taken into account into different models when performing multiple regression analyses. Furthermore, the interaction effects of total hospital expenditure with age and DM were examined. The statistical significance level was set at a two-sided P value of less than 0.05. All analyses used the SAS software version 9.3 (SAS Institute, Inc., Cary, NC).

Results

Patient Characteristics

For the study period 2004 to 2010, the inpatient claims for 347,961 patients with RF were retrieved for further analyses. There were

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