



30-year trends in asthma and the trends in relation to hospitalization and mortality

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ABSTRACT

Introduction: The present study examines how trends in the prevalence of asthma during the past three decades associate with hospitalization and mortality during the same period.

Methods: Altogether 54 320 subjects aged 25–74 years were examined in seven independent cross-sectional population surveys repeated every five years between 1982 and 2012 in Finland. The study protocol included a standardized questionnaire on self-reported asthma, smoking habits and other risk factors, and clinical measurements at the study site. Data on hospitalizations were obtained from the Care Register for Health Care, and data on mortality from the National Causes of Death register.

Results: During the study, the prevalence of asthma increased - especially in women. In asthmatic compared with non-asthmatic subjects, hospitalization was significantly higher for all causes, respiratory causes, cardiovascular causes and lung cancer. In addition, particularly in asthmatic subjects, mean yearly hospital days in the 5-year periods after each survey diminished. In asthmatic subjects, the decrease in yearly all-cause hospital days was from 4.45 (between 1982 and 1987) to 1.11 (between 2012 and 2015) and in subjects without asthma the corresponding decrease was from 1.77 to 0.60 ($p < 0.001$). Similarly between 1982 and 2015, COPD hospitalization decreased more in asthmatic than in non-asthmatic subjects. Generally in the present study, all-cause mortality decreased between 1982 and 2015, though mortality in asthmatic subjects compared with non-asthmatics was higher from all causes, respiratory causes and lung cancer.

Conclusion: There was an increasing trend in the prevalence of asthma and a declining trend in hospitalization, especially in asthmatic subjects.

1. Introduction

In recent decades the prevalence of asthma has been increasing [1–4]. In Sweden, the prevalence of asthma in adults increased from 8.4% to 10.9% between 1996 and 2016 [1]. In Canada, the age and sex-standardized asthma prevalence increased from 8.5% to 13.3% between 1996 and 2005 [4]. In Finnish Karelia between 1997 and 2007, the prevalence of self-reported asthma increased from 5.5% to 8.1% in adults [3].

In Finland between 1972 and 1986, also asthma-related hospitalizations increased [5]. However later, the number of hospital days due to asthma fell 54% between 1993 and 2003 [6]. Between 2000 and 2010, the reduction in asthma related hospital days was 65% in relation to the number of asthmatics in Finland [7]. Asthma hospitalizations

have declined in other countries too since the 1980s and 1990s [8,9]. Data on the effect of asthma on all-cause hospitalization is lacking. In addition, asthmatic subjects have had increased all-cause mortality [10,11] and smokers and ex-smokers with asthma have had higher mortality than never-smokers without asthma [12]. The present study examines the 30-year trends in the prevalence of self-reported asthma. Concurrent hospitalization and mortality were also assessed.

2. Methods

2.1. Subjects

The National Institute for Health and Welfare has conducted cross-sectional risk factor surveys every fifth year in Finland since 1972

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Table 1
Description of the study population by the survey year.

n	The survey year							Total
	1982	1987	1992	1997	2002	2007	2012	
Invited	11 395	7932	7927	11 500	13 498	12 000	10 000	74 252
Examined (men/women)	4615/4732	3109/ 3370	2849/ 3202	4253/4193	4482/5098	3740/4253	3041/3383	26 089/28 231
Non-responders (men/women)	1212/836	853/600	1116/760	1747/1307	2267/1651	2260/1747	1959/1617	11 414/8518
Participation rate (%)	82	82	76	73	71	67	64	73
Subjects with hospitalizations between survey and the end of 2015	8629	5832	4978	6438	5728	3109	1613	36 327
Subjects with hospitalizations during 5 years after each survey	3950	2830	2479	3522	3389	2241	1613 ^b	20 024
Number of deaths between 1982 and the end of 2015	3937	1916	1046	1552	728	296	83	9558
Self-reported asthma ^a	157	157	179	397	475	431	480	2276
Smoking status								
never smokers	3962	2804	2596	3752	4294	3634	3034	24 076
ex-smokers	2289	1675	1622	2317	2490	2425	1962	14 780
current smokers	2791	1805	1811	2117	2725	1855	1345	14 449
excluded ^c	305	195	22	260	71	79	83	1015

^a Diagnosed or treated within the past year.

^b Data of hospitalization between 2012 and the end of 2015.

^c Without data on smoking, and ex-smokers who had quit smoking less than one month ago (and due to a short abstinence not recorded as ex-smokers).

[13,14]. At each survey, an independent random population sample was drawn from the population register in five geographical areas [13,14]: the provinces of North Karelia and Kuopio in eastern Finland since 1972, the Turku-Loimaa region in south-western Finland since 1982, the capital area since 1992 and the Oulu province in north-western Finland since 1997 and Lapland since 2002. The sampling and methods complied with the protocol of the World Health Organisation Multinational MONItoring of trends and determinants in CARdiovascular disease (MONICA) project [15], and since 2002, the later recommendations of the European Health Risk Monitoring project (EHRM) [16].

The present study population consisted of altogether 54 320 subjects who participated in the cross-sectional surveys between 1982 and 2012 (Table 1). Subjects who had no data on the presence of asthma were excluded ($n = 1000$), as well as those without data on smoking habits and smokers who had quit smoking less than one month before the examination and because of a short abstinence could not be recorded as ex-smokers (Table 1).

2.2. Measurement of self-reported asthma, smoking status and other variables

At each survey, the participants completed a self-administered questionnaire [14]. Definition of self-reported (physician-diagnosed) asthma was based on a positive response to the same question 'Has a doctor diagnosed you with asthma or treated you for asthma during the past year (last 12 months)?' (The National FINRISK Study questionnaire has been presented earlier [14]). Smoking status, marital status, education, occupation, a history of diagnosed hypertension during the preceding 12 months and a history of diagnosed myocardial infarction and the use of asthma medication were asked with standardized questions in the same questionnaire. Body mass index (BMI) (kg/m^2) was calculated from height and weight measured at the examination.

Smoking status was classified into the three categories: never-, ex- and current smokers (Table 1). Smokers had smoked regularly (cigarettes, cigars, or pipe) at least a year and during the preceding month. Ex-smokers had stopped smoking at least a month before the survey. The educational background was classified into four categories: elementary school, vocational school, upper secondary school/college and an academic degree. Occupation was classified into seven categories: agriculture and dairy farming, factory, mine and construction work,

office work (or suchlike work, e.g. service activity), students, housewives, pensioners and unemployed. Marital status was classified into four categories: married or cohabitation without marriage, unmarried, divorced and widowed. The area of residence was classified into four categories: North Karelia and Kuopio, south-western Finland (Turku-Loimaa area), Oulu and Lapland, and the capital area.

2.3. Assessment of hospitalization and mortality

The annual hospital days during five years after each survey were calculated by summing up the hospital days in five years after each survey and then dividing this sum by five (or by the time until death if the subject died before the end of the five-year follow-up). For those examined in 2012 the sum was divided by 3.83 (the mean duration of the follow-up for this cohort). The hospitalization data was obtained from the Care Register for Health Care [18].

Between 1982 and 2015, there were three different revisions of the *International Classification of Diseases (ICD)* in Finland (i.e. *ICD-8* until 1986, *ICD-9* between 1987 and 1995 and *ICD-10* since 1996). In the present study, the concordance table was used for bridging the three revisions of ICD [17], and the first-listed (main) discharge diagnoses were classified into the following four major categories [18]: respiratory causes (the listing of the corresponding *ICD-8*, *ICD-9* and *ICD-10* codes have been presented earlier [18]), cardiovascular disease (= CVD), cancer and other causes. COPD (= chronic obstructive pulmonary disease) and lung cancer were also reanalysed separately.

The data on the length of the hospital visit was missing in 3890 cases, and the main discharge diagnosis was missing in 35 hospitalizations. Altogether, there were 20 024 subjects with hospitalizations during five years after each survey (Table 1).

Data on the underlying causes of death were obtained from the National Causes of Death register. There were 9558 deaths between 1982 and the end of 2015. For the present study, the underlying causes of death were classified into the same four (major) categories as the hospital diagnoses. Altogether ten subjects had a missing cause of death.

2.4. Statistical methods

The area-adjusted age-specific prevalence rates for asthma were calculated from the results of the logistic regression models, which were

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