Home Mechanical Ventilation Use in South Korea Based on National Health Insurance Service Data

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BACKGROUND: In Asian countries, nationwide data on patients undergoing home mechanical ventilation are limited. METHODS: This study investigated the prevalence and primary indications for home mechanical ventilation use in South Korea by using nationwide registry data from the National Health Insurance Service. RESULTS: The study period included a total of 4,785 subjects on home mechanical ventilation (mean ± SD age, 56.0 ± 23.9 y; females, 40.1%). The estimated overall prevalence of home mechanical ventilation use in South Korea was 9.3 per 100,000, with a prevalence of 6.3 per 100,000 among children (ages < 15 y). The most common primary diagnoses were neuromuscular diseases (42.0%) and lung and/or airway diseases (27.7%). The prevalence of lung and/or airway and cerebrovascular diseases as the primary diagnosis increased with age (r = 0.310, *P* < .001; and r = 0.156, *P* < .001, respectively). Noninvasive ventilation was used by 37.2% of all the subjects, with the highest prevalence in those with neuromuscular diseases (54.4%) or chest wall diseases (53.4%). Noninvasive ventilation use was lowest among subjects with brain lesions. Home mechanical ventilation was most commonly prescribed by internists (41.3% of cases), followed by rehabilitation and neurology physicians. CONCLUSIONS: These data will aid in planning the optimal health-care system for users of home mechanical ventilation locally and will allow for comparison of home mechanical ventilation use rates among countries. *Key words: home mechanical ventilation; noninvasive ventilation; prevalence.* [Respir Care 2019;64(5):528–535. © 2019 Daedalus Enterprises]

Introduction

The introduction of noninvasive ventilation (NIV) has resulted in a worldwide increase in home mechanical ventilation. Furthermore, advances in critical care medicine have led to an increasing number of patients who require home mechanical ventilation after surviving acute respiratory failure.[1] However, despite the increasing use of mechanical ventilation in the home, nationwide data on patients treated with home mechanical ventilation remain

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limited. Traditionally, diseases that cause progressive respiratory failure, for example, neuromuscular disease (NMD), were the most common indication for home mechanical ventilation and typically resulted in long-term dependence. Although less common, patients with acute respiratory failure and who are unable to be weaned off of mechanical ventilation have also required home mechanical ventilation. However, the primary diagnoses and prescribing practices for home mechanical ventilation can vary among countries.[2,3] This variability may be influenced by many factors, including cultural characteristics, access to home mechanical ventilation, health-care service organization, and adequacy of delivery.

Recently, novel ventilators and ventilation modes have been developed in an effort to improve patient-ventilator synchrony.[4,5] Telemonitoring of home mechanical ventilation delivery is also improving and has the potential to improve patient adherence.[6,7] However, organizing a health-care system to ensure effective use of home mechanical ventilation and optimal allocation of limited resources requires detailed knowledge regarding current home mechanical ventilation use and practices. Currently, nationwide data on home mechanical ventilation use are lacking, particularly in Asian countries, with the exception of Hong Kong.[8] This study used nationwide data from the National Health Insurance Service to investigate the current status of home mechanical ventilation use in South Korea.

QUICK LOOK

Current knowledge

Advances in critical care medicine have led to an increasing number of patients who require home mechanical ventilation. The estimated prevalence of home mechanical ventilation use varies among Western counties. However, nationwide data on home mechanical ventilation use are lacking in Asian countries.

What this paper contributes to our knowledge

The estimated overall prevalence of home mechanical ventilation use was 9.3 per 100,000; among children, the estimated prevalence was 6.3 per 100,000. Neuromuscular diseases were the most common primary diagnosis, and the frequency of home mechanical ventilation use for lung and/or airway diseases and for cerebrovascular diseases increased with age. In addition, the proportion of subjects with mask ventilation use was 37.2%, a much lower rate than for Canada (73%) and European countries (~87%).

Methods

Nationwide data for this cross-sectional study were obtained from the National Health Insurance Service database. Anonymous data were collected from patients with the National Health Insurance Service who had made an insurance claim for home mechanical ventilation use between August 2015 and July 2017. Patients were required to update their insurance claim forms every 2 y; therefore, 2-y data were analyzed. However, we also obtained the total number of users of home mechanical ventilation per year since 2010 to evaluate the trend in home mechanical ventilation use over time. In this study, home mechanical ventilation was defined as NIV or tracheostomy ventilation used at home on a daily basis. Patients had to satisfy one of the following inclusion criteria: 2 episodes of hypercapnia ($P_{aCO_2} \geq 45$ mm Hg) on different days, or the requirement for 24-h home mechanical ventilation, as prescribed by a physician. Patients on a CPAP device for obstructive sleep apnea were excluded from the study.

The following data were collected for each subject: age; sex; home province; symptoms of hypercapnia, including dyspnea, fatigue, headache, nighttime awakening and daytime sleepiness, anxiety, impaired alertness, and palpitations; primary diagnoses for home mechanical ventilation use; ventilator type; and prescribing department. The use of NIV or tracheostomy ventilation was also recorded. To estimate the prevalence of home mechanical ventilation use, the Korean census population in 2016 was used as a reference.[9] This study was approved by the Hallym University Institutional Review Board (IRB 2017-I139). The need for informed consent was waived based on the nature of the study.

Data and Statistical Analysis

The primary aims of this study were to estimate the prevalence of home mechanical ventilation use in South Korea and to evaluate the distribution of primary diagnoses for home mechanical ventilation. Secondary aims were a detailed assessment of lung and/or airway diseases and of NMDs as causes of chronic respiratory failure, identification of the departments that most often prescribe home mechanical ventilation, assessment of the distribution of primary diagnoses by age group, and evaluation of the relative proportions of NIV. In this study, descriptive analyses were primarily performed. All categorical variables are presented as number percentage, and all continuous variables are presented as mean ± SD. The Student *t* test was used to compare continuous variables, and the chi-square test was used to compare categorical variables. For correlation analysis, the Pearson correlation was used. All tests of significance were 2 tailed, and $P < .05$ was taken to indicate significance. All statistical analyses were performed by using SPSS for Windows software (version 22.0, IBM, Armonk, New York).

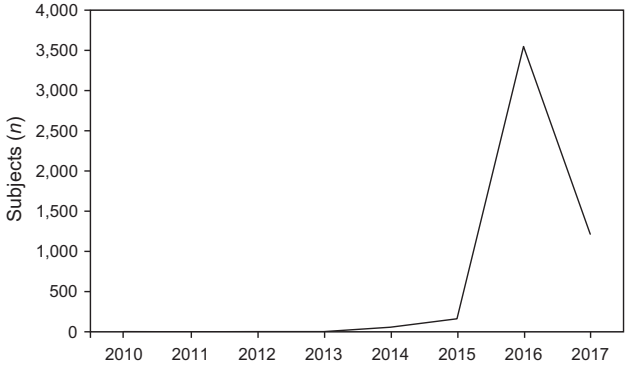

Fig. 1. The number of users of home mechanical ventilation in South Korea between 2010 and July 2017.

Results

Study Population and Estimated Prevalence of Home Mechanical Ventilation

Based on the National Health Insurance Service data, a total of 4,785 subjects in South Korea used home mechanical ventilation between August 2015 and July 2017; a huge increase in home mechanical ventilation use was observed in 2016 compared with previous years (Fig. 1). The mean ± age was 56.0 ± 23.9 y, and 40.1% ($n = 1,917$) were female. According to the Korean population census data for 2016 (51,269,554),[9] the estimated prevalence of home mechanical ventilation use was 9.3 per 100,000. The estimated 1,917 prevalence of home mechanical ventilation use among children was 6.3 per 100,000. Patients who resided in the capital areas (ie, Seoul, Gyeonggi, and Incheon) accounted for 38.1% of all home mechanical ventilation use (data not shown).

Home mechanical ventilation was initiated due to $P_{aCO_2} \geq 45$ mm Hg in 70.4% of cases (3,369/4,785), and, in the remainder of the cases (29.6%), it was initiated with an indication for 24 h according to a physician. At least one hypercapnic symptom was present in 62.6% of the subjects ($n = 2,995$); dyspnea (56.7%) and fatigue (36.4%) were the most commonly reported symptoms. Ancillary tests, polysomnography and pulmonary function tests, were performed in 3.3 and 24.2% of the subjects respectively. Life support ventilators, which incorporate both pressure and volume modes and were suitable for invasive applications, were used in 77.8% of the cases ($n = 3,724$). Non–life support ventilators, which only have pressure modes, were used by 22.2% of the subjects ($n = 1,601$). Eighty-two subjects (1.7%) used cough assist (ie, in-exsufflator) concurrently.

Primary Diagnosis for Home Mechanical Ventilation

NMDs and lung and/or airway diseases were the most common primary diagnoses (Table 1); these 2 disease categories accounted for 42.0% ($n = 2,008$) and for 27.7% ($n = 1,327$) of all home mechanical ventilation use. The next most common diagnoses were cerebrovascular disease (10.3%) and hypoxic brain damage (5.1%). Among NMDs, motor neuron disease accounted for 65.4% ($n = 1,314$) and muscular dystrophy accounted for 16.3% ($n = 327$) (Table 2). Among the lung and/or airway diseases, COPD ($n = 461$ [34.7%]) and tuberculosis ($n = 81$ [6.1%]) were most common (Table 2).

Table 1. Primary Diagnoses for Home Mechanical Ventilation Use

Disease	Results, *n* (%)
Neuromuscular diseases	2,008 (42.0)
Lung and/or airway diseases	1,327 (27.7)
Cerebrovascular disease	492 (10.3)
Hypoxic brain damage	246 (5.1)
Encephalopathy	198 (4.1)
C-spine injury	145 (3.0)
Ataxia	67 (1.4)
Central sleep apnea	60 (1.3)
Chest-wall disease	58 (1.2)
Brain tumor	51 (1.1)
Congenital anomaly	38 (0.8)
Others*	104 (2.2)

* Neonatal respiratory failure ($n = 38$), multiple systemic atrophy ($n = 26$), metabolic disease ($n = 24$), multiple sclerosis ($n = 12$), and prion disease ($n = 4$).

Table 2. Neuromuscular and Lung and/or Airway Diseases as Primary Diagnoses for Home Mechanical Ventilation Use

Disease	Results, *n* (%)
Neuromuscular diseases	
Motor neuron disease	1,314 (65.4)
Amyotrophic lateral sclerosis	743 (37.0)
Spinal muscular atrophy	295 (14.7)
Progressive bulbar paralysis	12 (6.0)
Other motor neuron diseases	264 (13.1)
Muscular dystrophy	327 (16.3)
Myopathy	228 (11.4)
Guillain-Barré syndrome	77 (3.8)
Myasthenia gravis	52 (2.6)
Peripheral neuropathy	10 (0.5)
Lung and/or airway diseases	
COPD	461 (34.7)
Tuberculosis-destroyed lung	81 (6.1)
Bronchiectasis	66 (5.0)
Idiopathic pulmonary fibrosis	45 (3.4)
Bronchial asthma	20 (1.5)
Other specified respiratory failures	654 (49.3)

Frequency of Primary Diagnosis by Age and Sex

NMDs were most common in subjects ages < 65 y, and lung and/or airway diseases were most common in sub-

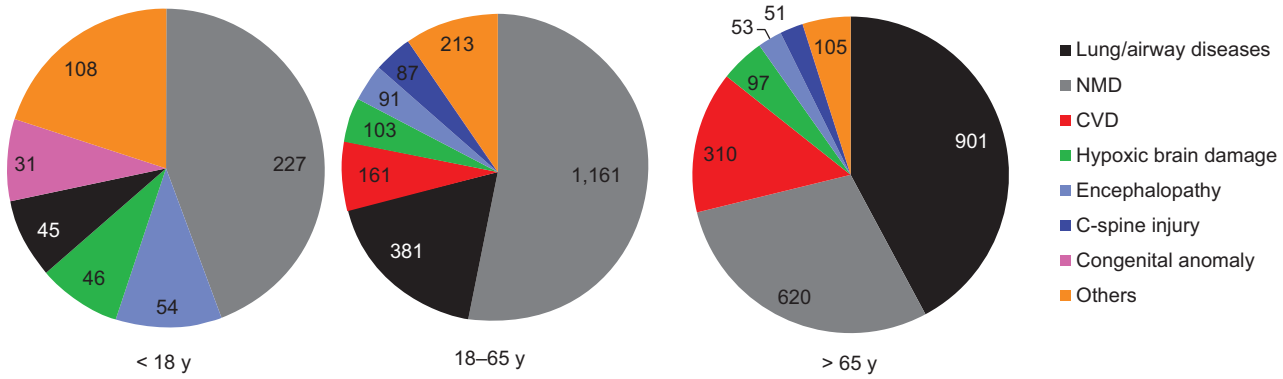

Fig. 2. Frequency of primary diagnoses of users of home mechanical ventilation in South Korea by age. Neuromuscular diseases (NMD) represented the most common diagnosis among subjects ages < 65 y, whereas lung and/or airway diseases were the most common in subjects ages > 65 y. The frequency of lung and/or airway diseases and cerebrovascular diseases increased with age. CVD = cerebrovascular disease.

jects ages > 65 y (Fig. 2). The frequency of both lung and/or airway and cerebrovascular diseases increased with age (r = 0.310, $P < .001$; and r = 0.156, $P < .001$, respectively). The frequency of NMDs was higher in the male than in the female subjects (45.2 vs 37.1%, $P < .001$). Lung and/or airway (29.7 for females vs. 26.4% for males, $P = .01$) and cerebrovascular diseases (12.6 for females vs. 8.8% for males, $P < .001$) were more common in female subjects.

Rate of the Use of NIV

NIV was used by 1,781 of 4,785 subjects (37.2%). Among the 1,781 subjects (10.9%) used nasal masks. NIV use was most common in subjects with NMDs (n = 1,092/2,008 [54.4%]) or chest wall disorders (n = 31/58 [53.4%]) (Fig. 3A). Fewer than 10% of the subjects with brain lesions used NIV (prion disease, 0%; brain tumor, 3.9%; hypoxic brain damage, 6.1%; and encephalopathy, 5.6%). The male subjects used NIV more frequently than did the female subjects (40.4 vs 32.4%, $P < .001$). The proportion of NIV use was highest in those ages 20–29 y (70.9%). The absolute number of NIV users was highest in those ages 60–69 y (n = 428/1,781) (Fig. 3B).

Departments Prescribing Home Mechanical Ventilation

The majority of home mechanical ventilation use was prescribed by internists (n = 1,978 [41.3%]), followed by rehabilitation (n = 993 [20.1%]) and neurology departments (n = 907 [19.0%]) (see the supplementary materials at http://www.rcjournal.com). Internists most commonly prescribed home mechanical ventilation for subjects with lung and/or airway diseases (58.8%) or NMDs (11.3%). Rehabilitation physicians most commonly prescribed home mechanical ventilation for subjects with NMDs (71.9%) or cervical spine injuries (9.4%) (see the supplementary materials at http://www.rcjournal.com).

Service Providers and Costs of Home Mechanical Ventilation

A total of 42 home respiratory care companies provided services to users of home mechanical ventilation in South Korea. They not only supplied ventilators and equipment but also delivered services on a regular basis to patients; once per month is mandatory. Almost all subjects rented a ventilator for use at home, and the rental fee for a ventilator was $535.00 per month. They also paid $240.00 for a mask and $170.00 for ventilator accessories per year. Hence, an estimated cost for home mechanical ventilation use was $569.20 per subject per month. Subjects were reimbursed by the government at a rate of 90.0% of the cost.

Discussion

This study, which used the National Health Insurance Service data, characterized several previously unknown trends regarding home mechanical ventilation use in South Korea. The estimated overall prevalence of home mechanical ventilation use was 9.3 per 100,000; among children, the estimated prevalence was 6.3 per 100,000. NMDs were the most common primary diagnosis, and the frequency of home mechanical ventilation use for lung and/or airway and for cerebrovascular diseases increased with age. Also, NIV was used by 37.2% of the subjects most frequently in patients with NMDs or chest wall diseases.

The estimated prevalence of home mechanical ventilation use varies among counties (Table 3).[2,8,10-17] In Europe, based on data from the Eurovent survey, the home mechanical ven-

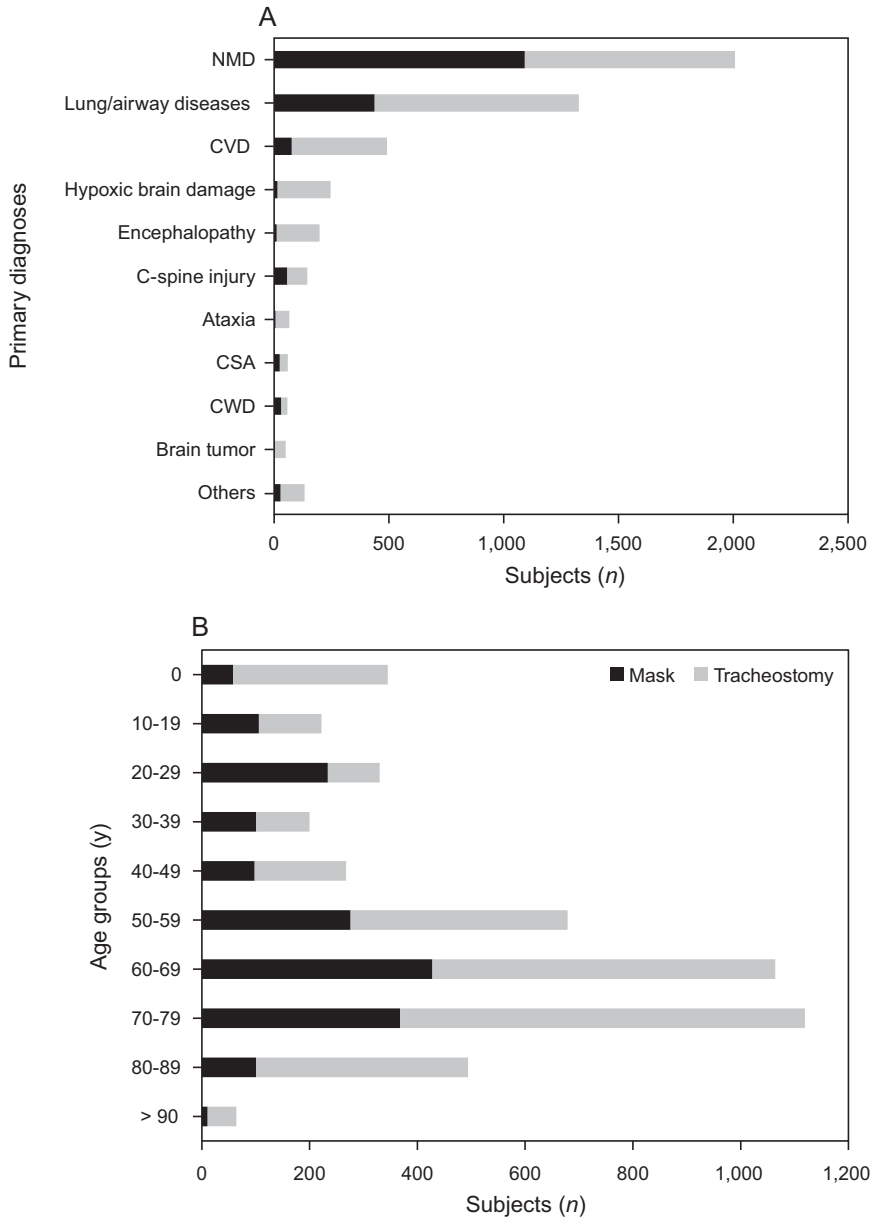

Fig. 3 The rate of mask ventilation use among patients who used home mechanical ventilation. (A) The rate of mask ventilation use was highest among subjects with neuromuscular disease (NMD) or chest-wall diseases (CWD). (B) The rate was highest in patients ages 20–29 y, but the absolute number of subjects was highest in those ages 60–69 y. CSA = central sleep apnea; CVD = cerebrovascular disease.

tilation use rate was estimated at 6.6 per 100,000 people, with the highest rate seen in France (17 per 100,000).[3] In Canada, the rate of home mechanical ventilation use was estimated to be 12.9 per 100,000 people.[17] Although nationwide data are lacking for the United States, Divo et al[18] noted that the prevalence of prolonged mechanical ventilation, irrespective of setting, increased from 2.8 per 100,000 in 1983 to 7.1 per 100,000 in 2006. These differences in prevalence among countries may be associated with differences in clinical practices and health-care systems, including reimbursement programs. For instance, in the United States, more patients who require long-term ventilation are managed in hospitals or long-term acute care facilities compared with European countries.[1,18] However, given the benefits of home mechanical ventilation use in reducing hospital costs and enhancing quality of life, the rate of home mechanical ventilation use is expected to increase.[19]

The primary indications for home mechanical ventilation use varied among countries. In European countries, the most common indication was NMD,[3] whereas, in Can-

Table 3. Prevalence of Home Mechanical Ventilation Use and Proportion of Mask Ventilation

Locations	Reference No.	Study Year	No. Estimated Prevalence (per 100,000)	Proportion of Mask Ventilation, %
All ages				
European countries	3	2001–2002	6.6 (0.1-17.0)	87
Canada	17	2012–2013	12.9	73
Massachusetts	2, 18	2006	3.4*	22
Australia and New Zealand	16	2011	9.8 and 12.0	96
Hong Kong (adults)	8	2002	2.9	94.8
South Korea	Current study	Aug 2015 to Jul 2017	9.3	37.2
Children				
Switzerland	10	2000	3.4	59.4
Massachusetts	2, 13	2005	9.6†	51
Pennsylvania	2, 11	2006	6.4	ND
Utah	12	2004	6.3	ND
Southwestern United Kingdom	14	2009	6.7	55.9
Italy	15	2007	6.3	ND
South Korea‡	Current study	Aug 2015 to Jul 2017	6.3	20.6

* A total of 221/6,437,197 based on the 2006 Massachusetts census population number.
† A total of 137/1,420,835 based on the estimated pediatric population of Massachusetts in 2009 (from Reference 2).
‡ A total of 431/6,856,319 children ages < 15 y.
ND = no data

ada, amyotrophic lateral sclerosis and muscular dystrophy were the most common.[17] In Australia and New Zealand, obesity hypoventilation syndrome accounted for most of the home mechanical ventilation prescriptions.[16] In the present study, NMDs (42.0%) and lung and/or airway diseases (27.7%) were the most common primary diagnoses in users of home mechanical ventilation. The benefits of home mechanical ventilation use are well established for patients with Duchenne muscular dystrophy and amyotrophic lateral sclerosis.[20,21]

A randomized controlled trial by Bourke et al[22] showed that home mechanical ventilation use improved both survival and quality of life in subjects with amyotrophic lateral sclerosis with preserved bulbar function. However, there also is evidence to support home mechanical ventilation use in patients with COPD. Köhnlein et al[23] showed that subjects with hypercapnic (P_{CO_2} > 51.9 mm Hg) stable COPD were likely to benefit from home mechanical ventilation and that lowering P_{CO_2} would be the best target. Murphy et al[24] also showed that home mechanical ventilation, when added to home oxygen therapy, could improve survival and prolong time to readmission in subjects with persistent hypercapnia after a life-threatening exacerbation.

In the present study, polysomnography was undertaken only in 3.3% of the subjects, possibly because polysomnography is performed in a limited number of patients with obstructive sleep apnea due to the high cost and is not covered by insurance in South Korea. Besides, we could not investigate ventilation modes or settings applied to the subjects due to the nature of the design. Only ventilator types (ie, life support and non–life support ventilators) were identified. However, volume modes are traditionally preferred in patients with NMDs[25] and offer an advantage in those with more-severe chronic respiratory failure.[26] In a European survey, subjects with NMDs used volume modes more frequently.[3] With regard to patients with COPD, Dreher et al[27] showed that subjects with severe disease may benefit from high-intensity NIV by using high-pressure support (eg, usually > 24.0 cm H_2O), which results in improved daytime P_{aCO_2} and FEV_1. Murphy et al[28] also reported similar results. Hence, physicians should understand the potential role of normalizing P_{aCO_2} in these patients.

Interestingly, in our study, rehabilitation physicians were found to be the second most common prescribers of home mechanical ventilation in South Korea. Contrary to internists, both rehabilitation and neurology physicians most commonly prescribed home mechanical ventilation for those patients with NMDs (71.9% and 77.0%, respectively) (see the supplementary materials at http://www.rcjournal.com). Not surprisingly, this reflects the increasing importance of pulmonary rehabilitation in patients with chronic respiratory failure.

The proportion of subjects with NIV use in this study was 37.2%, a much lower rate than for Canada (73%)[17] and European countries (~87%)[3] In particular, a nasal mask was used in only 10.9% of subjects with a noninvasive ventilator. Although mask ventilation use in Europe varied by disease category, it was also different among regions, with the lowest percentage (<20%) seen in Poland in subjects with NMDs.[3] Another finding in our study

was that the rate of NIV use was lowest (<10%) among subjects with brain lesions, such as encephalopathy, hypoxic brain damage, or prion disease. This is similar to previous studies conducted in Italy.[15,29] Among age groups, the rate of NIV use was highest in subjects ages 20–29 y. The higher rate of NIV in this group may reflect superior adherence by young adult patients. In general, patients who require 24-h home mechanical ventilation support are recommended to receive mechanical ventilation via tracheostomy,[30] and the rate of NIV in these patients may be affected by disease prevalence, interface type, and ethical considerations. Hence, the risks and benefits of NIV versus tracheostomy should be carefully evaluated for each disease category.

Among Korean children, the estimated prevalence of home mechanical ventilation use was 6.3 per 100,000. This is a similar rate to several Western countries (Table 3). NMDs were the most common primary diagnosis among these patients, followed by encephalopathy and hypoxic brain damage. As in the adult population, previous reports have shown that the primary diagnosis for home mechanical ventilation use in children varies among countries.[12,14,15] However, the rate of NIV use in this study remained lower (20.6%) than international norms. Although the lack of suitable masks for children may complicate optimal home mechanical ventilation use, other barriers, such as insufficient funding or caregivers, should also be considered in future studies.[15,17,31]

This study had several limitations. First, clinical findings and outcomes (ie, mortality) were not available due to the nature of the National Health Insurance Service database. Second, data on the hours of home mechanical ventilation required per day, the frequency of complications and ventilator settings were not available; these data may have provided insight into patient adherence. Third, some subjects initially on mask ventilation may have changed to tracheostomy ventilation during the course of their home mechanical ventilation use. Fourth, subjects may have died or been admitted to the hospital during the course of their home mechanical ventilation use; this may have resulted in overestimation of the prevalence of home mechanical ventilation in our study. However, due to the single-payer nature of the South Korean health-care system, it is highly likely that data were collected on all patients who used home mechanical ventilation nationwide. This, along with the large number of included subjects, represented the strengths of the current study. Future studies should evaluate the optimal start time and settings of home mechanical ventilation in a disease-specific fashion, identify the patient groups that benefit most from home mechanical ventilation, and evaluate the overall economic burden of home mechanical ventilation provision.

Conclusions

This study showed that, among South Koreans, the estimated overall prevalence of home mechanical ventilation use was 9.3 per 100,000. NMDs and lung and/or airway diseases were the most common primary diagnoses of users of home mechanical ventilation, and 37% of the subjects used NIV. Future large-scale studies will be needed to address unresolved issues about the provision of home mechanical ventilation.

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