

Review article

Signs of reversing trends in prevalence of asthma

Several recent reports have provided evidence that the burden of asthma may have levelled off, after increasing for decades. Implementation of the national and global asthma prevention and management guidelines that have led to earlier detection and improved treatment of asthmatics, is considered to be involved in this apparent change for the better. In addition, environmental influences associated with the modern life may have reached the maximum in inducing symptoms and disease in genetically susceptible individuals in some areas. Available data obtained from Canada and non-English-speaking countries in Europe show that the peak in asthma prevalence has been reached at the level of 8–12%. This review outlines the most recent literature on time trends in asthma prevalence and considers the possible causes of the current trends. Problems and pitfalls in appraising studies on time trends are also discussed.

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A number of earlier reports on time trends in asthma and atopy have shown a substantial increase in prevalence since the early 1960s and a consistent association between Western lifestyle and these disorders (1–4). Irrespective of intense research in the field, the ultimate causes of these phenomena remain unclarified. Much attention has been devoted to the hygiene hypothesis (5) postulating that scarcity of exposure to microorganisms in early life increases the risk for atopic disease in later life. This hypothesis centred first on common childhood infections and the T-helper (Th)1/2 paradigm, but has been later extended to cover a variety of microbes and microbial products as well as intestinal parasites, focusing now more on regulatory T cells and toll-like receptors (reviewed in Ref. 4). Serious measures have been undertaken nationally and globally to reduce asthma morbidity, first and foremost by producing asthma prevention and management programmes (6–10). Indeed, some most recent evidence suggests that the burden of asthma may have plateaued in some areas (11–13), assumed to be because of earlier detection and improved treatment of asthmatics.

Data on time trends in prevalence of asthma have been reviewed earlier by Magnus and Jaakkola (2), who analysed 16 studies reporting an increasing trend in asthma prevalence between 1983 and 1996, and by Wieringa et al. (3), who evaluated another 16 studies on asthma and atopy published between 1996 and 2000 (February), in which objective measurements have been used. In both papers, the rising trends in asthma prevalence were critically appraised and were largely considered to be the result of increased public and professional awareness of the diseases and changes in diagnostic labelling.

No systematic review of the data from the year 2000 onwards has been published. During the last 5 years, the

early effects of many asthma prevention and management programmes could be expected to have become discernible. This review outlines the most recent literature on time trends in asthma prevalence among children and adults. Because of the complexity of the current situation in trends of asthma and allergic conditions, the latter will be considered more comprehensively in a further separate paper.

Data were identified by Medline searches for the period between 1 January 2000 and 15 June 2004. Search terms were 'asthma', 'epidemiology', 'international' and 'time trends'. In addition, manual searches were performed from references of relevant articles. Articles in the English language only were reviewed. The searches identified 20 studies, of which five were among adults, 13 among children and two among both of them. In 13 of these 20 studies, a 'changed' (decreasing or stable) trend for asthma or current wheeze at any time during the study period was reported. In the following, the data providing evidence for decreasing or stable trends and that for continuously increasing trends are considered separately. The studies are summarized in Tables 1 and 2. Two studies (14, 15) were included in both tables as the trends behaved differently depending on the age group or prevalence (asthma *vs* asthma symptoms) considered.

Decreasing or stable (changed) trends in asthma prevalence

Adults and children

Flemming et al. (16) were among the first to report a downward trend in asthma prevalence in a large population sample. In their study, the age-specific weekly rates

Table 1. Summary of data on stable or decreasing trends in prevalence of asthma

First author, year (reference) Country	Population (aged), <i>n</i>	Number of surveys (response rates)	Years	Prevalence of	Trend	Method(s)
Adults						
Verlato, 2003 (12) Italy	Adults (20–44 years) c. 13 000	2 (88 and 78%)	1991–2000	12-month asthma attacks and symptoms	Stable	Questionnaire (ECRHS)
Woods, 2001 (19) Australia	Adults (20–44 years) 9046	4 (66–72%)	1990–1999	Phys-dg asthma	Increasing 1990–1998, stable 1998–1999	Questionnaire, telephone interviews (ECRHS)
Upton, 2000 (20) UK (Scotland)	Adults (45–54 years) 2832	2 (73 and 84%)	1972–1996	Self-reported asthma ever Asthma and/or wheeze, nonatopic asthma	Increasing stable	Questionnaire (MRC)
Adults and children						
Sentiliselvan, 2003 (18) Canada	All visitors to physician because of asthma	8 (100%)	1991–1998	Phys-dg asthma	Increasing 1991–1995, stable or decreasing 1996–1998	Medical records
Flemming, 2000 (16) UK	All visitors to general practitioner because of new asthma	Continuous (100%)	1989–1998	Phys-dg new asthma episodes	Increasing 1989–1993, decreasing 1993–1998	Medical records
Children						
Toelle, 2004 (21) Australia	Schoolchildren (8–11 years) 2442	3 (66–88%)	1982–2002	Phys-dg asthma ever, 12-month wheeze, use of asthma medication	Increasing 1982–1992, decreasing 1992–2002	Questionnaire
Braun-Fahrlander, 2004 (22) Switzerland	Schoolchildren (13–14 years) 4242	3 (74–81%)	1992–2000	Phys-dg asthma and wheeze ever, 12-month wheeze	Stable	Questionnaire (ISAAC)
Lee, 2004 (23) Hong Kong	Schoolchildren (6–7 years) 8066	2 (95%)	1995–2001	Phys-dg asthma and wheeze ever, 12-month wheeze, severe asthma symptoms	Stable, increasing	Questionnaire (ISAAC)
Wang, 2004 (14) Singapore	Schoolchildren (6–7 years) 7335	2 (90 and 91%)	1994–2001	Phys-dg asthma, 12-month wheeze	Stable, decreasing	Questionnaire (ISAAC)
Anderson, 2004 (15) UK	Schoolchildren (12–14 years) 30 838	2 (87%)	1995–2002	12-month wheeze, frequent asthma attacks	Decreasing	Questionnaire (ISAAC)
Maziak, 2003 (24) Germany (Western)	Schoolchildren (6–7, 13–14 years) 15 706	2 (81–94%)	1994–2000	Phys-dg asthma ever	Stable (6–7 years, 13–14 years, boys)	Questionnaire (ISAAC)
Akinbami, 2002 (13) USA	Children (0–17 years) NA	21 (NA)	1980–2000	Parental-reported asthma	Increasing (1980–1995), decreasing (1995–1996)	Questionnaire (NHIS)
Ronchetti, 2001 (11) Italy	Schoolchildren (6–14 years) 4621	3 (86–90%)	1974–1998	Parental-reported asthma attacks Phys-dg asthma ever, 12-month asthma attacks	Stable (1997–2000) Increasing (1974–1992), stable (1992–1998)	Questionnaire

NA, data not available; Phys-dg, physician-diagnosed; ECRHS, The European Community Respiratory Health Survey; MRC, The Medical Research Council; ISAAC, The International Study of Asthma and Allergy in Childhood; NHIS, The National Health Interview Study.

Table 2. Summary of data on continuously increasing trends in prevalence of asthma

First author, year (reference), Country	Population (aged), <i>n</i>	Number of surveys (response rates)	Years	Prevalence of	Trend	Method(s)
Adults						
Barracough, 2002 (17), UK	Adults (20–44 years), 5850	2 (51 and 47%)	1992–1999	Phys-dg asthma, 12-month asthma symptoms	Increasing	Questionnaire (ECRHS) (BHR and SPT in a subgroup)
Bråbäck, 2004 (25), Sweden	Military conscripts (17–20 years), 1 309 652	6 (91%)	Cohorts born, 1952–1981	Phys-dg asthma	Increasing (in cohorts born after 1961)	MSCR
Children						
Wang, 2004 (14), Singapore	Schoolchildren (12–15 years), 8266	2 (90 and 91%)	1994–2001	Phys-dg asthma ever, 12-month wheeze	Increasing	Questionnaire (ISAAC)
Anderson, 2004 (15) UK	Schoolchildren (12–14 years), 30 838	2 (87%)	1995–2002	Self-reported asthma ever	Increasing	Questionnaire (ISAAC)
Heinrich, 2002 (26), Germany (Eastern)	Schoolchildren (5–14 years), 7632	3 (69–92%)	1992–1999	Phys-dg asthma ever	Increasing	Questionnaire
Downs, 2001 (31), Australia	Schoolchildren (8–11 years), 2635	3 (71–88%)	1982–1997	Phys-dg asthma ever	Increasing	Questionnaire
Anthracopoulos, 2001 (32) Greece	Schoolchildren (8–10 years) 8496	3 (80–91%)	1978–1998	Phys-dg current asthma/wheeze (1978–1998), phys-dg asthma/wheeze ever (1991–1998)	Increasing	Questionnaire
Kwong, 2001 (33) UK	Schoolchildren (8–9 years) 9591	2 (85 and 83%)	1991–1999	Parental-reported asthma, wheeze ever	Increasing	Questionnaire (ISAAC)
Kuehni, 2001 (34) UK	Children (1–5 years) 3549	2 (86 and 84%)	1990–1998	Phys-dg asthma ever, wheeze ever, 12-month wheeze	Increasing	Questionnaire

NA, data not available; Phys-dg, physician-diagnosed; ECRHS, The European Community Respiratory Health Survey; BHR, bronchial hyperresponsiveness; MSCR, Military Service Conscript Register; ISAAC, The International Study of Asthma and Allergy in Childhood.

of new episodes of asthma presented to general practitioners and recorded in the Weekly Returns Service during the period of 1989–1998 were examined.

More than 90 practices covering a population of nearly 700 000 individuals, distributed throughout England and Wales, were included. It was found that episodes of new asthma increased from 1989 to 1993, but decreased gradually thereafter. This trend in new asthma incidence peaking in 1993 was similar in all age groups and all regions and was found both in asthma and acute bronchitis. This overall similarity in trends, however, raises the question of a change in recording or treatment practices (17), or in some administrative system that is reflected in these trends. This study, nonetheless, comprised a large database, a follow-up period of 10 years and a high number of repeated measurements from the same population.

The most recent data from Canada provide support to the findings of Flemming et al. The authors (18) conducted a study in which the annual number of all visits to physicians because of asthma during 1991–1998 in one province was analysed. Data were obtained from the physician services database. A subject with at least one visit to a physician for asthma was defined, as a case of physician-diagnosed asthma. Asthma-diagnosis was verified by linking the physician services database to the outpatient prescription drug database for checking the use of asthma drugs. This study revealed that physician-diagnosed asthma prevalence increased from 1991 to 1996 and thereafter was either stable or decreased, depending on the age group, in 1997 and 1998. Increasing trends in asthma prevalence were assumed to have entered into a decline; asthma prevalence that was on the increase in the early 1990s, stabilized or declined during the latter part of the decade in the study area.

Adults

A large Italian study among young adults that compared the results of two cross-sectional surveys using an extended questionnaire of the European Community Respiratory Health Survey (ECRHS) in 1991 and 2000 showed that the overall prevalence of asthma attacks and asthma-like symptoms (wheezing, chest tightness and breath shortness) during the past 12 months remained stable during the 1990s in Italy (although a further analysis by age groups revealed that prevalence of asthma-like symptoms tended to decrease in the older but increase in the younger subjects). The reasons for this obvious stabilization of asthma attack and symptom prevalence were assumed to include improvements in asthma management, as symptoms in the second survey were better controlled. The impact of possible changes in the environment was more difficult to evaluate (12).

An Australian study among young Melbourne adults (19) comprised four surveys in 1990, 1992, 1998 and 1999 (*n* > 9000 in total) using a postal questionnaire. The

prevalence of asthma-like symptoms (wheezing, nocturnal chest tightness, nocturnal dyspnoea) and asthma attacks during the past 12 months increased from 1990 to 1992, but then declined by 1998. The prevalence of physician-diagnosed asthma increased significantly between 1990 and 1998, but remained stable between 1998 and 1999. The stabilization of trends in the occurrence of asthma symptoms and attacks in the 1990s suggests that, in line with the results of the Italian study referred above (12), improved asthma management and increased use of asthma medication have had a positive effect on the trends (19).

Upton et al. (20) performed a study among a Scottish cohort of two generations in 1972–1976 and 1996. Data were collected with a postal questionnaire from 1708 parents and their 1124 offsprings at the age of 45–54 years. Prevalence of self-reported lifetime asthma and hay fever showed a several-fold increase during this period, both among never- and ever-smokers. However, increase was neither found in the prevalence of nonatopic asthma (defined indirectly as the absence of hay fever), nor in the overall prevalence of the disease using a boarder definition (asthma and/or wheeze), in the 20 years.

Children

Similarly to adults, several reports have provided evidence of changed asthma trends among children. Akinbami and Schoendorf (13) examined trends in childhood asthma from 1980 to 2000. Data were obtained using a postal questionnaire of the National Health Interview Survey (NHIS), which is a continuous household survey of a representative US population. Children aged 0–17 years were included. From 1980 to 1996, the parents were asked the occurrence of asthma in their child during the last 12 months and from 1997 to 2000, after the redesign of the questionnaire, the parents were asked the occurrence of asthma attacks during the last 12 months in their child who had physician-diagnosed asthma. The study showed that asthma prevalence increased twofold from 1980 to 1995, but then decreased by 17% in 1996. Asthma attack prevalence from 1997 to 2000 remained stable among all age groups. Racial and ethnic disparities were shown to be large during the whole study period.

Another study from Italy compared results of three questionnaire-based surveys in 1974, 1992 and 1998 among schoolchildren (11) and found that the prevalence of parental-reported physician-diagnosed asthma ever and 12-month asthma attacks increased significantly from 1974 to 1992, but remained stable during 1992–1998. It was concluded that some environmental factors associated with the current lifestyle may have continued to induce symptoms and disease in genetically predisposed individuals from 1974 to 1992, but the process has apparently reached the maximum and has come to an end in the study area.

These results have been replicated by Toelle et al. (21) who analysed the results of three questionnaire-based surveys in 1982, 1992 and 2002 among school children aged 8–11 years in Australia, Belmont and found no more increase in prevalence of physician-diagnosed asthma, neither in recent wheeze nor use of asthma medication during the last 10 years (1992–2002), contrary to the period of 1982–1992. However, the response rate in the last survey was only 66%, leaving the possibility for selection bias.

A recent large study comprising two surveys in 1992 and 2000 among schoolchildren aged 13–14 years from Switzerland (22), conducted in the frame of the International Study of Asthma and Allergy (ISAAC), showed that the prevalence of parental/self-reported physician-diagnosed asthma ever and current asthma symptoms remained stable during the study period of 1992–2000. The trends were similar also for hay fever and allergic sensitization rates (22). Similarly, among schoolchildren aged 6–7 years in Hong Kong (23) and Singapore (14), using the ISAAC methodology, no increase in prevalence of parental-reported asthma ever, wheeze ever or current wheeze was found during 1994–2001, albeit an increase in severe asthma symptoms in the former study (23) was observed. A German study comprising two surveys in 1994 and 2000 found no further increase in parental-reported physician-diagnosed asthma but an increasing tendency for asthma symptoms among the same age group using the same methodology (24). In all these four studies (14, 22–24), however, the follow-up has been 6–8 years, which is too short for any definitive conclusions in analysing time trends.

In sum, out of the 20 studies reviewed, 12 studies reported a stable or decreasing trend in prevalence of asthma in adults (12, 19, 20), in children (11, 13, 14, 21–24) or both (16, 18). In two of these 12 studies, the data were obtained from administrative databases, the other 10 studies relied on questionnaires. None of them used bronchial hyperresponsiveness (BHR) tests or other objective measurements. Most of the questionnaire-based studies used the ECRHS and ISAAC or other standardized and well-verified questionnaires. Stabilization or decline in prevalence was also reported with asthma-like symptoms in adults (12, 19) and children (14, 15), even with concomitant increase in prevalence of diagnosed asthma ever (15), indicating improved treatment of asthmatics.

Increasing trends in asthma prevalence

Contrary to the data presented above, several reports have shown no change in asthma trends during the last decade; discrepancies exist even between studies from the same country. In addition to differences in methodology and age distribution, differences in the degree of urbanization (26) as well as in the occurrence and magnitude of protective (yet only partially identified) factors (27)

between the study areas may be involved. Further, geoclimatic variables and topographical factors, e.g. the vertical level at which people live, may also affect asthma prevalence, as they appeared to explain much of the variation in prevalence in studies from Italy (28) and Spain (29). One more reason for discrepancies in trends for asthma prevalence obtained even in the same country may include misclassification bias because of linguistic and cultural differences in perception and reporting of disease and symptoms by individuals from different ethnic groups (30).

Adults

Barracough et al. (17) looked at time trends in asthma prevalence by conducting two cross-sectional surveys in 1992–1993 and 1998–1999 using a modification of the ECRHS questionnaire among randomly selected young adults in Newcastle-upon-Tyne. In both surveys, methacholine challenge was performed in a subgroup. Significant increase in prevalence of asthma symptoms, physician-diagnosed asthma and use of asthma medication were found in that young adult population during the 1990s. The rates of increase were most striking in subjects aged <30 years. The increase in asthmatic symptoms paralleled an increase in atopy, determined by the occurrence of hay fever (and by skin prick tests in a subgroup). Bronchial hyperresponsiveness, by contrast, decreased, which was largely explained by the increased use of inhaled corticosteroids. The authors proposed that the observed increase in prevalence of asthmatic symptoms, physician diagnosis and use of medication during the 1990s may not be real but largely be a consequence of better education, increased awareness of symptoms and/or readiness to report them, as well as an increased willingness of physician to diagnose asthma and start medication (17). However, the possibility of selection bias must also be taken into consideration in this study, as the response rates in the two surveys were only 47 and 51%. Moreover, this was a local survey, contrary to that by Flemming et al. (16), which may partly explain, in addition to different methodology, the discordant findings reported from the same country.

Nonetheless, evidence from Sweden shows that the saturation level in asthma prevalence has not yet been reached in all Western societies. Bråbäck et al. (25) conducted six surveys among military conscripts born between 1952 and 1981, examined at the age of 17–20 years and found that the prevalence of asthma increased more than threefold from the oldest to the youngest birth cohort, with a mean annual increase of 6%. Similar trends were observed for allergic rhinitis and eczema.

Children

A study from the former East Germany compared the results of three questionnaire-based surveys among

schoolchildren (5–14 years) in 1992–1993, 1995–1996 and 1998–1999 (26). A significant increase in prevalence of parental-reported physician-diagnosed asthma ever was observed in all birth cohorts. Further, an Australian study (31) that examined time trends among schoolchildren (8–11 years) between 1982 and 1997, showed that a similar rising trend in physician-diagnosed asthma found during the 1980s continued to 1997, parallel with atopy prevalence. A Greek study in 8–10-year-old children could neither reveal any change in the rising prevalence of parental-reported physician-diagnosed asthma or wheezing ever or asthma/wheezing in the last 2 years during a period of 20 years (32).

In line with the above-mentioned findings are those by Kwong et al. (33), who performed two surveys among 8–9-year-old schoolchildren in Sheffield, UK, using a modification of the ISAAC questionnaire. Lifetime prevalence of parental-reported asthma and wheeze increased significantly from 1991 to 1999 in this population, as 12-month prevalence of wheezing and the use of asthma medication also increased. The increase in prevalence of asthma and wheeze was confined mostly to mild cases, which was assumed largely to be the result of increased use of inhaled corticosteroids. The authors also found a significant proportion of children on asthma medication reporting no asthma symptoms, suggesting that many children may have been overtreated or diagnosed.

Further, it has been reported that all wheezing, even wheezing related to viral infections and early transient wheezing, has increased in children aged 1–5 years in the UK during the 1990s, suggesting that factors unrelated to atopy may largely be involved in the rising prevalence of wheeze in early childhood (34).

To summarize, eight of the 20 studies could not reveal any change in the continuously rising trends in asthma prevalence. Most of these eight studies concerned childhood asthma (15, 26, 31–34), but, with one exception, none of these included the most recent data from the 2000s. The latest data from the UK covering the year 2002 suggest improved asthma management among adolescents, as prevalence of asthma symptoms has changed for the better (15). Nonetheless, evidence on trends in childhood asthma is strongly contradictory. In nearly all studies showing no change in trends, data were based on questionnaires, BHR testing was performed in a subgroup in one study and in half (4/8) of such studies, the trends were based on only two-point prevalence estimates.

Disparities in trends of asthma and allergic rhinitis

Although allergic rhinitis is largely considered as one of the early events in the atopic march, there is growing evidence that asthma and allergic rhinitis as well as other atopic conditions may be rather distinct phenotypes (35).

Only a partial overlap between the occurrence of asthma and hay fever was found among German school children in the ISAAC II (35, 36). This view is further supported by an Italian study, which showed that geo-climatic variables affected significantly the occurrence of asthma, but not that of allergic rhinitis (28). The natural course of the various atopic disease appear also to differ (35). A study carried out in Leipzig, Germany, after the reunification of the country (37) was among the first to report disparities in trends for prevalence of asthma and allergic rhinitis, the steadily increasing trends for allergic rhinitis and the stable trend for asthma. One reason for this phenomenon was proposed to be the narrower window of opportunity of childhood asthma as compared with allergic rhinitis (37); even substantial societal changes do not affect the development of childhood asthma if they occur after the child's third birthday. Since 1998, similar results have been reported from Italy, UK and Hong Kong (12, 20, 23) (Table 3).

Problems in appraising studies on time trends in asthma prevalence

Definition of asthma in epidemiological studies

The comparison of studies on time trends in asthma prevalence is problematic, as there is no generally accepted definition of asthma for epidemiological studies, either no laboratory test or biochemical marker that could detect reliably the cases with variable aetiology and expression of symptoms (38). Particularly the case definition can be difficult among children (39) and no single definition of asthma is applicable to all studies (40). An arbitrary figure of 50% for the prevalence of 'current wheezing' has been recently used to indicate the prevalence of clinical asthma in children (41).

The importance of including objective measurements, such as lung function measurements and BHR tests, in assessing time trends in asthma prevalence has been emphasized earlier (2). It was argued that the evidence for rising trends in asthma prevalence found in many studies is weak because of the lack of objective measurements in

case definition. However, BHR tests, such as the methacholine challenge test, have been shown to lack sensitivity and specificity in the general population (42) and the occurrence of BHR has been shown to correlate poorly with that of asthma (17, 43). BHR measurements are prone to variability and standardizing the performance of BHR testing may be a major problem (40). As to children, performing the challenge test may often be unsuccessful and the test results are dependent on age and size; different age groups may not be compared with each other (44). When studying adults, smoking may be a significant confounding factor that is known to cause nonspecific BHR in a great proportion of smokers (45). A review critically examined the ability of BHR testing and symptom questionnaires to detect physician-diagnosed asthma (40). The analysis was based on 19 population studies published between 1986 and 1996. Although physician-diagnosed asthma is not the true gold standard of asthma, it was considered to represent the most appropriate standard for validating methods for epidemiological studies. The analysis showed that BHR testing has much lower sensitivity than symptom questionnaires to detect the cases and it was concluded that the method of choice for prevalence comparisons is standardized symptom questionnaire. In line with this review, a recent study among 1633 schoolchildren (39) revealed that questions on shortness of breath, wheezy chest and dry cough at night were highly sensitive and specific for clinical asthma defined on the basis of a symptom history consistent with asthma and at least one objective clinical, lung function or challenge test finding. It was concluded that symptom history forms the basis for defining asthma in both clinical and epidemiological settings as BHR tests only marginally increased the diagnostic accuracy after symptom history had been taken into account. The authors proposed that BHR should not be required for defining asthma in epidemiological studies.

Self-reported physician-diagnosed asthma has been considered useful as a simple and inexpensive measure of disease prevalence (19). On the contrary, using physician-diagnosed asthma for case definition in studies

Table 3. Summary of studies showing disparities in trends for asthma and allergic rhinitis

First author, year (reference), Country	Population (age), n	Number of surveys (response rates)	Year trends	Increasing trends	Decreasing/stable	Method(s)
Adults						
Verlato, 2003 (12), Italy	Adults (20–44 years) c. 13 000	2 (88 and 78%)	1991–2000	Allergic rhinitis	12-month asthma attacks and symptoms	Questionnaire (ECRHS)
Upton, 2000 (20), UK (Scotland)	Adults (45–54 years), 2832	2 (73 and 84%)	1972–1996	Hay fever ever	Nonatopic asthma, asthma and/or wheeze	Questionnaire (MRC)
Children						
Lee, 2004 (23), Hong Kong	Schoolchildren (6–7 years), 8066	2 (95%)	1995–2001	Rhinitis ever, 12-month rhinitis, 12-month rhino-conjunctivitis	Phys-dg asthma and wheeze ever, 12-month wheeze	Questionnaire (ISAAC)

Phys-dg, physician-diagnosed; ECRHS, The European Community Respiratory Health Survey; ISAAC, The International Study of Asthma and Allergies in Childhood.

on time trends has been criticized, as diagnosis may change under the influence of new information of the disease (3).

Other methodological aspects

In addition to the lack of generally accepted criteria for asthma applicable in epidemiological studies, several other factors, including the number of surveys in each time trend analysis and the response rates of each survey (3), should be considered when appraising the studies. Time-series analyses that have been based on only two surveys may contain a large degree of imprecision and invalidity (3). Here, 11 of the 20 studies were based on more than two surveys. Response rates could also cause a problem particularly in repeated epidemiological surveys. Except three studies (17, 19, 21), the response rate here has been acceptable, in several studies even >90%. This information was not available in one (13) study. One more problem in time-trend studies may come from recall bias. Treated patients in remission or individuals with 'outgrown' asthma may be a source of bias in questionnaire-based surveys, although this possibility for asthma that is often a highly emotional experience, is smaller for events with no emotional component (46). Problems and pitfalls in appraising time-trend studies of asthma prevalence are summarized in Table 4.

Possible causes of reversed trends in prevalence

To which extent the reported changes in time trends for asthma prevalence represent true changes in previously steadily increasing trends? Such factors like increased public and professional awareness, changes in disease severity, improved asthma management and treatment

practices because of dissemination of global and national asthma management guidelines have undoubtedly impact on time trends. Their relative roles are, however, difficult to evaluate. Moreover, is the change in asthma severity, the increasing proportion of patients with mild relative to those with moderate-to-severe disease reported by some authors (33, 47), merely because of improved management and increased use of asthma medication, or has this change in disease severity occurred independently from improved treatment, because of, e.g. some environmental or behavioural factors? It has been proposed that a change in the epidemiology of factors associated with asthma initiation or in the host response to these triggering factors may have occurred and could partly explain the changed trends (16). On the contrary, questionnaire-based surveys do not usually allow to detect changes in disease severity and in studies that report decreasing/stable trends, there is the possibility that reduction in disease severity, rather than a genuine decline in diagnosed disease prevalence, has taken place (12).

Increased awareness

The impact of increased general awareness of asthma has been proposed in several papers to explain to a large extent, even entirely, the increasing trends in asthma prevalence in a certain time period (2, 17). As most studies on time trends in asthma prevalence have relied on questionnaires, this possibility cannot be excluded. Nonetheless, increased public and professional awareness can be a confounding factor when rising trends are examined but less so in the case of decreasing or stable trends. Among children, however, increased professional awareness may affect decreasing trends, as recent studies have shown that many children have been overdiagnosed and treated (33) and mislabelling of infection-associated wheezing as asthmatic may occur.

Improved management and treatment of asthma – impact of global and national programmes

The finding that inflammatory changes were found in bronchial epithelium of even untreated patients with mild asthma and duration of symptoms of a few months (48) led to a randomized controlled 3-year study of anti-inflammatory medication as the first-line treatment (49–51). The encouraging results were put in practice in a national asthma prevention and management programme in Finland (6). Along with the implementation of the programme in 1994, beneficial effects in terms of early recovery of the patients, preservation of their functional capacity and well-being, decrease of the proportion of patients with moderate-to-severe disease and decrease of bed days and annual costs have been achieved (47). Similarly, an evaluation of the National Asthma Campaign (52), launched in Australia in 1990, showed that the programme has contributed to better asthma

Table 4. Possible causes of changed trends in asthma prevalence and problems and pitfalls in appraising time-trend studies of asthma prevalence

Possible causes of changed asthma trends

- Increased professional awareness of the disease; can reduce overdiagnosis in children
- Implementation of national and global asthma prevention and management guidelines; have led to earlier detection and improved treatment of asthmatics
- Changes in disease severity; asthma may have become milder, independently of increased use of inhaled corticosteroids, which may be reflected in changed trends of prevalence
- Environmental influences have reached maximum in inducing disease in susceptible individuals

Problems and pitfalls in appraising time-trend studies of asthma prevalence

- Lack of definition of asthma for epidemiological studies; particularly a problem in children
- Low number of surveys in time-trend analysis
- Low response rate in any of the surveys
- Recall bias of treated patients in perception and reporting of disease and symptoms
- Linguistic and cultural differences between different ethnic groups

management and improved treatment (19, 53). Possible causes of changed trends in asthma prevalence are summarized in Table 4.

Conclusion

Accumulating evidence from several countries indicates that rising trends in asthma prevalence among adults may have plateaued or even decreased after increasing for decades. The data are more contradictory in children; several studies have shown stable trends in childhood asthma since the late 1990s, whereas others have not shown any change in the steadily rising asthma trends. However, nearly all of the latter lack the most recent data from the 2000s.

Environmental and lifestyle factors may continue to induce asthma symptoms in susceptible individuals till the saturation level in prevalence, determined by the genetic composition of the population, is achieved (11). Defects in environmental Th1 triggering and in inborn Th1 maturation (54) are examples of such environment- and gene-associated factors that may be involved. The available data suggest that the prevalence of diagnosed asthma ever in affluent, mainly non-English speaking westernized societies has reached the maximum at the level of 8–12% (11, 18, 22, 23). However, several-fold higher peak prevalence values have been reported from Australia (19, 21) and in many countries with high asthma rates, no peak prevalence values have been reported yet. As nearly all

studies referred here were conducted in affluent westernized countries, no consideration of the results in the light of the east–west gradient (4) could be performed. The long-term follow-up results from the large multinational surveys (ECRHS, ISAAC) in the future will finally show the behaviour of current asthma trends in a global scale.

Although the asthma prevention and management programmes have undoubtedly contributed favourably to asthma prevalence in many countries, the possibility that asthma has become milder, independently of the increased use of inhaled corticosteroids, cannot be excluded. Further, very few studies have analysed time trends in prevalence of atopic and nonatopic asthma separately. Limited data from UK and Finland (20, 55) show that during the last few decades, prevalence of atopic asthma has continued to increase, whereas that of nonatopic asthma has not increased. This may indicate that the proportions of atopic and nonatopic asthma in the whole asthma burden are also changing, which may additionally explain the finding that asthma has become milder. Whether the increased use of antibiotics is involved in the stabilization or decrease particularly found in prevalence of nonatopic adult asthma (20), in which an infectious aetiology has been proposed (56, 57), remains to be seen.

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