

The age-related characteristics of adults with asthma who visited emergency departments in Korea from 2007 to 2012

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ABSTRACT

Background: Understanding the patterns of emergency department (ED) visits of patients with asthma is important for disease control and prevention of exacerbations.

Objective: This study aimed to investigate the characteristics of adult patients who visited EDs because of their asthma.

Methods: Patients with asthma, ages ≥ 19 years old, who visited 117 EDs throughout Korea between January 2007 and December 2012 were identified in the National Emergency Department Information System (NEDIS) data base using the International Classification of Disease, 10th revision, codes J45 (asthma) and J46 (status asthmaticus).

Results: A total of 97,835 adult patients with asthma visited 117 EDs throughout Korea during the study period. There was a slight female preponderance (male-to-female ratio, 1:1.09). The number of patients aged 70–79-years-old was 28,031 (28.7%), the highest among the patients with asthma. ED visits showed a seasonal distribution, with most occurring in winter and spring, followed by autumn. The seasonal distribution varied by age; most patients ages 19–49 years presented in autumn (September), whereas those patients ages ≥ 50 years presented to the ED most often in winter. Overall, 65.5% of patients were admitted to the hospital, including 12.6% admitted to an intensive care unit (ICU). Overall, 209 patients (0.2%) died. The rates of hospital admission to general wards and ICUs were highest in those patients ≥ 70 years old; this group also had the highest mortality rate.

Conclusion: In this nationwide study, which spanned 6 years, of adult patients with asthma, we observed an age-specific seasonal pattern of ED visits. Identifying the causes of age-related deterioration and seasonal visits to the ED will help prevent asthma symptoms and reduce medical costs.

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In 2003, the World Health Organization reported that 235 million people had asthma worldwide.¹ In disability-adjusted life years, a measure of the loss of years of healthy life due to early death, ill health, or disability, asthma was the third-most burdensome disease in Korea in 2002, after diabetes mellitus and cerebrovascular disease.^{2,3} Globally, the prevalence of asthma ranges from 1 to 38% in children and adolescents, depending on geographic location and age, and is increasing.^{4,5} The prevalence of physician-diagnosed asthma has increased over the past decade, probably due to an increase in awareness of the diagnosis, not a

true increase.⁶ There is little research on the population and time-specific prevalence of asthma in adults.⁷

The patterns of hospitalization, mortality, and deteriorating seasons differ by sex and age.^{8–10} Boys are hospitalized more commonly than girls, whereas women are hospitalized more commonly than men.^{11,12} Korea has a continental climate with four distinct seasons. A study conducted in 2002 reported that particulate matter under 10 microns in size (PM₁₀) and ozone concentrations are associated with hospital visits by patients with asthma.¹³ Korean children with asthma and adolescents frequently visit the emergency department (ED) in the autumn, and this age group has been affected by infections, e.g., the H1N1 pandemic, *Mycoplasma pneumoniae* epidemic.¹⁴ The present study aimed to investigate factors that affect asthma exacerbations by analyzing the characteristics of ED visits by adult patients with asthma and the prevalence which can prevent future asthma exacerbations, and thereby reduce the number of ED visits and minimize socioeconomic costs.

METHODS

Study Population and Statistical Analysis

The study subjects were adult patients (ages ≥ 19 years) who visited 117 EDs throughout the country

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Table 1 The incidence of ED visits for asthma, stratified by age and sex, 2007–2012

Age (yr)	Total ED Visits (N = 97,835)				Midyear Population, 2007–2012			ED Visits per 10,000 Population	
	Men	Women	M:F ratio	Total (%)	Men	Women	M:F ratio	Men	Women
19–29	3156	3723	1:1.18	6879 (7.0)	23,911,390.0	22,195,553.5	1:0.93	1.3	1.7
30–39	3362	4429	1:1.32	7791 (8.0)	25,673,831.0	24,716,467.0	1:0.96	1.3	1.8
40–49	4260	4578	1:1.07	8838 (9.0)	26,443,400.5	25,496,750.0	1:0.96	1.6	1.8
50–59	6009	5913	1:0.98	11,922 (12.2)	19,762,245.5	19,695,176.5	1:1.00	3.0	3.0
60–69	9774	7793	1:0.80	17,567 (18.0)	11,457,472.0	12,708,816.5	1:1.11	8.5	6.1
70–79	13,676	14,355	1:1.05	28,031 (28.7)	5,994,775.0	8,878,551.0	1:1.48	22.8	16.2
80–89	6032	9174	1:1.52	15,206 (15.5)	1,402,999.0	3,300,195.5	1:2.35	43.0	27.8
≥90	498	1103	1:2.21	1601 (1.6)	12,1248.5	451,274.0	1:3.72	41.1	24.4

ED = Emergency department; M = male; F = female.

between January 2007 and December 2012, and who were diagnosed with asthma. The sex and age of the subjects, year and month of ED visits, rate of hospitalizations to the general ward and the intensive care unit (ICU), and the number of deaths were analyzed. Data that corresponded to the ED visits of patients coded according to the *International Classification of Disease, 10th Revision*¹⁵ codes J45 (asthma) and J46 (status asthmaticus) were retrospectively investigated by using the National Emergency Department Information System. Information from the Korean Statistical Informational Service was used to determine the midyear population. Institutional review boards waived deliberation of this study. Statistical analysis was performed by using PASW Statistics version 18.0 (SPSS Inc., Chicago, IL) and SAS version 9.4 (SAS Institute, Cary, NC). Each variable was compared by using the χ^2 test. Statistical significance was defined as a *p* value of <0.05 by using two-tailed test. M.-H. Lee and H.-J. Seo contributed equally to this study as the co-first authors.

RESULTS

Sex and Age Distribution of Adult Patients with Asthma Who Visited the ED

A total of 97,835 patients with asthma visited 117 EDs throughout the country between 2007 and 2012, with a male-to-female ratio of 1:1.09. The majority of the patients were >60 years old; ED visits due to asthma were the most common in the age group 70–79 years (28.7% [28,031]) (*p* < 0.001) (Table 1). A sex difference was observed between the age groups, with more women in the 19–49-years-old and more men in the 50–69-years-old groups (Table 1). Women accounted for the majority of patients ages ≥70 years old (Table 1). This was a somewhat different sex distribution from the Korean Statistical Informational Service

distribution. The patients who visited the ED per 10,000 population increased with age, and more women were in the 19–49-years-old age group, more men were in the >50-years-old group (Table 1).

Annual and Monthly Distributions of ED Visits for Asthma

The annual number of ED visits for all the patients with asthma ages ≥19 years gradually increased from 2007, which reached a high of 20,158 visits in 2012, and more than half were admitted to the general ward (*p* < 0.001) (Table 2). The ED visits per 10,000 population increased from 3.0 in 2007 to 5.1 in 2012, and the number of hospitalizations per 10,000 population increased from 2.0 to 3.3 (Table 2). Annual ED visits, stratified by age, tended to increase year after year; this increase was greater in those patients ages ≥50 years (Fig. 1). Overall, the seasonal distribution of patients with asthma who visited the ED over the 6-year study period was highest in January (winter), followed by May (spring), as shown in Fig. 2. In terms of specific years, the most ED visits occurred in September (autumn), followed by May, in 2007. In 2009, most visits occurred in spring, followed by winter. In 2008, and from 2010 to 2012, visits were most frequent in winter and least frequent in summer (Fig. 2).

The monthly distribution of ED visits of patients with asthma varied by age group (*p* < 0.001) (Fig. 3). Among those ages 19–49 years, most ED visits occurred in September, gradually decreased until December (early winter), and gradually increased thereafter until May (Fig. 3). Among patients 50–69 years old, most visits occurred in December and January, followed by May. In the young age group (<30 years of age), most ED visits for asthma occurred in autumn. In addition, a second peak was found during spring in all adult patients except those ages ≥90 years. Among

Table 2 Annual ED visits for asthma from 2007 to 2012

Year	Total ED Visits*	ED Visits per 10,000 Population	Hospitalizations*		Hospitalization per 10,000 Population	Discharged, no. (%)	Transferred, no. (%)	Died, no. (%)	Unknown, no. (%)
			General Ward, no. (%)	ICU, no. (%)					
2007	11,278	3.0	6155 (54.6)	1233 (10.9)	2.0	3539 (31.4)	194 (1.7)	29 (0.3)	128 (1.1)
2008	14,634	3.8	8018 (54.8)	1707 (11.7)	2.6	4548 (31.1)	252 (1.7)	32 (0.2)	77 (0.5)
2009	15,709	4.1	8398 (53.5)	1932 (12.3)	2.7	5027 (32.0)	223 (1.4)	36 (0.2)	93 (0.6)
2010	17,748	4.6	9231 (52.0)	2294 (12.9)	3.0	5929 (33.4)	224 (1.3)	31 (0.2)	39 (0.2)
2011	18,308	4.6	9447 (51.6)	2535 (13.8)	3.0	6047 (33.0)	211 (1.2)	43 (0.2)	25 (0.1)
2012	20,158	5.1	10,483 (52.0)	2629 (13.0)	3.3	6735 (33.4)	245 (1.2)	38 (0.2)	28 (0.1)
Total	97,835	4.2	51,732 (52.9)	12,330 (12.6)	2.8	31,825 (32.5)	1,349 (1.4)	209 (0.2)	390 (0.4)

ED = Emergency department; ICU = intensive care unit.

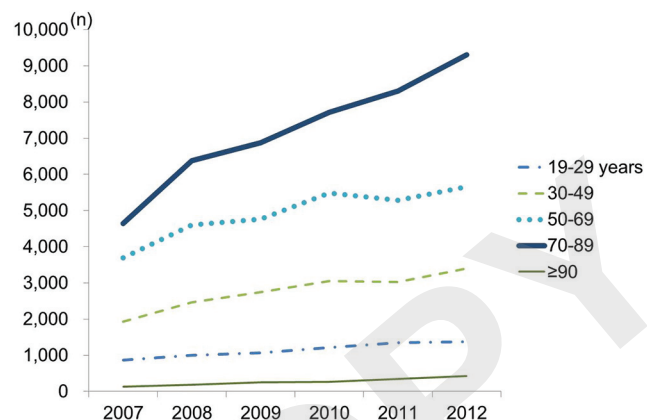
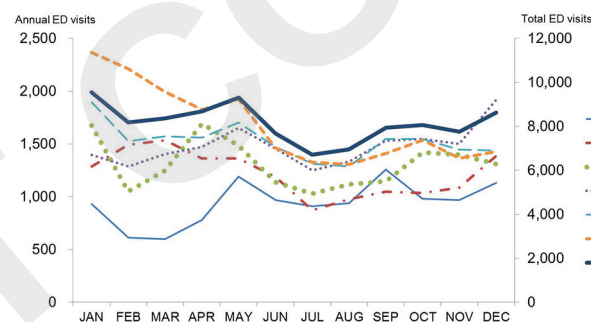
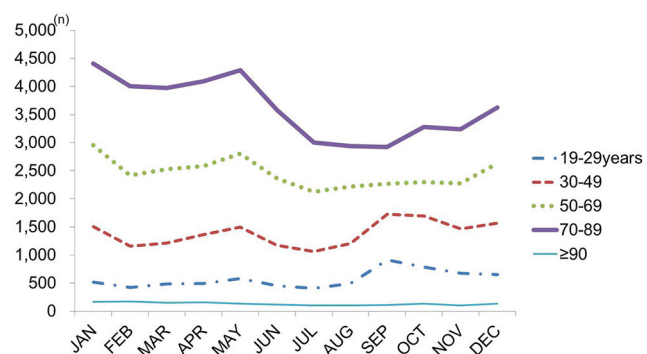
* $p < 0.001$.Figure 1. The number of annual emergency department visits due to asthma from 2007 to 2012 by age groups ($p < 0.001$).

Figure 2. The number of annual emergency department visits due to asthma from 2007–2012 by month.

Figure 3. The monthly emergency department visits due to asthma, stratified by age groups ($p < 0.001$).

all age groups, the number of patient visits to the ED for asthma was lowest from June to August, the summer months.

Hospitalization and Mortality Rates of Adult Patients with Asthma Who Visited the ED

Over the study period, the 97,835 ED visits resulted in 64,062 hospitalizations (65.5%), including 12,330 patients (12.6%) admitted to the ICU, and 209 deaths (0.21%) (Table 2). Both hospitalizations to the general ward and the ICU were increased year after year ($p <$

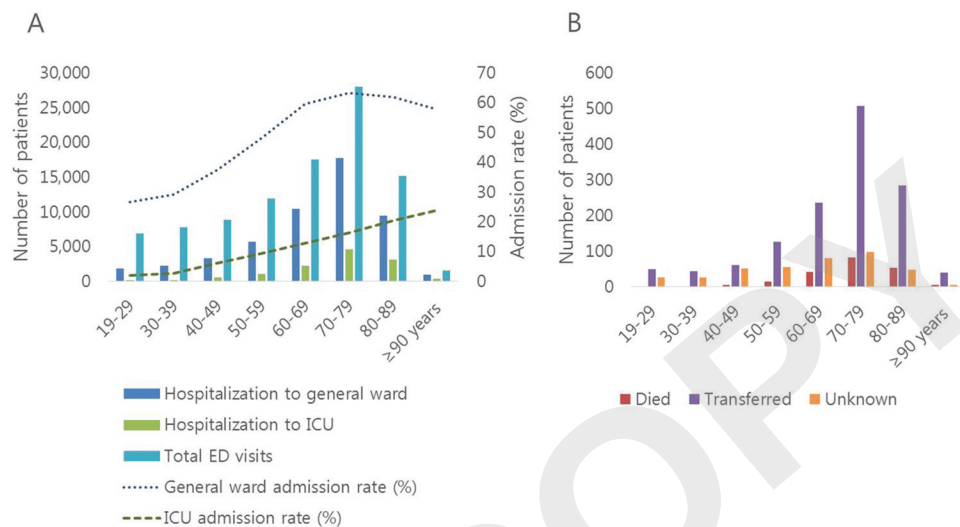


Figure 4. Clinical outcomes at emergency department stratified by age groups. (A) The number of hospitalization and the rate; (B) The number of non-hospitalized patients.

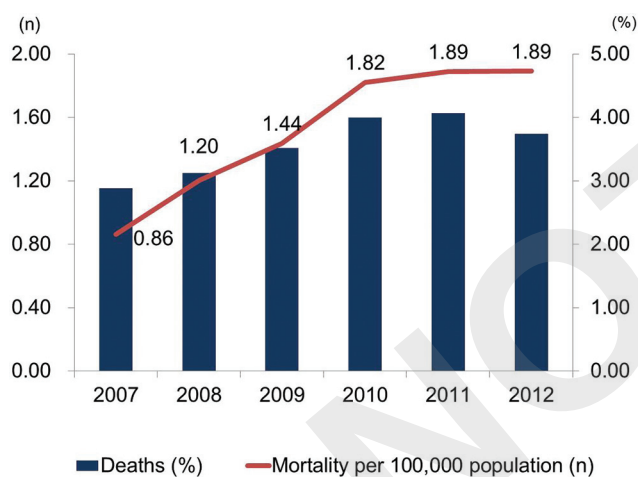


Figure 5. The annual emergency department deaths and in-hospital deaths due to asthma and mortality per 100,000 population.

0.0001). The highest hospitalization rate of ICU admissions (23.0%) was in the ≥ 90 -years-old age group; hospitalizations to the general ward were highest (63.3%) in those ages 70–79 years (Fig. 4 A). The hospitalization rate was lowest among patients 19–29 years old. The total number of patients who attended the ED was lowest in the ≥ 90 -years-old age group, but this group had the highest rate of hospitalizations to the ICU (Fig. 4 A).

Most deaths occurred in the 70–79-years-old age group, followed by the 80–89-years-old and 60–69-years-old age groups ($p < 0.0001$) (Fig. 4 B). Both ED and in-hospital deaths increased annually from 2007 to 2012 (Fig. 5). This increase was gradual; the mortality rate was 2.9% in 2007, which increased to 4.1% in 2011 and decreased slightly to 3.7% in 2012. The annual mortality rate (ED and in-hospital deaths) per 100,000 population increased (Fig. 5). Including in-hospital deaths, the mortality rate was 0.86 per 100,000 population in 2007 and increased to 1.89 by 2012 (Fig. 5).

DISCUSSION

Data from the Korean National Health Insurance Service claims data base showed that the financial burden of asthma in 2008 was \$831 million, with an annual mean cost per patient of \$336.¹⁶ Although the largest proportion of the entire cost was attributed to children, the highest cost per person was for those ages ≥ 50 years.¹⁶ According to a study of the Nationwide Emergency Department Sample in the United States, morbidity and mortality were higher among those ages ≥ 55 years than among children and younger adults, consistent with the result of the present study.^{16,17}

In the United States, primary care visits and death rates per 1,000 population among patients with asthma declined from 2001 to 2009, but their ED visits and rates of hospitalizations did not change.¹⁸ In this study, ED visits, hospitalizations with asthma, and deaths per 100,000 population in adults increased annually (Table 2; Fig. 5).¹⁸ This may be because asthma control efforts and prevention of asthma exacerbations have been suboptimal or because there may have been an increase in aggravating factors. However, it is likely that mortality was higher among the elderly patients with various comorbidities, when considering that the older age group (≥ 70 years) accounted for most hospitalizations and deaths. Among the Organization for Economic Co-operation and Development (OECD) member countries, Korea is anticipated to have the most rapid shift toward an aging population.¹⁹ In elderly asthma, it is difficult to control asthma because of various comorbidities, various medications, and lack of awareness of the use of asthma medications.²⁰ As the elderly population increases, action plans and education regarding prevention of asthma exacerbations targeted at the elderly, annual seasonal influenza vaccination, in addition to symptom management, are required.

ED visits due to asthma showed a female preponderance in the 19–49 and ≥ 70 -years-old age groups (Table 1). This did not mirror the population distributions of 2007–2012 because there were more men in the 19–59-years-old age group, and more women ages ≥ 60 years. Although the cause of this sex difference was not clear, there are many factors, such as aging, obesity, menopause, and sex differences in exposures.^{21–23}

There was an obvious seasonal difference in ED visits for asthma according to age group. There were peaks in September and May for those ages 19–49 years and in winter for those ages 50–69 years, with a slight increase in May (Fig. 3). In the elderly patients, ED visits were most common in winter (Fig. 3). Pediatric patients with asthma show two peaks in ED visits: in spring and in autumn.¹⁴ This result clearly shows that the causal factors of asthma exacerbations vary by age group. In other words, the months in which most ED visits took place differed between children and adults, and between younger and older adults, which implied that factors associated with asthma exacerbations were age specific and that the immunopathology of asthma symptom development and susceptibility also differed by age.

The limitations of this study included the National Emergency Department Information System being the source of data because it does not include information on treatment, symptoms, and investigation results of patients with asthma who visited the ED. Therefore, the severity of the disease or how the diagnosis was made was unclear. Some patients with asthma diagnosed by physicians may be excluded from the diagnosis by reevaluation.²⁴

Hospitalizations due to asthma increased markedly during the H1N1 influenza pandemic of 2009.^{25,26} It can be speculated that one of the reasons why so many patients with asthma in the ≥ 40 -years-old age group visited ED during winter in this study might be due to influenza. With increasing age, pulmonary function decreases, drug response declines due to changes in respiratory receptors, and airway responsiveness increases, and the reaction to a bronchodilator decreases.²⁷ In the present study, ICU admissions increased with increasing age. One reason may be because of discrepancies in drug action as well as airway hypersensitivity in older compared with younger adults with asthma.

An investigation of pollen and skin reaction tests conducted in Korea from 2008 to 2013, showed that the concentration of pollen was highest in May, followed by September, and the new pollen calendar, based on research on the changed types of pollen due to climate change in Korea, also reported the same results, consistent with the findings of the present study.^{28,29} The prevalence of atopy and asthma is higher in industrialized countries due to air pollution, which increases

respiratory inflammation.³⁰ Acute exacerbations of patients with refractory asthma have been reported to be associated with increased SO₂ levels as the ambient temperature decreases in winter.³¹ Although the prevalence of refractory asthma is not high, this may have partially contributed to the peak of ED visits during winter in the elderly patients. Because the possibility of the increase of ED visits due to environmental factors such as pollen or yellow dust and particulate matter [particulate matter under 10 microns in size (PM₁₀) or particulate matter under 2.5 microns on size (PM_{2.5})] cannot be excluded in Asia, activation of pollen forecasts and measures to reduce air pollution are required.

Interestingly, unit temperature (celsius) changes were associated with asthma-related ED visits; this influence was greatest in autumn and in the elderly patients, which indicated that temperature may be an important factor for asthma exacerbations,³² similar to the finding of age-related seasonal variation in this study. The peaks of May and September in the 19–39-years-old age group in the present study can be explained by the effect of the diurnal temperature range; this age group showed the same pattern as in children and adolescents. In other words, the pathophysiology of asthma was different in those ≥ 40 years old compared with younger patients with asthma. Particularly, the lungs develop until the age of 20–25 years; thereafter, pulmonary function decreases. Moreover, the epithelial lining of the airways produces fluid that contains plenty of antioxidant. This fluid protects the respiratory system from ozone or particulate matter. However, the composition of this fluid changes with age, which leads to increasing susceptibility to environmental pollution among the elderly patients.²⁷

ED visits for asthma increased during the influenza season (Fig. 2); there was a pandemic of H1N1 influenza in 2009–2010, thus, ED visits were more frequent than in any other year.¹⁴ Although the number of hospitalized patients increased from 2009 to 2012, in 2009 the hospitalization rates of the general ward and ICU were 53.5 and 12.3%, respectively, showing no remarkable increase compared with rates in other years (Table 2). The hospitalization rate of ICU was increased, which indicated that infection with H1N1 influenza increased the severity of acute asthma exacerbations.

In other studies, the asthma exacerbations observed during autumn are explained by rhinovirus infection or the influence of fungus.^{26,33} There were mycoplasma epidemics (that usually occur every 3–4 years) in 2007 and in 2011, the peak occurred in September and October, which influenced the ED visits by patients with asthma, the incidence of asthma exacerbations, and pneumonia in children.^{14,34} In the present study, similar to that ob-

served in children and adolescents, the peak in adults was also in September and October during the mycoplasma epidemics of 2007 and 2011 (Fig. 2). Although the mycoplasma infection rate of adult patients with asthma is lower than that of children and adolescents, asthma exacerbations are more common in adults who are either coinfectd or infected with *M. pneumoniae* as a single etiologic agent.^{35,36}

CONCLUSION

ED visits of adults with asthma varied according to age and sex. The number of ED visits and hospitalizations was greatest in the 70–79-years-old age group, and the number of ED visits per 10,000 population was the highest in the 80–89-years-old age group with 70.8 patients (male 43.0, female 27.8). In addition, the seasonal pattern of ED visits varied by age, being highest during autumn among patients 19–49 years old and during winter among those patients ages ≥50 years. The results of this study showed that the factors that influenced asthma exacerbations varied according to age and indicated that the pathophysiology of and susceptibility to asthma exacerbations also varied with age. It is necessary to identify these age-related exacerbating factors to find ways to reduce ED visits and hospitalizations. The present study was based on reliable data, and the findings provided useful data for future research on the pathophysiology, exacerbating factors, prevalence, and medical and socioeconomic costs of asthma in adults, stratified by age.

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