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## Original Article

# Longitudinal changes in the prevalence of adult asthma: An epidemiological survey among Japanese salaried employees and their dependents using healthcare insurance claim from 1999 to 2019

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LTRA, leukotriene receptor antagonist

FY, fiscal year

## ABSTRACT

**Background:** Information on changes in asthma prevalence and the treatment status for asthma is used as basic information for taking medical and administrative measures against asthma. However, this information among adults is relatively limited.

**Methods:** To elucidate changes in the prevalence of asthma and treatment status over time among Japanese adults, health insurance claim data from some health insurance societies covering salaried employees and their dependents were studied longitudinally. Claim data from FY1999 to 2007 were obtained from two health insurance societies, and data from FY 2011 to 2019 were obtained from three different health insurance societies, and changes in standardized asthma prevalence among subjects aged 20–59 years, proportion of asthma patients prescribed ICS, leukotriene receptor antagonist (LTRA), and LABA, and the mean number of acute asthma exacerbations per year were analyzed.

**Results:** The prevalence of asthma increased from 1.6% in 1999 to 3.0% in 2007 and 2.9% in 2011 to 4.6% in 2019. Increased trends in asthma prevalence from 2011 to 2019 were more noticeable in subjects in their 50s than those in their 20s for both sexes. The number of emergency visits related to asthma was 1.5 per year in 1999, which decreased to 0.8 per year in 2019. The proportion of people prescribed all anti-asthma medications (ICS, LTRA, and LABA) increased over time.

**Conclusions:** The prevalence of adult asthma among Japanese salaried employees and their dependents has increased over the last 20 years, suggesting more attention should be paid to the prevention of this disease in adults.

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## Introduction

Asthma is a major worldwide public health concern, with prevalence rates varying from a few percent to 20% in different countries.<sup>1</sup> A nationwide survey using the European Community Respiratory Health Survey questionnaire performed in 2006 in Japan showed that the prevalence of asthma among adults aged 20–79 years was 4.2%.<sup>2</sup>

Information on time-trend in prevalence and the treatment status of asthma is used as basic information for taking medical and administrative measures against asthma. Although the current prevalence of asthma in many countries is significantly higher than it was half a century ago, over the last 10–20 years, the prevalence in some countries was reported to have flattened out or decreased.<sup>3–6</sup> Regarding the prevalence of asthma in childhood in Japan, large-scale epidemiological surveys have been performed on elementary school children in western Japan. The prevalence was reported to have increased from 3.2% in 1982 to 6.5% in 2002,<sup>7</sup> whereas it was decreased to 4.7% in 2012.<sup>8</sup> A more recent set of nationwide epidemiological surveys performed on 6–8-year-old children in Japan also showed a decrease in the prevalence of current wheeze from 13.6% in 2005 to 10.2% in 2015.<sup>9</sup> However, time-trends in asthma prevalence among Japanese adults are relatively limited. The only long-term study on the prevalence of asthma in adults in Japan was an epidemiological survey conducted in Fujieda City, Shizuoka Prefecture from 1985 to 2006, during which the prevalence continuously increased, at a rate of about 1.5-fold every 10 years.<sup>10</sup> However, information on time-trends in the prevalence after 2006 is limited. In a survey of residents in Kamishihoro, a town in Hokkaido, a decrease in the prevalence of wheezing in the last 12 months from 12.9% among men and 9.8% among women in 2006 to 10.7% among men and 8.3% among women in 2011, respectively was reported.<sup>11</sup>

A major reason for the difficulty in conducting prevalence surveys in adults is related to the absence of an entity that can mediate surveys on the general population (i.e. schools for children). In recent years, epidemiological surveys using the Basic Resident Ledger, which used to be possible, can no longer be conducted due to the protection of personal information. Therefore, we have been studying the feasibility of prevalence surveys using the data of health insurance claims as an alternative to conventional population-based surveys, and have reported some of the results.<sup>12,13</sup> More recently, we reported the validity of the identification of asthma using health insurance claims data on the basis of criteria we developed compared with asthma diagnosis using medical charts.<sup>14</sup> In Japan, all citizens are covered by any of the public medical insurance schemes, and anyone can visit a medical institution of their choice at a relatively low cost. Thanks to this system, almost all asthma patients receiving treatment in Japan are treated under this public insurance system. This is one of the advantages of conducting medical surveys in Japan using health insurance claims data.

The purpose of this study was to examine changes in the prevalence and treatment status of Japanese adult asthma patients over time by analyzing health insurance claims data from several health insurance societies from 1999 to 2019. Asthma patients were discriminated by disease name and pattern of prescriptions on the claim data and previously reported asthma discrimination criteria were used for this purpose.<sup>14</sup> Changes in asthma treatment over time were examined by analyzing the prescription of anti-asthma medications to asthma patients and the number of treatments for acute asthma exacerbation.

## Methods

### Study design

Changes in asthma prevalence and asthma treatment were investigated using data from health insurance claims collected from five health insurance societies between fiscal year (FY) 1999 and FY 2019. Claim data for FY1999, FY2003 and FY2007 were obtained in paper form from two health insurance societies (population 1), which consisted of approximately 85,000 subjects in total. Data for FY2011–FY2019 were obtained in electronic form from different three health insurance societies (population 2), which consisted of approximately 65,000 subjects. These health insurance societies covered the medical expenses of salaried employees (insured persons) of large companies and all their dependents who were enrolled in such schemes, and data from subjects aged 20–59 years were analyzed in this study. The dataset of health insurance claims contained information on diagnoses, prescription, any outpatient treatment, and hospitalizations, and were obtained through MHI Co., Ltd., a company engaged in the inspection of health insurance claims, medical cost analysis and disease analysis in response to requests from health insurers.<sup>12</sup> The dataset was converted to anonymous data and then provided to the researchers with the agreement of the health insurance societies. The ethics committee of the Sagami National Hospital approved the study protocol (No. 2016-20).

### Data handling

Data on each subject's health insurance claims were organized as annual data, with information compiled from April of that year to March of the following year. Regarding the prescription status of anti-asthma medications, the number of prescriptions for all brands of anti-asthma medications including inhalers, oral medications, and patches were first counted separately. Then, they were grouped together by type of medical effectiveness. Thus, the number of ICS prescribed to an individual patient in this study was calculated by summing up the total annual number of canisters of all brands of separate ICS inhalers and combination inhalers including ICS prescribed to the patient. The number of LTRA prescription days was calculated as the total annual number of prescription days for all brands of LTRA oral medications. The number of LABA was calculated by summing up the total number of canisters of all brands of separate LABA inhalers and combination inhalers including LABA. If oral or patch medication of LABA was prescribed, a prescription corresponding to a 30-day supply was converted as corresponding to one canister and that was also added to the annual total number of canisters of LABA. The frequency of acute asthma exacerbations per year was estimated by the number of outpatient treatments for acute asthma exacerbation (xanthine drip or  $\beta_2$ -agonist nebulizer) per year.

### Discrimination criteria for asthma and its prevalence

Asthma in this study was determined by disease name code and prescription patterns, on the basis of criteria we developed in a previous study<sup>14</sup> with some minor modifications. A subject was considered to have asthma when they met condition I and condition II in the same fiscal year. Conditions I and II were as follows: Condition (I) labeled as asthma ICD-10 (J45 and J46) in any month of the year, and Condition (II) meeting either or both of the two following criteria: (i) outpatient treatment for acute asthma

exacerbation (xanthine drip or  $\beta_2$ -agonist nebulizer)  $\geq$  once in the year, or (ii) prescription for asthma; total annual prescriptions include one or more of the following: inhaled corticosteroids  $\geq 1$  canister, leukotriene receptor antagonists  $\geq 150$  days, long acting  $\beta_2$ -agonists  $\geq 1$  canister, short-acting  $\beta_2$ -agonists  $\geq 1$  canister, xanthine formulation  $\geq 30$  days, or inhaled sodium cromoglycate  $\geq 1$  canister.<sup>14</sup> Prevalence of asthma was calculated by dividing the number of persons meeting these criteria by the number of subjects enrolled in the health insurance societies after stratification by sex and age groups (20s, 30s, 40s and 50s). Standardized total asthma prevalence was calculated using the age and sex distribution of the national census taken on October 1, 2010.

### Statistical analysis

We used the Cochran-Armitage trend test for longitudinal changes in prevalence over time. Fisher's exact test was used to assess the differences in prevalence between sexes. The increments in prevalence per fiscal year were estimated by calculating partial regression coefficients and applying a linear regression model for the change in prevalence over time. For separate male and female analyses, linear regression analyses were conducted to detect increments in the prevalence of other age groups compared with the prevalence in the 20s, with prevalence as a dependent variable and year, age group and interaction terms as explanatory variables. Finally, p-values for the interaction terms were reported. A p-value  $< 0.05$  was considered statistically significant. The collected data were analyzed using SPSS V.25.0 software (SPSS, Chicago, IL, USA).

### Results

The number of people aged 20–59 years in the studied populations is shown in Table 1. Populations 1 and 2 included about 70,000 and 40,000 subjects aged 20–59 years, respectively. Because there was a difference in the sex-age distribution between populations and between years as shown in Figure 1, asthma prevalence was standardized for sex-age distribution in the national census taken on October 1, 2010, and its change is shown in Figure 2A. The standardized prevalence of asthma in population 1 increased significantly from 1.6% in FY1999 to 3.0% in FY2007 (p for trend  $< 0.001$ ) and for population 2, it increased from 2.9% in FY2011 to 4.7% in FY2019 (p for trend  $< 0.001$ ). When a linear regression model was applied to the time-trend in the prevalence of asthma,

the partial regression coefficient was 0.17 and 0.24 for populations 1 and 2, respectively (data not shown), indicating that the estimated increment in asthma prevalence was 0.17% per year during FY1999 and FY2007, and 0.24% per year during FY2011 and FY2019. As shown in Figure 2B, the standardized prevalence of asthma was significantly higher in women than in men throughout the observation periods (p  $< 0.001$  for all studied years).

Figure 3 shows changes in the prevalence by sex and age-group. Table 2 shows the partial regression coefficients estimated by linear regression analysis after stratification by sex and age-group. An increased trend in asthma prevalence was more noticeable in subjects in older groups than those in their 20s for both sexes. Particularly for population 2 (from 2011 to 2019), the increment in prevalence per fiscal year was larger for both sexes in their 50s than for those in their 20s.

Figure 4A shows the change in the mean frequency of acute asthma exacerbations per year among subjects meeting the asthma criteria. This decreased significantly from FY1999 to FY2007, but remained almost unchanged since FY2011. The prevalence of subjects prescribed with ICS  $\geq 1$  canister per year among subjects meeting the asthma criteria significantly increased from 37.1% in FY1999 to 56.8% in FY2007 (p for trend  $< 0.001$ ), and 75.6% in FY2011 and 81.3% in FY2019 (p for trend  $< 0.001$ ) (Fig. 4B). Additionally, the prevalence of subjects prescribed with LTRA  $\geq 150$  days per year and LABA  $\geq 1$  canister per year among subjects meeting the asthma criteria was also significantly increased to 7.32% for LTRA in FY2019 (Fig. 4C) and 80.3% for LABA in FY2019 (Fig. 4D). There were no statistically significant differences in the prevalence of subjects prescribed anti-asthma medication between sexes.

### Discussion

This study is the first to reveal changes in the real-world medical status and prevalence of asthma among Japanese adults over a 20-year period using large-scale healthcare insurance claim data. The prevalence of adult asthma among Japanese salaried employee and their dependents has been on the rise over this period. Additionally, the increase in asthma prevalence was more noticeable in subjects in older groups, especially those in their 50s, than those in their 20s for both sexes. This study also revealed that the frequency of ICS use among patients with asthma had increased remarkably over the past 20 years.

**Table 1**

Number of people aged 20–59 years in the studied populations and those who met the asthma criteria.

|                                                                                | Total number of people in studied populations |        |        | Total number of people aged 20–59 years in studied populations |        |        | Number of people aged 20–59 years who met asthma criteria |     |       | Unstandardized prevalence (%) of asthma (95%CI) among people aged 20–59 years <sup>†</sup> |               |               |
|--------------------------------------------------------------------------------|-----------------------------------------------|--------|--------|----------------------------------------------------------------|--------|--------|-----------------------------------------------------------|-----|-------|--------------------------------------------------------------------------------------------|---------------|---------------|
|                                                                                | Total                                         | Men    | Women  | Total                                                          | Men    | Women  | Total                                                     | Men | Women | Total                                                                                      | Men           | Women         |
| Number in population 1 (sum of the number of two health insurance societies)   |                                               |        |        |                                                                |        |        |                                                           |     |       |                                                                                            |               |               |
| FY1999                                                                         | 87,507                                        | 49,833 | 37,674 | 72,950                                                         | 42,641 | 30,309 | 1168                                                      | 610 | 558   | 1.6 (1.5–1.7)                                                                              | 1.4 (1.3–1.5) | 1.8 (1.7–2.0) |
| FY2003                                                                         | 84,005                                        | 47,960 | 36,045 | 69,821                                                         | 41,071 | 28,750 | 1561                                                      | 787 | 774   | 2.2 (2.1–2.4)                                                                              | 1.9 (1.8–2.0) | 2.7 (2.5–2.9) |
| FY2007                                                                         | 81,805                                        | 47,149 | 34,656 | 68,482                                                         | 40,516 | 27,966 | 1952                                                      | 987 | 965   | 2.9 (2.7–3.0)                                                                              | 2.4 (2.3–2.6) | 3.5 (3.2–3.7) |
| Number in population 2 (sum of the number of three health insurance societies) |                                               |        |        |                                                                |        |        |                                                           |     |       |                                                                                            |               |               |
| FY2011                                                                         | 62,691                                        | 35,593 | 27,098 | 40,115                                                         | 23,657 | 16,458 | 1162                                                      | 522 | 640   | 2.9 (2.7–3.1)                                                                              | 2.2 (2.0–2.4) | 3.9 (3.6–4.2) |
| FY2012                                                                         | 64,096                                        | 36,558 | 27,538 | 40,857                                                         | 24,222 | 16,635 | 1248                                                      | 579 | 669   | 3.1 (2.9–3.3)                                                                              | 2.4 (2.2–2.6) | 4.0 (3.7–4.3) |
| FY2013                                                                         | 64,762                                        | 37,123 | 27,639 | 41,290                                                         | 24,638 | 16,652 | 1409                                                      | 634 | 775   | 3.4 (3.2–3.6)                                                                              | 2.6 (2.4–2.8) | 4.7 (4.3–5.0) |
| FY2014                                                                         | 65,059                                        | 37,326 | 27,733 | 41,487                                                         | 24,768 | 16,719 | 1565                                                      | 701 | 864   | 3.8 (3.6–4.0)                                                                              | 2.8 (2.6–3.0) | 5.2 (4.8–5.5) |
| FY2015                                                                         | 64,135                                        | 36,743 | 27,392 | 40,817                                                         | 24,378 | 16,439 | 1687                                                      | 768 | 919   | 4.1 (3.9–4.4)                                                                              | 3.2 (2.9–3.4) | 5.6 (5.2–5.9) |
| FY2016                                                                         | 63,502                                        | 36,521 | 26,981 | 40,333                                                         | 24,200 | 16,133 | 1745                                                      | 830 | 915   | 4.3 (4.1–4.6)                                                                              | 3.4 (3.2–3.7) | 5.7 (5.3–6.0) |
| FY2017                                                                         | 63,338                                        | 36,576 | 26,762 | 40,115                                                         | 24,161 | 15,954 | 1686                                                      | 800 | 886   | 4.2 (4.0–4.5)                                                                              | 3.3 (3.1–3.5) | 5.6 (5.2–5.9) |
| FY2018                                                                         | 63,502                                        | 36,778 | 26,724 | 40,226                                                         | 24,242 | 15,984 | 1893                                                      | 901 | 992   | 4.7 (4.5–5.0)                                                                              | 3.7 (3.5–4.0) | 6.2 (5.8–6.6) |
| FY2019                                                                         | 63,290                                        | 36,782 | 26,508 | 40,036                                                         | 24,242 | 15,794 | 1862                                                      | 929 | 933   | 4.7 (4.4–4.9)                                                                              | 3.8 (3.6–4.1) | 5.9 (5.5–6.3) |

Claim data for FY1999–FY2007 were obtained in paper form from two health insurance societies (population 1) and data for FY2011–FY2019 were obtained in electronic form from three different health insurance societies (population 2).

<sup>†</sup> Calculated by dividing the number of people aged 20–59 years who met the asthma criteria by the total number of people aged 20–59 years in the studied populations.

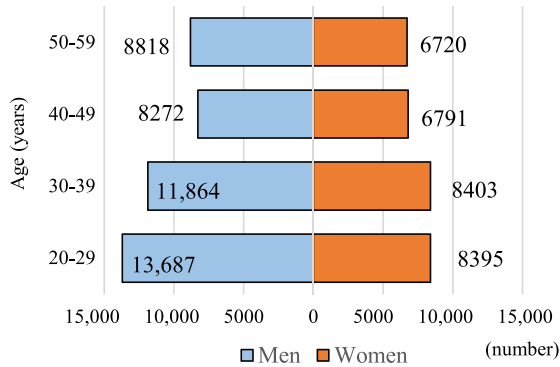
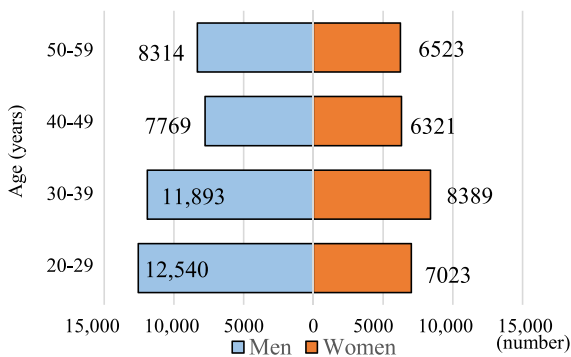
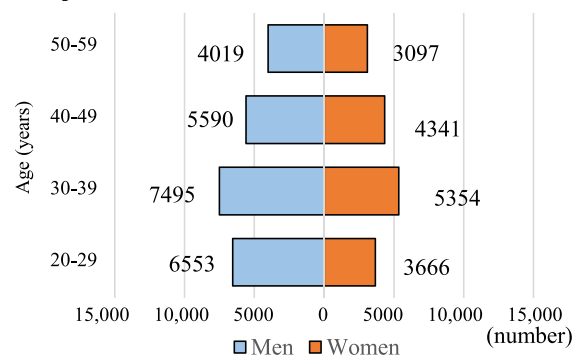
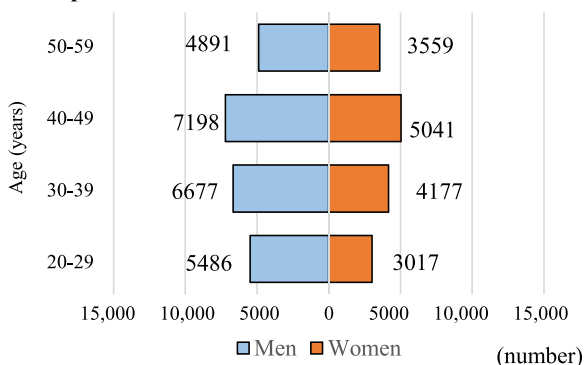
**A. Population 1 at FY1999****B. Population 1 at FY2007****C. Population 2 at FY2011****D. Population 2 at FY2019**

**Fig. 1.** Age distribution of subjects analyzed at FY1999 (A), FY2007 (B), FY2011 (C), and FY2019 (D). FY1999 and FY2007 were the first and last fiscal years of the observation period of population 1. FY2011 and FY2019 were the first and last fiscal years of the observation period of population 2.

In some developed countries, a recent increase in asthma prevalence has not been observed.<sup>3,6</sup> In Japan, the prevalence of asthma in childhood has not increased over the last 20 years.<sup>8,9</sup> However, the findings of this study suggest that the prevalence of asthma in adults is still increasing in Japan (Fig. 2). In order to identify age and sex groups with a more pronounced increase in asthma prevalence, this study also examined increments in the prevalence per year by sex and age group, and found significantly pronounced increases in men and women in their 50s compared to those in their 20s (Fig. 3, Table 2), which is one of the novel findings in this study.

Adult asthma is a syndrome with different clinical phenotypes, and it is generally considered that atopic asthma accounts for a large proportion of asthma patients in younger age groups, such as those in their 20s, whereas atopic asthma accounts for fewer middle-aged people.<sup>15,16</sup> The fact that the prevalence of asthma is not significantly increasing among people in their 20s, who are more likely to have atopic asthma, is consistent with the finding that the prevalence of childhood asthma, which is mostly of the atopic type, has not increased from 2002 to 2012 in epidemiological studies in western Japan.<sup>8</sup>

One possible explanation for the pronounced increase in asthma prevalence in those aged in their 50s compared to other age groups may be related to the increase in the prevalence of obesity in Japanese adults. Obesity has been internationally recognized as an important risk factor for the development of asthma.<sup>17,18</sup> Most of the cluster analysis studies on asthma populations have identified obesity-related asthma clusters, which were characterized by middle-age.<sup>19,20</sup> Our previous study using healthcare insurance claims data also identified an increased BMI and waist circumference as significant risk factors for incident asthma among women aged 40–59 years.<sup>21</sup> In Japan, the government (Ministry of Health, Labour and Welfare) required all health insurance societies throughout Japan to conduct “specific health checkups” on their members aged 40–74 years from 2008. Thus, most of the subjects aged 40–74 years in our health insurance claims data are linked to data of “specific health checkups”. Indeed, the percentage of subjects with a BMI of 30 kg/m<sup>2</sup> or higher among the studied subjects with “specific health checkups” data increased significantly from 1.36% in 2011 to 2.95% in 2019 ( $p < 0.001$  by Fisher’s exact test) in men aged 40–59 years, and from 0.4% in 2011 to 1.17% in 2019 ( $p < 0.001$  by Fisher’s exact test) in women aged 40–59 years (data not shown).

The prevalence of asthma among women in their 30s also showed a pronounced increase compared with women in their 20s. Because “specific health checkups” in those in their 30s are not mandatory, we do not have data on sufficient sample sizes to determine whether the prevalence of obesity among women in their 30s has increased. We consider that one possible explanation for a more pronounced increase in women in their 30s may be related to the rapid changes in the employment environment for women in this age group. Studies have shown associations between work stress and higher asthma prevalence<sup>22</sup> or poorer asthma quality life.<sup>23</sup> According to the website of the cabinet office of the Japanese government,<sup>24</sup> the employment rate of women aged 30–34 years increased rapidly from 48.4% in 1986 to 70.3% in 2016.

Significant increases in the rate of ICS use observed in our study are in line with findings from previous studies and can be regarded as a result of the dissemination of the asthma guidelines in Japan. We previously reported a significant increase in the prevalence of ICS use among patients with asthma, who visited allergy or respiratory departments of national hospitals across Japan, from 62% in 1995 to 89% in 2006.<sup>16</sup> A telephone survey of asthma patients from

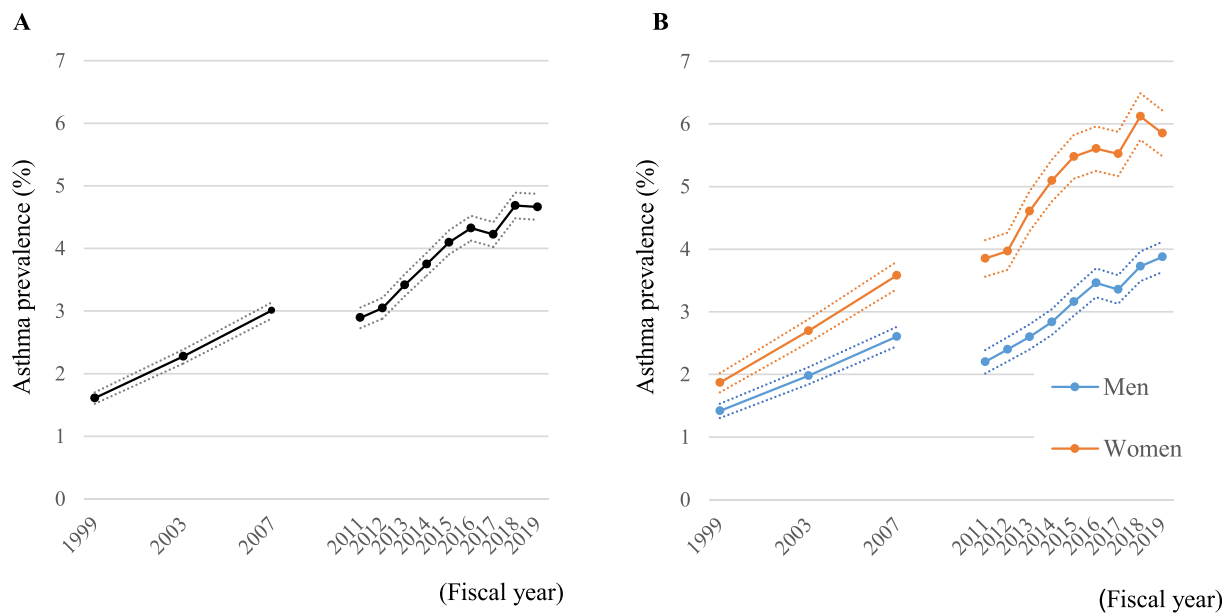


**Fig. 2.** Changes in the standardized prevalence of asthma determined on the basis of health claims data among overall subjects (A) and by sex (B). Solid lines indicate asthma prevalence and dotted lines indicate their 95%CI. Asthma prevalence was standardized for sex-age distribution in a national census taken on October 1, 2010.

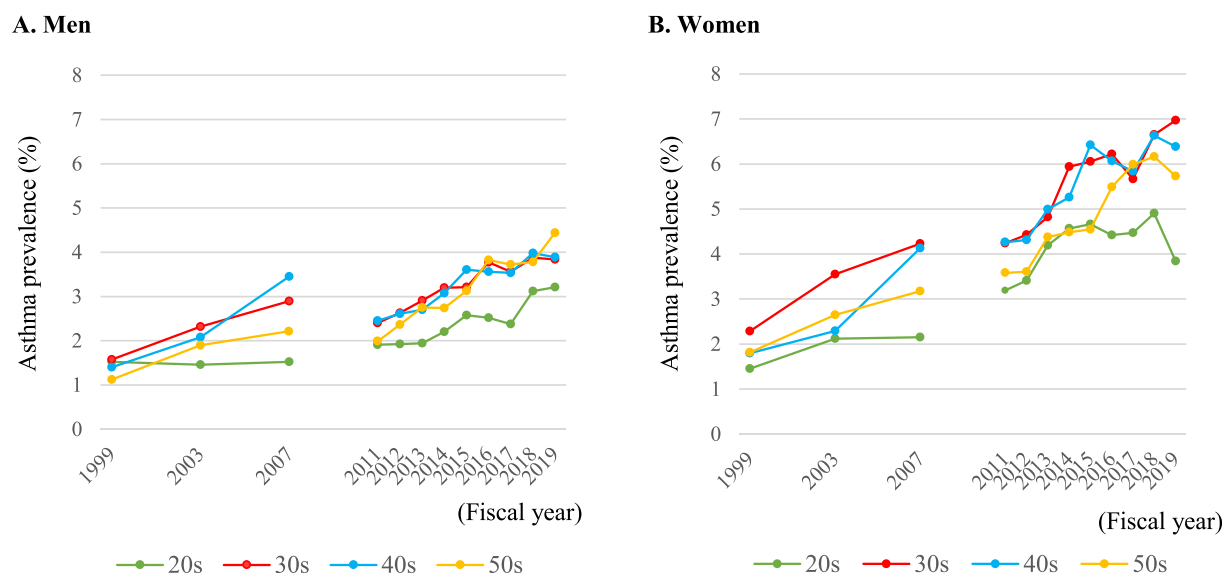


**Fig. 3.** Change in the prevalence of asthma by age-group among men (A) and women (B).

the general Japanese population also revealed an increase in the rate of ICS use from 12% in 2000 to 18% in 2005.<sup>25</sup>

The population we studied included employees of large companies and their dependents enrolled in health insurance societies. Thus, there is a possibility that the asthma prevalence calculated in this study is different from the prevalence among general Japanese adults. Of note, people enrolled in National Health Insurance are known to have different background profile compared with those having employment-based health insurance, and asthma prevalence defined by our criteria among people in National Health Insurance have not been studied yet. However, a recent study comparing the Shizuoka Kokuho Database (SKDB, data from the National Health Insurance in Shizuoka prefecture) and JMDC Claims Database (data from health insurance societies in Japan) found that,

although prevalences of the diseases which affect the ability to continue working, i.e. mental diseases and hemiplegia, were markedly higher among people in SKDB, there were no clinically relevant differences in the prevalences of most chronic diseases (not including asthma) (Sato *et al.* Abstract for poster presentation in the 79th Annual meeting of Japanese Society of Public Health, 2020). Therefore, we assume that there was no difference in the prevalence of asthma between people in National Health Insurance and people with employment-based health insurance. However, future studies are needed to determine whether there is a difference in asthma prevalence between different types of health insurance scheme.

One important limitation of our study was related to external validation. In our study, we included health insurance societies

**Table 2**  
Increment of asthma prevalence (%) per fiscal year calculated by linear regression analysis by sex and age-group.

| Age (years) | From FY1999 to FY2007<br>in population 1 |         |        | From FY2011 to FY2019<br>in population 2 |         |        |
|-------------|------------------------------------------|---------|--------|------------------------------------------|---------|--------|
|             | Increment (%)<br>per fiscal year         | 95%CI   |        | Increment (%)<br>per fiscal year         | 95%CI   |        |
|             |                                          | Lower   | Upper  |                                          | Lower   | Upper  |
| Men         |                                          |         |        |                                          |         |        |
| 20-29       | 0.0004                                   | -0.1147 | 0.1155 | 0.1664                                   | 0.1060  | 0.2268 |
| 30-39       | 0.1645*                                  | 0.0091  | 0.3200 | 0.1899                                   | 0.1411  | 0.2388 |
| 40-49       | 0.2559*                                  | -0.3773 | 0.8892 | 0.2004                                   | 0.1469  | 0.2539 |
| 50-59       | 0.1363                                   | -0.2800 | 0.5526 | 0.2842*                                  | 0.2251  | 0.3432 |
| Women       |                                          |         |        |                                          |         |        |
| 20-29       | 0.0871                                   | -0.4919 | 0.6662 | 0.1252                                   | -0.0291 | 0.2795 |
| 30-39       | 0.2434                                   | -0.2886 | 0.7753 | 0.3236*                                  | 0.2046  | 0.4474 |
| 40-49       | 0.2992                                   | -0.9396 | 1.5227 | 0.2916                                   | 0.1731  | 0.4452 |
| 50-59       | 0.1701                                   | -0.1029 | 0.4432 | 0.3413*                                  | 0.2384  | 0.4443 |

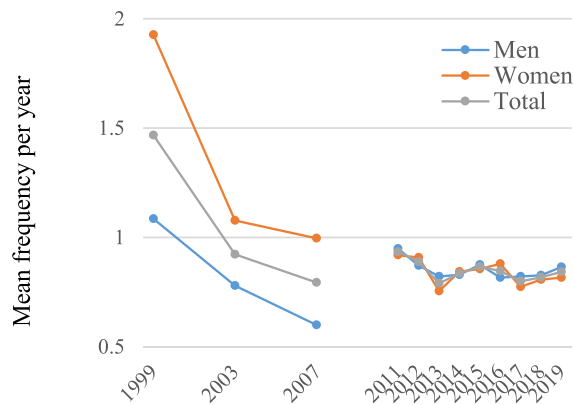
\*p-interaction<0.05 compared with an increase in subjects aged 20–29 years of the same sex.

that included workers engaged in various types of occupations living in western and eastern Japan in order to minimize selection bias as much as possible. However, we cannot completely rule out the possibility that there was some selection bias in our study population, which may have skewed the results. Another possible limitation is related to the fact that this study used data

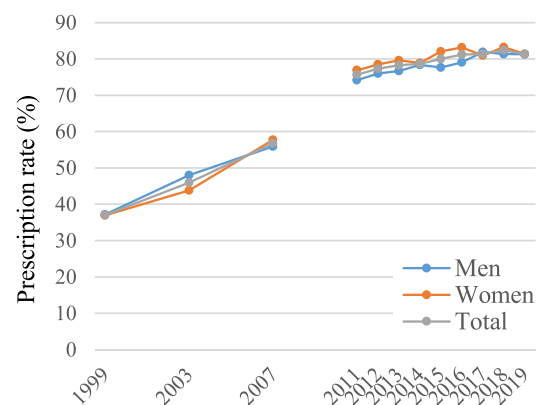
from health insurance claims and defined asthma on the basis of claims data. Asthma is a syndrome that includes patients with variable severity, from very intermittent symptoms to those with severe persistent symptoms. Although the definition of asthma used in this study was designed to include patients with an outpatient visit at least once a year, patients with intermittent asthma symptoms who do not require even one visit per year might have been overlooked. It is also possible that subjects meeting the asthma criteria included cases with other respiratory disorders that are difficult to differentiate from asthma. This phenomenon might have occurred more frequently in older age groups in recent years, which might have resulted in the pronounced increase trend in asthma prevalence in those aged in their 50's. Another limitation is that we were unable to show asthma prevalence among elderly people aged 60 years or more because the sample size in this age group among the studied population was small. This age group is an important population because of their higher mortality rate compared with younger age groups. An epidemiological survey using healthcare insurance claims data for this age group is required in the future.

In conclusion, this study examined healthcare insurance claims data over a period of about 20 years since 1999 and suggested that the prevalence of adult asthma in Japan has been on the rise over that period. More attention should be paid to changes in the prevalence of adult asthma over time, and continued observation is needed in the future.

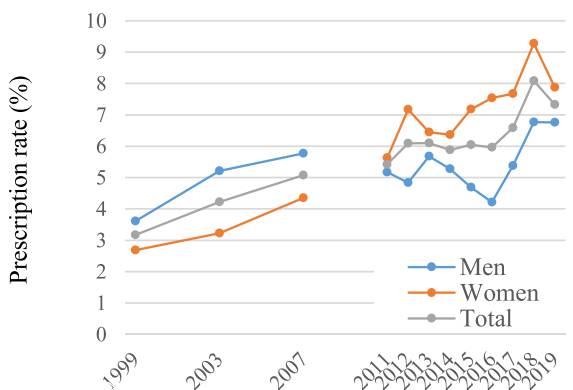
#### A. Frequency of acute asthma exacerbation



#### B. Inhaled corticosteroid $\geq 1$ canister



#### C. Leukotriene receptor antagonist $\geq 150$ days



#### D. Long-acting beta-agonists $\geq 1$ canister (or 30 days)

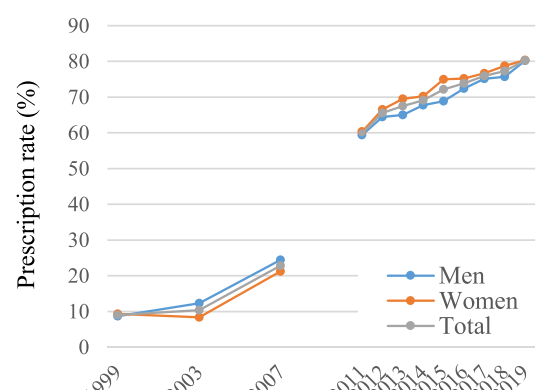


**Fig. 4.** Change in the mean frequency of acute asthma exacerbations per year (A), and the prevalence of subjects prescribed anti-asthma medications (B, C, D) among subjects meeting the asthma criteria. Prevalence of those prescribed inhaled corticosteroids  $\geq 1$  canister per year, leukotriene receptor antagonist  $\geq 150$  days per year and long-acting beta-agonists  $\geq 1$  canister (or 30 days) per year are shown in (B), (C), and (D), respectively.

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### Authors' contributions

All authors contributed to this report. YF and MT developed the concept; MI and KA were responsible for collecting and cleaning the data; KN, YF, EN, and YH were responsible for analyses. KN, YF, EN, YH, YT, KW, YK, KS, YN, CO, TS, MN, TF and MT were responsible for the interpretation of results; KN wrote the manuscript; and, YF, EN, YH and MT contributed to the critical revision of the manuscript.

### Conflict of interest

YF received payment or honoraria for lectures, presentations, speaker's bureaus, manuscript writing or educational events from Thermo Fisher Diagnostics, Novartis Pharma, Kyorin Pharmaceutical, Sanofi, Taiho Pharmaceutical, and AstraZeneca. YH received payment or honoraria for lectures, presentations, speaker's bureaus, manuscript writing or educational events from Novartis Pharma. MI is an employee of Nihon Medical Insurance Institute, and was formerly an employee of MHI. KA is an employee of MHI. YK received payment or honoraria for lectures, presentations, speaker's bureaus, manuscript writing or educational events from Sanofi, GlaxoSmithKline, and AstraZeneca. KS received payment or honoraria for lectures, presentations, speaker's bureaus, manuscript writing or educational events from Novartis Pharma, Kyorin Pharmaceutical, Sanofi, Taiho Pharmaceutical, GlaxoSmithKline, and AstraZeneca. MN received payment or honoraria for lectures, presentations, speaker's bureaus, manuscript writing or educational events from Viatriis. TF received payment or honoraria for lectures, presentations, speaker's bureaus, manuscript writing or educational events from Maruho, and reported leadership or fiduciary role in Japanese Society of Pediatric Allergy and Clinical Immunology. MT received payment or honoraria for lectures, presentations, speaker's bureaus, manuscript writing or educational events from GlaxoSmithKline, Sanofi, and Novartis Pharma. The rest of the authors have no conflicts of interest.

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