

Review article

Is the prevalence of asthma declining? Systematic review of epidemiological studies

Asthma prevalence has increased very considerably in recent decades such that it is now one of the commonest chronic disorders in the world. Recent evidence from epidemiological studies, however, suggests that the prevalence of asthma may now be declining in many parts of the world, which, if true is important for health service planning and also because this offers the possibility of generating and testing new aetiological hypotheses. Our objective was to determine whether the prevalence of asthma is declining worldwide. We undertook a systematic search of EMBASE, Medline, Web of Science and Google Scholar, for high quality reports of cohort studies, repeat cross-sectional studies and analyses of routine healthcare datasets to examine international trends in asthma prevalence in children and adults for the period 1990–2008. There were 48 full reports of studies that satisfied our inclusion criteria. The large volume of data identified clearly indicate that there are, at present, no overall signs of a declining trend in asthma prevalence; on the contrary, asthma prevalence is in many parts of the world still increasing. The reductions in emergency healthcare utilization being reported in some economically developed countries most probably reflect improvements in quality of care. There remain major gaps in the literature on asthma trends in relation to Africa and parts of Asia. There is no overall global downward trend in the prevalence of asthma. Healthcare planners will for the foreseeable future, therefore, need to continue with high levels of anticipated expenditure in relation to provision of asthma care.

**C. Anandan¹, U. Nurmatov¹,
O. C. P. van Schayck^{1,2}, A. Sheikh^{1,2}**

¹Allergy & Respiratory Research Group, Centre for Population Health Sciences, University of Edinburgh, Edinburgh, UK; ²CAPHRI, University Maastricht, the Netherlands

Key words: asthma; epidemiology.

A. Sheikh
Allergy & Respiratory Research Group
Centre for Population Health Sciences
The University of Edinburgh
20 West Richmond Street
Edinburgh EH8 9DX
UK

Accepted for publication 25 September 2009

Asthma is now one of the most common chronic diseases affecting an estimated 300 million people worldwide (1). The prevalence of asthma (and other local allergic conditions) increased very markedly over the second half of the last century, especially in westernized societies, where it now poses a considerable disease burden on individuals and economic disease burden on healthcare systems and society (2, 3). There have, however, been recent reports that its prevalence may now be declining (or has at least plateaued) (4–7), and these are, if true, important for future national and international healthcare planning (6, 8, 9).

To inform these deliberations, we aimed to search systematically for, and appraise, published reports on the epidemiology of asthma. We endeavoured to include studies using appropriate study designs and validated instruments [such as the International Study of Asthma and Allergies in Childhood (ISAAC) (10) and the European Community Respiratory Health Survey (ECRHS)] (11) to assess recent international trends in asthma prevalence and more specifically to assess if asthma prevalence is declining.

Methods

We searched EMBASE (from 1990), Medline (from 1990), ISI Web of Science (from 1990) and Google Scholar for reports describing trends in asthma prevalence using appropriate Medical Subject Heading (MeSH) and free text searches embracing the following concepts/terms: asthma\$ AND epidemiology OR prevalence OR time trends OR cohort OR repeat questionnaire OR repeat survey OR ISAAC OR ECRHS from 1990 onwards, in English and in all age groups. In addition, we drew on our personal databases of literature on the epidemiology of asthma and our own sources of routine data. Bibliographies of papers found were scanned for additional papers of interest.

We only included full reports of studies that presented data on estimates of asthma prevalence for at least two time points during the period 1990–2008. We stipulated that these studies needed to employ appropriate designs to assess disease trends (i.e. cohort studies, repeat cross-sectional surveys and analysis of routine healthcare data), validated instruments and approaches to asthma diagnosis, and comparable approaches for each period of time under study.

Quality assessments were independently carried out on each study by two reviewers using an adaptation of the Critical Appraisal Skills Programme approach, which involved an assessment of both internal and external validity (12). We assessed the agreement of reviewers on methodological quality assessment, and any disagree-

ments were resolved by discussion or, if agreement could not be reached, by arbitration by a third reviewer. Reviewers were not masked to study details when assessing study quality.

Data were independently extracted onto a customized data extraction sheet by two reviewers, and any discrepancies were resolved by discussion or, if agreement could not be reached, by arbitration by a third reviewer. Because of differences in design and reporting approaches and the heterogeneity of findings, meta-analysis was neither possible nor desirable. Rather, trends were explored descriptively by study design, age group (children *vs* adults) and continent.

Results

We identified 2321 titles for review (Fig. 1) of which 48 full reports of studies satisfied our inclusion criteria. Overall, these studies reveal that there is no single global trend (Fig. 2). Tables 1–6 detail data from key epidemiological studies on changing trends in asthma prevalence since 1990. Tables 1–3 draw on ISAAC questionnaire derived data (see Panel 1 for questions used) and identify countries where asthma prevalence is increasing (Table 1), decreasing (Table 2) and remaining stable (Table 3). Tables 4–6 detail findings from other epidemiological studies, these in the main comprising repeat cross-sectional studies and secondary analyses of routine datasets and one cohort study.

In the following text, we summarize overall trends by continent. For each region, where available, we begin by presenting data from the more robust epidemiological studies and then turn to analyses of routine healthcare data.

Africa

We found only limited data on asthma trends in Africa and none using serial cohort designs. In South Africa (Cape Town), the 12-month prevalence of wheezing, assessed using ISAAC phase I and phase III questionnaires in 13- to 14-year-olds, was found to have increased from 16.0% to 20.3% over the period 1995–2002, but there was no corresponding increases in the prevalence of clinician-diagnosed asthma over this same time period

Panel 1. Key questions from the International Study of Asthma and Allergies in Childhood questionnaire

Have you ever had wheezing or whistling in the chest at any time in the past?
Have you had wheezing or whistling in the chest in the last 12 months?
How many attacks of wheezing have you had in the last 12 months?
In the last 12 months, how often, on average, has your sleep been disturbed because of wheezing?
In the last 12 months, has wheezing ever been severe enough to limit your speech to only one or two words at a time between breaths?
In the last 12 months, has your chest sounded wheezy during or after exercise?
In the last 12 months, have you had a dry cough at night, apart from a cough associated with a cold or chest infection?

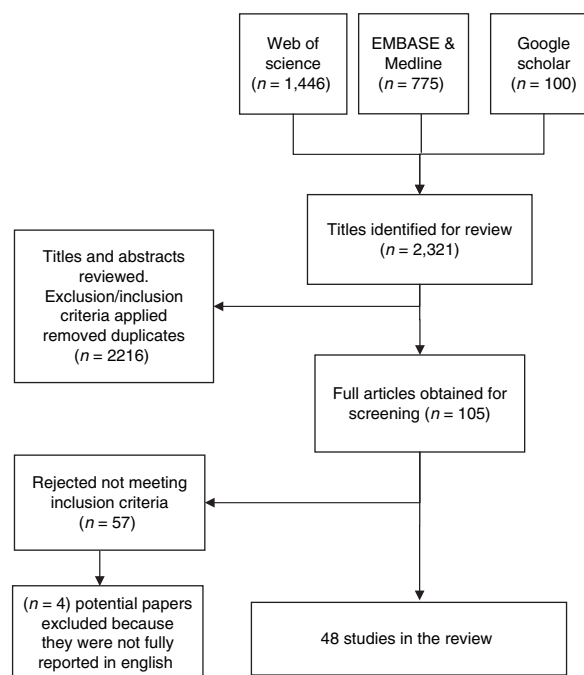


Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

(13) (Table 1). In Morocco, Bouayad et al. (14) reported an increase in the prevalence of wheezing in the last 12 months (in children aged 13–14) of 1.0% from phase I (1994/1995) to phase III (2002) using the ISAAC questionnaire in Casablanca (Table 1), but a decrease of 0.2% in Marrakech in children of the same age over the same time period (Table 2).

Although asthma prevalence has been reported in other parts of Africa, for example, in Ethiopia (15–17), Nigeria (18, 19), Kenya (20, 21) and Tunisia (22) as part of the worldwide ISAAC reports (23–25), no serial data have as yet been reported.

Asia and the Middle East

There are again only a limited number of reports for this region with conflicting results; none of these studies have used cohort designs. In studies using the ISAAC questionnaire, an increase in 12-month prevalence of symptoms indicative of asthma has been reported in 6- to 7-year-olds in Singapore [from 9.9% (1994) to 11.9% (2001)] (26) and Thailand in Bangkok [from 11.0% (1995) to 15.0% (2001)] and Chiang Mai [from 5.5% (1995) to 7.8% (2001)] (27), as well as adolescents (12- to 15-year-olds) in Korea [from 2.7% (1995) to 5.3% (2000)] (28), Taiwan [from 4.5% (1995/1996) to 6.0% (2001)] (29) and Singapore [from 9.9% (1994) to 11.9% (2001)] (26) (Table 1). A decrease in prevalence of asthma symptoms has, however, been reported in Hong Kong [from 11.2% (1994/1995) to 10.2%

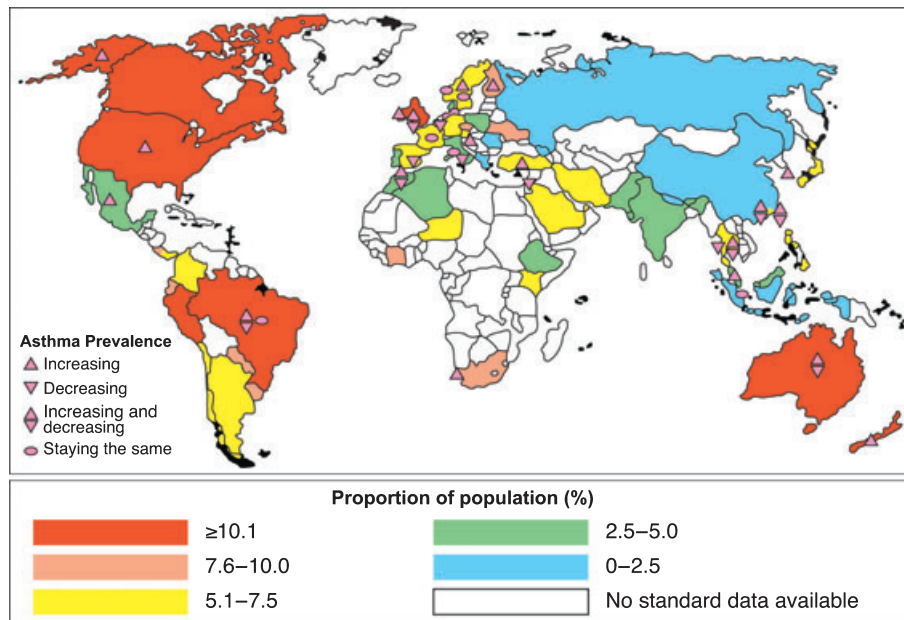


Figure 2. World map of the prevalence of clinician-diagnosed asthma adapted to demonstrate disease trends over the period 1990–2008 (reproduced with kind permission from Masoli et al. (2004) (1).

(2002)] (30) and Thailand [in Chaing Mai (from 12.7% (1995) to 8.7% (2001))] and little change in Bangkok [from 13.5% (1995) to 13.9% (2001)] (27) in 13- to 14-year-olds (Table 2). One other cross-sectional study (Table 6) in Hong Kong reported no change in asthma symptoms in the over 1970s between 1993 and 2001 (31). An ISAAC study in Israel (Table 2) showed a decrease in asthma symptoms in 6- to 7-year-olds and 13- to 14-year-olds [from 7.0% (1997) to 6.4% (2003), respectively] (32).

Other studies have reported asthma symptom prevalence in Taiwan (33), north-eastern Thailand (34) and India (35, 36), but no serial data have been reported.

Australasia

For Australasia, we found evidence of conflicting trends in asthma prevalence. A study using the ISAAC questionnaire reported a 7.3% decrease in the prevalence of physician-diagnosed asthma [from 38.3% (1992) to 31.0% (2002)] in 8- to 11-year-olds (37) (Table 2). Increases in the prevalence of physician-diagnosed asthma were reported in Australia using a cross-sectional survey in those aged 15 or older, from 7.5% (1990) to 12.2% (2003) (38, 39) (Table 4), and also for 8- to 11-year-olds from 30.5% (in 1992) to 38.6% (in 1997) (40) (Table 4).

Europe

There was a much larger set of studies for Europe than for other regions, but here too the picture was far from

uniform. In the UK, three repeat cross-sectional studies used the ISAAC questionnaire (Table 1). One reported a significant increase in physician-diagnosed asthma prevalence from 19.9% (1991) to 29.7% (1999) (41) in 8- to 9-year-olds. The second study reported an increase in current wheeze in both 6- to 7- and 13- to 14-year-olds from 1995/1996 to 2001/2002 (6- to 7-year-olds: girls 15.4–23.3%, boys 21.0–27.6%; 13- to 14-year-olds: girls 21.8–21.4%, boys 18.0–23.2%) with the increase more striking amongst boys (42). The third study showed an increase in lifetime asthma in 12- to 14-year-olds from 20.6% (1995) to 25.9% (2002) (43). In other cross-sectional studies (Table 4), Burr et al. (44) reported an increase in reported asthma in 12-year-olds from 5.5% in 1988 to 27.3% in 2003; Upton et al. (45) reported an over twofold increase in the prevalence of asthma in adults from 3.0% (1972) to 8.2% (1996) (45); Rizwan et al. (46) reported an increase in 5- to 11-year-olds from 17.7% (1991) to 29.8% (1998); Butland et al. (47) in 7- to 8-year-olds from 12.9% (1991) to 17.8% (2002); and Anderson reported asthma prevalence increased from the 1960s to early 2000s (48) (Table 4). One cohort study reported an increase in the annual prevalence of physician-diagnosed asthma in women and men, respectively, from 3.0% (1990) to 5.1% (1999) (49). Routine data sources (50–52) and surveys [Scottish Health Survey (53) and the Health Survey for England (54)] have also found asthma symptom prevalence to be increasing in the UK for all ages (Table 4).

In the Republic of Ireland, physician-diagnosed asthma increased from 18.2% in 1998 to 21.6% by 2003, in 13- to

Table 1. Studies using ISAAC questionnaire finding that the prevalence of asthma is increasing

Study	Where	Age	Measure	Magnitude	Conclusion	Quality assessment
<i>Africa</i> Zar et al. (2007) (13)	Cape Town, South Africa	13–14 years	ISAAC phase I and III – video questionnaire responses	12-month prevalence of wheezing (16.0% 1995 vs 20.3% 2002) and severe wheeze (5.1% vs 7.8%) increased significantly. There was a small increase in the percentage of children diagnosed with asthma from 1995 to 2002 (13.1% vs 14.4%), this was not significant	Symptoms of asthma in adolescents have increased over the past 7 years in this geographical area	Good
Bouayad et al. (2006) (14)	Morocco	13- to 14-years	ISAAC questionnaire Phase I and III (1995 and 2002)	In Casablanca, the % change of wheezing in the last 12 months from phase I (1994/1995) to phase III (2002) was 10% (an increase of 1.0%, $P < 0.001$)	In Casablanca, there was a significant increase in wheezing (in the last 12 months) from phase I to phase III	Moderate
<i>Asia and the Middle East</i> Trakultivakorn et al. (2007) (27)	Bangkok and Chiang Mai, Thailand	6–7 and 13–14 years	ISAAC phase III	There was an increase in the prevalence of current symptoms of asthma in the 6- to 7-year-olds in Bangkok [from 11.0% (1995) to 15.0% (2001)] and Chiang Mai [from 5.5% (1995) to 7.8% (2001)]	Asthma increased in the 6- to 7-year-olds	Moderate
Wang et al. (2004) (26)	Singapore	6–7 and 12–15 years	ISAAC questionnaire 1994 and 2001	The prevalence of current wheeze increased in the 12–15 year age group (9.9% to 11.9%) but decreased in the 6–7 year age group (16.6–10.2%)	Asthma prevalence increased in the 12- to 15-year-olds but decreased in the 6- to 7-year-olds	Good
Hong, et al. (2004) (28)	Korea	12–15 years	ISAAC questionnaire, 1995 and 2000	Lifetime prevalence of asthma diagnosis increased significantly from 2.7% in 1995 to 5.3% in 2000	Asthma prevalence is increasing	Good
Lee et al. (2007) (29)	Taiwan	12–15 years	ISAAC questionnaire 1995/1996 and 2001	Lifetime prevalence (physician-diagnosed asthma): phase I 4.5% (1995/1996); phase III 6.0% (2001)	Asthma prevalence is increasing	Good
<i>Europe</i> Shanssain (2007) (42)	NE England, UK	6- to 7- and 13- to 14-years	Two cross- sectional surveys 6 year apart	Increase in current wheeze in both 6- to 7- and 13- to 14-year-olds from 1995/1996 to 2001/2002 (6- to 7-year-olds: girls 15.4–23.3%, boys 21.0–27.6%; 13- to 14-year-olds: girls 21.8–21.4%, boys 18.0–23.2%)	Asthma prevalence is increasing	Good
Ng Man Kwong et al. (2001) (41)	UK	8–9 years	ISAAC questionnaire 1991 and 1999	There were significant increases between the two surveys in the prevalence of asthma ever (19.9% v 29.7%, mean difference 11.9%, 95%CI 10.2 to 13.6, $p < 0.001$).	An increase in asthma prevalence	Moderate
Anderson et al. (2004) (43)	UK	12–14 years	ISAAC questionnaire, 1995 and 2002	Prevalence of lifetime asthma (ever having asthma) increased by 5.3% from 20.6% (1995) to 25.9% (2002)	An increase in asthma prevalence	Good

Table 1. (Continued)

Study	Where	Age	Measure	Magnitude	Conclusion	Quality assessment
Manning et al. (2007) (94)	Republic of Ireland	13–14 years	ISAAC questionnaire, 1998 and 2002/2003	Physician-diagnosed asthma increased from 18.2% in 1998 to 21.6% by 2003	An increase in asthma prevalence	Moderate
Maziak et al. (2003) (56)	Munster, Germany	6–7 and 13–14 years	ISAAC questionnaire. 1994/1995 and 1999/2000	12-month wheeze: 6- to 7-year-olds – boys 12–13.6%, girls 7.5–12.7%. 13- to 14-year-olds – boys 12.9–15.2%, girls 15.2–19.7%	Increase in asthma prevalence from 1994/1995 to 1999/2000	Good
Bjerg-Backlund et al. (2006) (57)	Sweden	7–8 years followed up to 11–12 years	ISAAC questionnaire 1996 and 2000	The prevalence of physician-diagnosed asthma increased from 5.7% at age 7–8 to 7.7% at age 11–12. Lifetime prevalence of wheeze was 34.7% at age 11–12	The prevalence of asthma increased continuously during the primary school ages	Good
Galassi et al. (2006) (59)	Italy	6- to 7- and 13- to 14-year-olds	ISAAC questionnaire 1994 and 2002	Lifetime prevalence of asthma: 6- to 7-year-olds – 9.1% (1994/1995) and 9.5% (2002), an increase of 0.6%; 13- to 14-year-olds – 9.1% (1994/1995) and 10.4% (2002), an increase of 1.4%	Asthma prevalence increased from 1994/1995 to 2002 for both 6- to 7- and 13- to 14-year-olds	Good
Migliore et al. (2005) (58)	Italy	6–10 years	ISAAC questionnaire 1994–1995 and 1999	Asthma (lifetime) increased 2.5% from 10.7% (1994/1995) to 13.3% (1999)	Increase in asthma prevalence	Good
Ones et al. (2007) (60)	Istanbul, Turkey	6- to 12-year	ISAAC questionnaire 1995 and 2004	The overall lifetime prevalence of wheeze increased from 15.1% to 25.3%; prevalence odds ratio (POR) = 1.91, 95% confidence interval (95% CI) = 1.64–2.21, and $P < 0.001$. The overall 12-month prevalence of wheeze increased from 8.2% to 11.3%; POR = 1.43, 95% CI = 1.18–1.75, and $P < 0.001$. The prevalence of asthma increased significantly from 9.8% to 17.8%; POR = 1.99, 95% CI = 1.67–2.36, and $P < 0.001$	In the 9-year period from 1995 to 2004, the prevalence of asthma symptoms has increased in 6- to 12-year-old schoolchildren in Istanbul. Risk factors affecting asthma prevalence remained unchanged during the 9-year period	Good
Garcia-Marcos, et al. (2004) (61)	Spain	6–7 and 13–14 years	ISAAC questionnaire 1994–1995 (phase I) and 2002–2003 (phase II)	Lifetime prevalence of asthma – asthma diagnosis by physician increased from 10.4% (1994/1995) to 12.8% (2002/2003)	Asthma diagnosis has increased from 1995 to 2002/2003	Good
<i>South America</i> Barraza-Villarrea et al. (2007) (78)	Cuernavaca, Mexico	6–8 and 11–14 years	ISAAC questionnaire 1995 and 2002	The prevalence of asthma diagnosed by a doctor was 5.8% (95% CI, 5.2, 6.4) for 1995 vs 9.1% (95% CI, 8.3, 10.0) for 2002, with a greater prevalence in children aged 6–8 years in 2002 (5.7% vs 9.0%). No significant differences were found over time for wheezing in the last 12 months: 7.7% (95% CI, 7.1, 8.4) in 1995 and 8.0% (95% CI, 7.3, 8.8) in 2002	The results suggest an increase in the prevalence of asthma diagnosed by a doctor. However, no difference was observed in the prevalence of wheezing in the last 12 months, which may indicate a possible absence of 'epidemic asthma' in the city of Cuernavaca among schoolchildren	Moderate

ISAAC, International Study of Asthma and Allergies in Childhood.

Table 2. Studies using ISAAC questionnaire finding that the prevalence of asthma is decreasing

Study	Where	Age	Measure	Magnitude	Conclusion	Quality assessment
<i>Africa</i>						
Bouayad et al. (2006) (14)	Morocco	13- to 14-years	ISAAC questionnaire Phase I and III (1995 and 2002)	% Change from phase I to phase III: Marrakech = 5.7 (-0.18 , $P < 0.05$) wheezing in the last 12 months	In Marrakech, there was a significant decrease in wheezing (in the last 12 months) from phase I to phase III	Moderate
<i>Asia and the Middle East</i>						
Wong, et al. (2004) (30)	Hong Kong	13–14 years	Phase III ISAAC questionnaire compared to phase I (1994–1995)	Prevalence rate of physician-diagnosed asthma was 11.2% in 1994/1995. This decreased to 10.2% in 2002	Asthma prevalence has not increased from 1994 to 2002	Good
Trakulivakorn et al. (2007) (27)	Bangkok and Chiang Mai, Thailand	6–7 and 13–14 years	ISAAC phase I and III	There was a decrease in the prevalence of current asthma in the 13- to 14-year-olds in Chaing Mai (from 12.7% (1995) to 8.7% (2001)) and little change in Bangkok (from 13.5% (1995) to 13.9% (2001))	Asthma decreased in the 13- to 14-year-olds	Moderate
Romano-Zelekha et al. (2007) (32)	Israel	6–7 and 13–14 years	Modified ISSAC questionnaire 1997 and 2003	Asthma prevalence was 7.0% in 1997 and 6.4% in 2003, respectively ($P = 0.1$). Wheezing in the past 12 months decreased significantly from 17.9% in 1997 to 13.8% in 2003 ($P < 0.001$)	The prevalence of asthma symptoms decreased in Israel from 1997 to 2003	Moderate
<i>Australasia</i>						
Toelle, et al. (2004) (37)	Australia	8–11 years	3 cross-sectional surveys using ISAAC questionnaire in 1982, 1992, 2002	Asthma diagnosed in 1982 9.1%; 1992 38.3% and 2002 31.0%. Absolute increase -7.3% (95% CI -11.8 to -2.8)	No evidence of increasing prevalence of asthma from 1982 to 2002	Moderate
<i>South America</i>						
Sole et al. (2007) (80)	Brazil	13–14 years	ISAAC phase I and III	The prevalence of wheezing in the last 12 months was 27.7 in 1994/1995 vs 19.9% in 2002 ($P < 0.01$)	There was a small but significant mean decrease in the prevalence wheezing. The prevalence of asthma symptoms in Brazil, despite its mean trend to a decrease, is still one of the highest in Latin America	Moderate

ISAAC, International Study of Asthma and Allergies in Childhood.

Table 3. Studies using ISAAC questionnaire finding the prevalence of asthma is remaining stable

Study	Where	Age	Measure	Magnitude	Conclusion	Quality assessment
Riedi, et al. (2005) (79)	Brazil	13–14 years	ISAAC 1995 and 2001 questionnaire	The prevalence of symptoms of asthma, probable asthma in 1995 and 2001 was 18.4% and 18.7%, respectively	No change in asthma over the past 6 years	Moderate

ISAAC, International Study of Asthma and Allergies in Childhood.

14-year-olds (Table 1). In Galway, Ireland, the prevalence of current asthma was 18.5% in 2002, showing no change since 1992 (Table 6) (55).

An increase in asthma prevalence has been reported using the ISAAC questionnaire in Germany for both boys and girls aged 6–7 and 13–14 (56) (Table 1). For example, an increase in asthma prevalence from 12.2% in 1994/1995 to nearly 13.6% in 1999/2000 was reported for boys aged 6–7 (56). In the rest of Europe, an increase in asthma prevalence using the ISAAC questionnaire in children aged 6–14 was also found in Sweden (physician-diagnosed asthma increased from 5.7% (aged 7–8) to 7.7% (aged 11–12) (57), Italy [lifetime prevalence in 6- to 7-year-olds and 13- to 14-year-olds, respectively, from 9.1% (1994/1995) to 9.5% (2002): in 6- to 10-year-olds 10.7% (1994/1995) to 13.3% (1999)] (58, 59), Turkey [lifetime prevalence of wheeze increased from 15.1% (1995) to 25.3% (2004)] (60) and Spain [lifetime prevalence of asthma (6- to 7-year-olds and 13- to 14-year-olds, respectively) from 10.4% (1994/95) to 12.8% (2002/2003)] (61) (Table 1). An increase in asthma symptoms was reported in Sweden (62) and Croatia (63, 64) using the ISAAC questionnaire, but follow-up data were not presented.

Asthma prevalence was reported as increasing in one cross-sectional survey in Denmark (Table 4) from 4.1% (1986) to 11.7% (1998) in 7- to 17-year-olds (65). Other cross-sectional surveys that also showed an increase in prevalence were in Greece [lifetime prevalence of asthma increased from 9.6% (1998) to 12.4% (2003)] (66) (Table 4). Other routine data sources that showed an increase in prevalence were from Finland (physician-diagnosed asthma, relating only to men, from 0.3% (1960) to 3.5% (2003) (67).

In Norway (68) and Sweden (69), however, stable prevalences were reported using the ISAAC questionnaire, but follow-up data were not presented. Other studies that reported a plateau in asthma prevalence used cross-sectional surveys (see Table 6) in Switzerland (5- to 7-year-olds) (70), Italy (6- to 14-year-olds) (71) and Germany (72) (9- to 11-year-olds). A review in Norway reported a levelling off of asthma prevalence over the last 10 years (73).

A decline in asthma prevalence was found in two studies in the Netherlands: one used a repeat cross-sectional

study in 8- to 9-year-olds between 1989 and 2001 (6), whilst the other analysed routine healthcare datasets (74) (Table 5).

North America

A mixed picture was also found to exist in the United States. Akinbami and Schoendorf (75) reported that annual asthma prevalence increased from 3.7% (1980/1981) to 6.9% (1995/1996) (Table 4), whereas Mannino et al. (76) reported a decline from 1997 to 1999 (Table 5). In Alaska, a yearly increase in asthma prevalence was reported (from 1.0% in 1999 to 2.2% in 2002 ($P < 0.001$) Table 4) (77).

Barraza-Villarrea et al. (78) reported an increase in physician-diagnosed asthma prevalence in 6- to 8-year-olds and 11- to 14-year-olds from 5.8% (1995) to 9.1% (2002), in Mexico (Table 1).

South America

In South America, using the ISAAC questionnaire, Riedi et al. (79) reported no change in the prevalence of asthma symptoms (from 18.4% to 18.7%) in 13- to 14-year-olds between 1995 and 2001 in Brazil (Table 3), whereas Sole et al. (80) reported a decrease in the prevalence of wheezing in the same age group from 27.7% (1994/95) to 19.9% (2002) (Table 2). Although Mallol et al. (81) reported an increase in wheezing for the last 12 months using the ISAAC questionnaire, data were only presented for 1999/2000.

Gaps in the epidemiological evidence

Although a global picture of trends in asthma prevalence can be presented (Fig. 2), there are still areas where little or no data have been collected, these including parts of Asia, Africa and South America. In areas where asthma prevalence has only been reported in single cross-sectional studies, it would seem prudent to invest resources to generate serial data. These areas include Africa, Trinidad and Tobago (82), Dhakar (83), Albania (84), Greece (85), Nigeria (18), Israel (86), Beirut (87), United Arab Emirates (88), Kuwait (89), Palestine (90), Tamil Nadu, India (35) and Qatar (91).

Table 4. Other studies (repeat cross-sectional surveys, routine healthcare data and cohort studies) showing an increasing prevalence of asthma

Study	Where	Age	Measure	Magnitude	Conclusion	Quality assessment
<i>Repeat cross-sectional surveys</i>						
<i>Australasia</i>						
Downs, et al. (2001) (40)	Australia	8–11 years	A cross-sectional study in 1997 compared with studies of similar design in 1992	Between 1992 and 1997, the prevalence of asthma diagnosis increased by 8.1% (95% CI 3.8–12.4). Prevalence 12.9% (1982), 30.5% (1992) and 38.6% (1997)	The prevalence of asthma diagnosis in Wagga Wagga has continued to increase from 1982 to 1997	Good
Wilson, et al. (2003) (38) and (2006) (39)	South Australia	≥15 years	Cross-sectional survey 1990–2003	Between 1990 and 2003, physician-diagnosed asthma prevalence increased significantly ($P < 0.001$) from 75% (1990), with a peak of 13.4% in 2002 and 12.2% in 2003	Asthma prevalence increased from 1990 to 2003	Good
<i>Europe</i>						
Burr, et al. (2006) (44)	South Wales, UK	12 years	A questionnaire survey of 12 year old children, where surveys had taken place in 1973, 1988 and 2003	The prevalence of reported asthma ever rose during each 15-year period: 5.5% (1973), 12.0% (1988) and 27.3% (2003)	The prevalence of asthma has risen from 1973 to 2003.	Moderate
Scottish Health Survey (53)	Scotland, UK	1995: 16–64 years. 1998: 2–74 years. 2003: all ages	Cross-sectional survey. Questionnaire in 1995, 1998 and 2003	There has been an increase in asthma prevalence – doctor-diagnosed asthma: males –10.7% (1998) to 13.0% (2003). Females –12.2% (1998) to 14.0% (2003)	Asthma prevalence appears to be increasing in Scotland from 1995 to 2003	Good
Upton et al. (2000) (45)	Scotland, UK	45–64	Two epidemiological surveys in 1972–1976 and 1996	Asthma and or wheeze increased from 6.4% (age- and sex-standardized prevalence) in 1972–1976 up to 8.5% in 1996	The prevalence of asthma in adults increased more than twofold in 20 years	Good
Anderson et al. (2007) (48)	UK	≥2 years	A variety of data sources were used	Prevalence increased from 10% in the 1960s and 1970s to 20–30% in the late 1990s and early 2000s	The prevalence of a lifetime diagnosis of asthma increased in all age groups	Good
Butland, et al. (2006) (47)	UK	7–8 years	Cross-sectional survey in 1991 and 2002	The prevalence of wheeze in the last 12 months increased from 12.9% in 1991 to 17.8% in 2002 [prevalence ratio 1.4 (95%CI 1.2–1.6)]	There is evidence of an increase in the prevalence of asthma among British primary school children between 1991 and 2002	Moderate
Rizwan, et al. (2004) (46)	UK	5–11 years	Three cross-sectional surveys 1991, 1993 and 1998	Between 1991 and 1998, the prevalence of reported doctor-diagnosed asthma increased from 17.7% to 29.8% ($P < 0.001$)	Increasing prevalence of asthma between 1991 and 1998	Good
Health Survey for England (54)	England	All ages	Cross-sectional annual survey from 1991	The prevalence of doctor-diagnosed asthma was significantly higher in 2001 than in 1995–1996, increasing from 11.0% to 13.0% among men and from 12.0% to 16.0% among women	Asthma prevalence appears to be increasing in England	Good
Porsbjerg et al. (2006) (65)	Copenhagen, Denmark	7–17 years	Two questionnaire surveys were conducted in 1989 and 1998	The point prevalence of asthma increased from 4.1% at the first survey (1986) to 11.7% (1998) at follow-up	Asthma increased from 1986 to 1998	Good

Table 4. (Continued)

Study	Where	Age	Measure	Magnitude	Conclusion	Quality assessment
Anthracopoulos et al. (2007) (66)	Greece	8–10 years	Four population-based cross-sectional parental questionnaire surveys	The prevalence rates of current asthma and/or wheezing in 1978, 1991, 1998 and 2003 were 1.5%, 4.6%, 6% and 6.9%, respectively (P for trend <0.001). The lifetime prevalence of asthma and/or wheezing in the three more recent surveys was 8%, 9.6% and 12.4%, respectively (P for trend <0.001)	There is an increase in asthma and wheezing	Good
<i>Cohort studies</i> Soriano, et al. (2003) (49)	UK	≥5 years	A retrospective cohort study from the General Practice Research Database from January 1990 to February 1999	From 1990 to 1998, annual prevalence rates of managed physician-diagnosed asthma in women rose from 3.0% (95%CI 2.99–3.03) to 5.1% (95%CI 5.10–5.18), and in men, from 3.4% (95%CI 3.41–3.46) to 5.1% (95%CI 5.02–5.10) (P for trend <0.01 in both)	Asthma prevalence increased from 1990 to 1998	Good
<i>Routine healthcare data</i> Latvala, et al. (2005) (67)	Finland	18–19 years	Young men nationwide study 1966–2003	There was an increase in physician-diagnosed asthma prevalence (men only) from 0.3% 1960 to 3.5% in 2003	An increase in asthma prevalence was reported from 1960 to 2003	Moderate
Gupta, et al. (2004) (50)	UK	≥2 years	Secondary analysis of data 1990–2001	Prevalence of recent wheeze increased from 12% to 26% (preschool children 1990–1998) 17% to 19% (8–9 years, 1991–1999). Ever diagnosed with asthma increased from 11% to 18% (<5 s) and 18% to 30% (8–9 years)	Increase in asthma prevalence	Moderate
Anandan et al. (2009) (51)	UK	≥2 years	Secondary analysis of data 1995–2005	The lifetime prevalence of diagnosed asthma increased from 20% in 1995 to 24% in 2002	Increase in asthma prevalence	Moderate
Hippisley-Cox et al. (2006) (52)	UK	All ages	Secondary analysis of data 2001–2005	Age- sex-standardized prevalence increased from 10.0% (2001) to 11.2% (2005)	Increase in asthma prevalence	Moderate
Akinbami and Schoendorf, (2002) (75)	USA	0–17 years	Five data sources from the National Center for Health Statistics, 1980–2000	Annual asthma prevalence (in the last 12 months) increased from 3.7% (1980/1981) to 6.9% (1995/1996)	Increase in asthma prevalence	Moderate
Gessner and Neeno (2005) (77)	Alaska	All ages	A retrospective review of Alaskans younger than 20 years enrolled in Medicaid during 1999–2002	Yearly prevalence of asthma increased from 1.0% in 1999 to 2.2% in 2002 ($P < 0.001$)	Increase in asthma prevalence reported	Good

Table 5. Other studies (repeat cross-sectional surveys and routine healthcare data) showing a declining prevalence of asthma

Study	Where	Age	Measure	Magnitude	Conclusion	Quality assessment
<i>Repeat cross-sectional surveys</i>						
Mommers, et al. (2005) (74)	The Netherlands	8–9 years	Parental questionnaire on the respiratory health children, 2001	Wheezing in the past year decreased from 13.4% (1989), 13.3% (1993), 11.9% (1997) and 9.1% (2001)	The prevalence of recent wheeze in Dutch schoolchildren has declined steadily since 1989	Good
<i>Routine healthcare data</i>						
van Schayck and Smit (2005) (6)	The Netherlands	All ages	Data from Continuous Morbidity Registration, Nijmegen (CMR), the Netherlands, began in 1967	After an initial increase, the prevalence of respiratory complaints in children is now stabilizing or even declining	A downward trend seems to have set in around the late 1990s, especially among young children	Moderate
Mannino et al. (2002) (76)	USA	All ages	Centre for Disease Control, 1980–1999	In 1980–1996, asthma prevalence increased. In 1997–1999, asthma prevalence decreased	Asthma prevalence appears to be decreasing	Moderate

Table 6. Other studies (repeat cross-sectional surveys) showing a stable prevalence of asthma

Study	Where	Age	Measure	Magnitude	Conclusion	Quality assessment
<i>Repeat cross-sectional surveys</i>						
Shabu et al. (2007) (55)	Galway, Ireland	9–10 years	One page questionnaire circulated in 1992 and 2004	The prevalence of asthma was 18.5%. Comparison with the study of 1992 shows little change in the prevalence of current wheeze or asthma	Asthma prevalence appears to be stable in 9- to 10-year-olds from 1992 to 2004	Moderate
Grize, et al. (2006) (70)	Switzerland	5–7 years	Four cross-sectional surveys in 5- to 7-year-olds in seven different communities in Switzerland between 1992 and 2001	Wheeze in past 12 months: 11.9% (1992), 10.3% (1995), 9.2% (1998) and 9% (2001)	Wheeze in the past 12 months decreased from 1992 to 2001	Good
Ronchetti, et al. (2001) (71)	Italy	6–14 years	Two primary schools, validated questionnaire, 6–14 years, 1974, 1992 and 1998	Physician-diagnosed asthma increased from 5.5% (1974) to 12.2% (1992) and 12% (1998)	Asthma prevalence increased from 1974 to 1998	Good
Zollner et al. (2005) (72)	Germany	9- to 11-year-olds	Cross-sectional surveys conducted between October 1992 and March 1993, and then repeated five times during the same season in 1993/1994, 1994/1995, 1996/1997, 1998/1999 and 2000/2001	No real increase in physician-diagnosed asthma from 4.9% (1992/1993) to 4.3% (1996/1997) and 5.6% (2000/2001)	There has been no further increase in the prevalence of asthma since 1992	Moderate
Ko et al. (2006) (31)	Hong Kong	≥70 years	Two questionnaire surveys were conducted in 1991–1992 and 2003–2004	No change for asthma prevalence from 5.1% in 1991 to 5.8% in 2003	No real increase in asthma prevalence	Good

Discussion

This systematic review of the international literature has clearly shown that there is overall no decline in the prevalence of asthma. This is particularly apparent from the various higher quality epidemiological studies, many of which reveal that, if anything, the prevalence of symptoms suggestive of asthma may still be increasing.

Although a global problem, asthma remains predominantly a western disease

The *Global Burden of Asthma* report (2004) (1) indicates that the highest prevalence of physician-diagnosed asthma is still in the UK and Australasia but that the USA and parts of South America have high prevalence. The lowest prevalence is in Indonesia, Albania, Nepal and India. This report thus highlights that asthma is still predominantly a western English-speaking area disease but that people in all world regions are nonetheless now affected. It has been suggested that this epidemiological picture may reflect the English origin bias of many of the asthma instruments used. Indeed, the word asthma and asthma-related symptoms are translated differently or can have different meanings in non-English speaking countries (92). For example, the word 'wheezing' cannot be translated literally in most other languages. The implications for this can affect both physician and public awareness of asthma and therefore data collection in non-English speaking countries might not be as complete.

In the 2007 phase III ISAAC study (25), the countries with the highest asthma prevalences (for the previous 12 months) for 6- to 7-year-olds were Costa Rica (34.8%), Australia (23.6%), Panama (23.1%), Brazil (22.9%), New Zealand (22.6%) and the UK (19.6%). Of these, prevalence increased in the past 12 months in Costa Rica, Brazil, New Zealand and the UK. The lowest prevalences (for the previous 12 months) were in Indonesia (3.5%), Nigeria (5.2%), Lithuania (5.6%), Malaysia (6.2%) and Albania (6.3%) with prevalence increasing in the past 12 months in Nigeria and Lithuania (25).

In 13- to 14-year-olds, the highest prevalence of symptoms suggestive of asthma (for the previous 12 months) was reported in the Isle of Man (32.3%), Channel Isles (30.8%), New Zealand (28%), Republic of Ireland (27.9%) and the UK (27.1%). The lowest prevalence of suggestive symptoms (for the previous 12 months) was in Albania (3%), Indonesia (3.6%), China (5.1%) and Taiwan (6.2%), with prevalence increasing in the past 12 months in all of these countries (25).

Strengths and limitations of this study

The main strengths of this study are the comprehensiveness of the searches involving interrogation of a number of datasets, our standardized approach to study selection,

quality assessment and data extraction. The resulting picture of asthma trends globally is we believe the most comprehensive assessment to date and this will we hope be of considerable benefit to healthcare planners globally.

There are, however, a number of limitations that need to be considered, these including our reliance on only including studies that have reported in full in English. We did, however, in the course of undertaking this work, also collect these non-English reports ($n = 4$) and study the abstracts of all of these reports, which have been translated into English. Based on the assessments of these abstracts, we are reasonably confident that inclusion of these additional studies would not have substantially altered our conclusions. A list of these additional four studies is included as an Appendix to this report. Also of relevance is that because of resource constraints, we were unable to search for unpublished material; whilst this is clearly a limitation of this exercise, given the heterogeneity of trends uncovered, inclusion of additional studies would have been unlikely to undermine our overall conclusion, namely that there is no clear global trend suggesting a decline in asthma prevalence.

There is still a need for high quality epidemiological data

The *Global Burden of Asthma* report highlights that the true prevalence of asthma is still difficult to determine because there is no definitive diagnostic test and because of the differing classifications of the disease throughout the world (1). The rapid transitions noted in many parts of the world and the gaps uncovered highlight the need for continued attempts to better understand the epidemiology of asthma.

Conclusion

No overall decline in asthma prevalence

The isolated reports of a decline in asthma are mainly based on extrapolation from measures of healthcare utilization and appear, therefore, largely to reflect improvements in quality of care (of which, greater use of preventative treatments is likely to be of greatest importance). For example, van Schayck et al. (6) showed in the Netherlands that before 1990, asthma mortality was still common, but dramatically dropped after the introduction of primary care guidelines in which the use of inhaled steroids was strongly advocated. After this, there was a clear association between the declining trend in respiratory symptoms and the medication use in wheezing children over a 12-year period. Similarly, Haahtela et al. (93) showed that in Finland, the introduction of primary care teams resulted in a 75% increase in inhaled steroid use, which was accompanied by an 80% decrease in hospitalization and mortality because of asthma.

In summary, the available data suggest that in most parts of the world, asthma prevalence is continuing to increase or remaining stable. The sense of optimism that asthma prevalence may be declining, for the present time at least, appears largely unfounded.

Acknowledgments

Our thanks to Professor Liam Smeeth for his helpful comments on an earlier draft of this paper.

References

- Masoli M, Fabian D, Holt S, Beasley R. The global burden of asthma: executive summary of the GINA Dissemination Committee report. *Allergy* 2004;**59**: 469–478.
- Kay AB. Allergy and allergic diseases. First of two parts. *N Engl J Med* 2001;**344**:30–37.
- Strachan DP. Parallels with the epidemiology of other allergic diseases. In: Williams HC, editor. *The epidemiology of atopic dermatitis*. Cambridge: Cambridge University Press, 2000:221–232.
- Pearce N, Douwes J. Commentary: asthma time trends—mission accomplished? *Int J Epidemiol* 2005;**34**:1018–1019.
- Ponsonby AL, Glasgow N, Pezic A, Dwyer T, Ciszek K, Kljakovic M. A temporal decline in asthma but not eczema prevalence from 2000 to 2005 at school entry in the Australian Capital Territory with further consideration of country of birth. *Int J Epidemiol* 2008;**37**:559–569.
- van Schayck CP, Smit HA. The prevalence of asthma in children: a reversing trend. *Eur Respir J* 2005;**26**:647–650.
- Sunderl RS, Fleming DM. Continuing decline in acute asthma episodes in the community. *Arch Dis Child* 2004;**89**:282–285.
- Castro HJ, Malka-Rais J, Bellanti JA. Current epidemiology of asthma: emerging patterns of asthma. *Allergy and Asthma Proceedings* 2005;**26**:79–82.
- Lawson JA, Senthilselvan A. Asthma epidemiology: has the crisis passed?. *Current Opinions in Pulmonary Medicine* 2005;**11**:79–84.
- The International Study of Asthma and Allergies in Childhood <http://isaac.auckland.ac.nz/> (last accessed 21/07/09). [cited].
- European Community Respiratory Health Survey <http://www.ecrhs.org/> (last accessed 21/07/09). [cited].
- Appraisal Tools <http://www.phru.nhs.uk/Pages/PHD/resources.htm> (last accessed 20/07/09). [cited].
- Zar HJ, Ehrlich RI, Workman L, Weinberg EG. The changing prevalence of asthma, allergic rhinitis and atopic eczema in African adolescents from 1995 to 2002. *Pediatric Allergy & Immunology* 2007;**18**:560–565.
- Bouayad Z, Aichane A, Afif A, Benouhoud N, Trombati N, Chan-Yeung M et al. Prevalence and trend of self-reported asthma and other allergic disease symptoms in Morocco: ISAAC phase I and III. *Int J Tuberc Lung Dis* 2006;**10**:371–377.
- Haileamlak A, Lewis SA, Britton J, Venn AJ, Woldemariam D, Hubbard R et al. Validation of the International Study of Asthma and Allergies in Children (ISAAC) and UK criteria for atopic eczema in Ethiopian children. *Br J Dermatol* 2005;**152**:735–741.
- Hailu S, Tessema T, Silverman M. Prevalence of symptoms of asthma and allergies in schoolchildren in Gondar town and its vicinity, northwest Ethiopia. *Pediatr Pulmonol* 2003;**35**:427–432.
- Melaku K, Berhane Y. Prevalence of wheeze and asthma related symptoms among school children in Addis Ababa, Ethiopia. *Ethiop Med J* 1999;**37**: 247–254.
- Falade AG, Olawuyi F, Osinusi K, Onadeko BO. Prevalence and severity of symptoms of asthma, allergic rhinoconjunctivitis and atopic eczema in secondary school children in Ibadan, Nigeria. *East Afr Med J* 1998;**75**:695–698.
- Falade AG, Olawuyi JF, Osinusi K, Onadeko BO. Prevalence and severity of symptoms of asthma, allergic rhinoconjunctivitis, and atopic eczema in 6- to 7-year-old Nigerian primary school children: the international study of asthma and allergies in childhood. *Med Princ Pract* 2004;**13**:20–25.
- Esamai F, Anabwani GM. Prevalence of asthma, allergic rhinitis and dermatitis in primary school children in Uasin Gishu district, Kenya. *East Afr Med J* 1996;**73**:474–478.
- Esamai F, Ayaya S, Nyandiko W. Prevalence of asthma, allergic rhinitis and dermatitis in primary school children in Uasin Gishu district, Kenya. *East Afr Med J* 2002;**79**:514–518.
- Khalidi F, Fakhfakh R, Mattoussi N, Ben Ali B, Zouari S, Khemiri M. Prevalence and severity of asthma, allergic rhinoconjunctivitis and atopic eczema in “Grand Tunis” schoolchildren: ISAAC. *Tunis Med* 2005;**83**:269–273.
- Strachan D, Sibbald B, Weiland S, Ait-Khaled N, Anabwani G, Anderson HR et al. Worldwide variations in prevalence of symptoms of allergic rhinoconjunctivitis in children: the International Study of Asthma and Allergies in Childhood (ISAAC). *Pediatr Allergy Immunol* 1997;**8**:161–176.
- The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee. Worldwide variation in prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and atopic eczema. *Lancet* 1998;**351**:1225–1232.
- Pearce N, Ait-Khaled N, Beasley R, Mallol J, Keil U, Mitchell E et al. Worldwide trends in the prevalence of asthma symptoms: phase III of the International Study of Asthma and Allergies in Childhood (ISAAC). *Thorax* 2007;**62**:758–766.
- Wang XS, Tan TN, Shek LP, Chng SY, Hia CP, Ong NB et al. The prevalence of asthma and allergies in Singapore; data from two ISAAC surveys seven years apart. *Arch Dis Child* 2004;**89**:423–426.
- Trakultivakorn M, Sangsupawanich P, Vichyanond P. Time trends of the prevalence of asthma, rhinitis and eczema in Thai children-ISAAC (International Study of Asthma and Allergies in Childhood) Phase Three. *Journal of Asthma* 2007;**44**:609–611.
- Hong SJ, Lee MS, Sohn MH, Shim JY, Han YS, Park KS et al. Self-reported prevalence and risk factors of asthma among Korean adolescents: 5-year follow-up study, 1995–2000. *Clin Exp Allergy* 2004;**34**:1556–1562.
- Lee Y-L, Hwang B-F, Lin Y-C, Guo YL, Taiwan ISG. Time trend of asthma prevalence among school children in Taiwan: ISAAC phase I and III surveys. *Pediatric Allergy & Immunology* 2007;**18**:188–195.
- Wong GW, Leung TF, Ko FW, Lee KK, Lam P, Hui DS et al. Declining asthma prevalence in Hong Kong Chinese schoolchildren. *Clin Exp Allergy* 2004;**34**:1550–1555.
- Ko FW, Lai CK, Woo J, Ho SC, Ho CW, Goggins W et al. 12-year change in prevalence of respiratory symptoms in elderly Chinese living in Hong Kong. *Respir Med* 2006;**100**:1598–1607.

32. Romano-Zelekha O, Graif Y, Garty B-Z, Livne I, Green MS, Shohat T. Trends in the prevalence of asthma symptoms and allergic diseases in Israeli adolescents: results from a national survey 2003 and comparison with 1997. *Journal of Asthma* 2007;**44**:365–369.
33. Yan DC, Ou LS, Tsai TL, Wu WF, Huang JL. Prevalence and severity of symptoms of asthma, rhinitis, and eczema in 13- to 14-year-old children in Taipei, Taiwan. *Ann Allergy Asthma Immunol* 2005;**95**:579–585.
34. Teeratakulpisarn J, Wiangnon S, Kosalaraksa P, Heng S. Surveying the prevalence of asthma, allergic rhinitis and eczema in school-children in Khon Kaen, Northeastern Thailand using the ISAAC questionnaire: phase III. *Asian Pac J Allergy Immunol* 2004;**22**: 175–181.
35. Chakravarthy S, Singh RB, Swaminathan S, Venkatesan P. Prevalence of asthma in urban and rural children in Tamil Nadu. *Natl Med J India* 2002;**15**:260–263.
36. Mistry R, Wickramasingha N, Ogston S, Singh M, Devasiri V, Mukhopadhyay S. Wheeze and urban variation in South Asia. *Eur J Pediatr* 2004;**163**:145–147.
37. Toelle BG, Ng K, Belousova E, Salome CM, Peat JK, Marks GB. Prevalence of asthma and allergy in schoolchildren in Belmont, Australia: three cross sectional surveys over 20 years. *Bmj* 2004;**328**: 386–387.
38. Wilson DH, Adams RJ, Appleton SL, Hugo G, Wilkinson D, Hiller J et al. Prevalence of asthma and asthma action plans in South Australia: population surveys from 1990 to 2001. *Med J Aust* 2003;**178**:483–485.
39. Wilson DH, Adams RJ, Tucker G, Appleton S, Taylor AW, Ruffin RE. Trends in asthma prevalence and population changes in South Australia, 1990–2003. *Med J Aust* 2006;**184**:226–229.
40. Downs SH, Marks GB, Sporik R, Belosouva EG, Car NG, Peat JK. Continued increase in the prevalence of asthma and atopy. *Arch Dis Child* 2001;**84**:20–23.
41. Ng Man Kwong G, Proctor A, Billings C, Duggan R, Das C, Whyte MK et al. Increasing prevalence of asthma diagnosis and symptoms in children is confined to mild symptoms. *Thorax* 2001;**56**:312–314.
42. Shamssain M. Trends in the prevalence and severity of asthma, rhinitis and atopic eczema in 6- to 7- and 13- to 14-yr-old children from the north-east of England. *Pediatric Allergy & Immunology* 2007;**18**:149–153.
43. Anderson HR, Ruggles R, Strachan DP, Austin JB, Burr M, Jeffs D et al. Trends in prevalence of symptoms of asthma, hay fever, and eczema in 12–14 year olds in the British Isles, 1995–2002: questionnaire survey. *Bmj* 2004;**328**:1052–1053.
44. Burr ML, Wat D, Evans C, Dunstan FD, Doull IJ. Asthma prevalence in 1973, 1988 and 2003. *Thorax* 2006;**61**:296–299.
45. Upton MN, McConnachie A, McSharry C, Hart CL, Smith GD, Gillis CR et al. Intergenerational 20 year trends in the prevalence of asthma and hay fever in adults: the Midspan family study surveys of parents and offspring. *Bmj* 2000;**321**:88–92.
46. Rizwan S, Reid J, Kelly Y, Bundred PE, Pearson M, Brabin BJ. Trends in childhood and parental asthma prevalence in Merseyside, 1991–1998. *J Public Health (Oxf)* 2004;**26**:337–342.
47. Butland BK, Strachan DP, Crawley-Boevey EE, Anderson HR. Childhood asthma in South London: trends in prevalence and use of medical services 1991–2002. *Thorax* 2006;**61**:383–387.
48. Anderson HR, Gupta R, Strachan DP, Limb ES. 50 years of asthma: UK trends from 1955 to 2004. *Thorax* 2007;**62**: 85–90.
49. Soriano JB, Kiri VA, Maier WC, Strachan D. Increasing prevalence of asthma in UK primary care during the 1990s. *Int J Tuberc Lung Dis* 2003;**7**:415–421.
50. Gupta R, Sheikh A, Strachan DP, Anderson HR. Burden of allergic disease in the UK: secondary analyses of national databases. *Clin Exp Allergy* 2004;**34**:520–526.
51. Anandan C, Gupta R, Simpson C, Fischbacher C, Sheikh A. Epidemiology and disease burden from allergic disease in Scotland: analyses of national databases. *Journal of The Royal Society of Medicine* 2009;**102**:431–442.
52. Hippisley-Cox J, Jumbu G, Fenty J, Holland R, Porter A, Heaps M. Primary care epidemiology of allergic disorders: analysis using QRESEARCH database 2001–2006. Final Report to the Information Centre and Department of Health. QRESEARCH and The Information Centre for health and social care. Nottingham. 2006.
53. Scottish Health Survey <http://www.scotland.gov.uk/Topics/Statistics/Browse/Health/scottish-health-survey> (last accessed 14/07/09).
54. Health Survey for England <http://www.dh.gov.uk/en/Publicationsandstatistics/PublishedSurvey/HealthSurveyForEngland/index.htm> (last accessed 14/07/09).
55. Shabu A, Flanagan O, Dineen B, Loftus BG. Prevalence of asthma in Galway school children 2004. *Ir Med J* 2007;**100**:491–493.
56. Maziak W, Behrens T, Brasky TM, Duhme H, Rzehak P, Weiland SK et al. Are asthma and allergies in children and adolescents increasing? Results from ISAAC phase I and phase III surveys in Munster, Germany. *Allergy* 2003;**58**:572–579.
57. Bjerg-Backlund A, Perzanowski MS, Platts-Mills T, Sandstrom T, Lundback B, Ronmark E. Asthma during the primary school ages—prevalence, remission and the impact of allergic sensitization. *Allergy* 2006;**61**:549–555.
58. Migliore E, Piccioni P, Garrone G, Ciccone G, Borraicino A, Bugiani M. Changing prevalence of asthma in Turin school children between 1994 and 1999. *Monaldi Arch Chest Dis* 2005;**63**:74–78.
59. Galassi C, De Sario M, Biggeri A, Bisanti L, Chellini E, Ciccone G et al. Changes in prevalence of asthma and allergies among children and adolescents in Italy: 1994–2002. *Pediatrics* 2006;**117**:34–42.
60. Ones U, Akcay A, Tamay Z, Guler N, Zencir M. Rising trend of asthma prevalence among Turkish school-children (ISAAC phases I and III). *Allergy* 2006;**61**:1448–1453.
61. Garcia-Marcos L, Quiros AB, Hernandez GG, Guillen-Grima F, Diaz CG, Urena IC et al. Stabilization of asthma prevalence among adolescents and increase among schoolchildren (ISAAC phases I and III) in Spain. *Allergy* 2004;**59**:1301–1307.
62. Roel E, Faresjo A, Zetterstrom O, Trell E, Faresjo T. Clinically diagnosed childhood asthma and follow-up of symptoms in a Swedish case control study. *BMC Fam Pract* 2005;**6**:16.
63. Banac S, Tomulic KL, Ahel V, Rozmanic V, Simundic N, Zubovic S, et al. Prevalence of asthma and allergic diseases in Croatian children is increasing: survey study. *Croat Med J* 2004;**45**:721–726.
64. Stipic-Markovic A, Pevec B, Pevec MR, Custovic A. [Prevalence of symptoms of asthma, allergic rhinitis, conjunctivitis and atopic eczema: ISAAC (International Study of Asthma and Allergies in Childhood) in a population of school-children in Zagreb]. *Acta Med Croatica* 2003;**57**:281–285.
65. Porsbjerg C, von Linstow ML, Ulrik CS, Nepper-Christensen S, Backer V. Risk factors for onset of asthma: a 12-year prospective follow-up study. *Chest* 2006;**129**:309–316.

66. Anthracopoulos MB, Liolios E, Panagiotakos DB, Triantou K, Priftis KN. Prevalence of asthma among schoolchildren in Patras, Greece: four questionnaire surveys during 1978–2003. *Arch Dis Child* 2007;**92**:209–212.
67. Latvala J, von Hertzen L, Lindholm H, Haahtela T. Trends in prevalence of asthma and allergy in Finnish young men: nationwide study, 1966–2003. *Bmj* 2005;**330**:1186–1187.
68. Selnes A, Nystad W, Bolle R, Lund E. Diverging prevalence trends of atopic disorders in Norwegian children. Results from three cross-sectional studies. *Allergy* 2005;**60**:894–899.
69. Hedman L, Lindgren B, Perzanowski M, Ronmark E. Agreement between parental and self-completed questionnaires about asthma in teenagers. *Pediatr Allergy Immunol* 2005;**16**:176–181.
70. Grize L, Gassner M, Wuthrich B, Bringolf-Isler B, Takken-Sahli K, Sennhauser FH et al. Trends in prevalence of asthma, allergic rhinitis and atopic dermatitis in 5–7-year old Swiss children from 1992 to 2001. *Allergy* 2006;**61**:556–562.
71. Ronchetti R, Villa MP, Barreto M, Rota R, Pagani J, Martella S et al. Is the increase in childhood asthma coming to an end? Findings from three surveys of schoolchildren in Rome, Italy. *Eur Respir J* 2001;**17**:881–886.
72. Zollner IK, Weiland SK, Piechotowski I, Gabrio T, von Mutius E, Link B et al. No increase in the prevalence of asthma, allergies, and atopic sensitisation among children in Germany: 1992–2001. *Thorax* 2005;**60**:545–548.
73. Carlsen KH. Asthma—a condition of our time, a condition in change?. *Tidsskr Nor Laegeforen* 2001;**121**:836–840.
74. Mommers M, Gielkens-Sijstermans C, Swaen GM, van Schayck CP. Trends in the prevalence of respiratory symptoms and treatment in Dutch children over a 12 year period: results of the fourth consecutive survey. *Thorax* 2005;**60**:97–99.
75. Akinbami LJ, Schoendorf KC. Trends in childhood asthma: prevalence, health care utilization, and mortality. *Pediatrics* 2002;**110**:315–322.
76. Mannino DM, Homa DM, Akinbami LJ, Moorman JE, Gwynn C, Redd SC. Surveillance for asthma—United States, 1980–1999. *MMWR Surveill Summ* 2002;**51**:1–13.
77. Gessner BD, Neeno T. Trends in asthma prevalence, hospitalization risk, and inhaled corticosteroid use among Alaska native and nonnative medicaid recipients younger than 20 years. *Ann Allergy Asthma Immunol* 2005;**94**:372–379.
78. Barraza-Villarreal A, Hernandez-Cadena L, Moreno-Macias H, Ramirez-Aguilar M, Romieu I. Trends in the prevalence of asthma and other allergic diseases in schoolchildren from Cuernavaca, Mexico. *Allergy & Asthma Proceedings* 2007;**28**:368–374.
79. Riedi CA, Rosario NA, Ribas LF, Backes AS, Kleiniibing GF, Popija M et al. Increase in prevalence of rhinoconjunctivitis but not asthma and atopic eczema in teenagers. *J Investig Allergol Clin Immunol* 2005;**15**:183–188.
80. Sole D, Melo KC, Camelo-Nunes IC, Freitas LS, Britto M, Rosario NA et al. Changes in the prevalence of asthma and allergic diseases among Brazilian schoolchildren (13–14 years old): comparison between ISAAC Phases One and Three. *Journal of Tropical Pediatrics* 2007;**53**:13–21.
81. Mallol J, Sole D, Asher I, Clayton T, Stein R, Soto-Quiroz M. Prevalence of asthma symptoms in Latin America: the International Study of Asthma and Allergies in Childhood (ISAAC). *Pediatr Pulmonol* 2000;**30**:439–444.
82. Monteil MA, Joseph G, Changkit C, Wheeler G, Antoine RM. Comparison of prevalence and severity of asthma among adolescents in the Caribbean islands of Trinidad and Tobago: results of a nationwide cross-sectional survey. *BMC Public Health* 2005;**5**:96.
83. Kabir ML, Rahman F, Hassan MQ, Ahamed F, Mridha MA. Asthma, atopic eczema and allergic rhinoconjunctivitis in school children. *Mymensingh Med J* 2005;**14**:41–45.
84. Priftanji AV, Qirko E, Layzell JC, Burr ML, Fifield R. Asthma and allergy in Albania. *Allergy* 1999;**54**:1042–1047.
85. Papageorgiou N, Gaga M, Marossis C, Reppas C, Avarlis P, Kyriakou M et al. Prevalence of asthma and asthma-like symptoms in Athens, Greece. *Respir Med* 1997;**91**:83–88.
86. Shohat T, Golan G, Tamir R, Green MS, Livne I, Davidson Y et al. Prevalence of asthma in 13–14 yr-old schoolchildren across Israel. *Eur Respir J* 2000;**15**:725–729.
87. Ramadan FM, Khoury MN, Hajjar TA, Mroueh SM. Prevalence of allergic diseases in children in Beirut: comparison to worldwide data. *J Med Liban* 1999;**47**:216–221.
88. al-Maskari F, Bener A, al-Kaabi A, al-Suwaidi N, Norman N, Brebner J. Asthma and respiratory symptoms among school children in United Arab Emirates. *Allerg Immunol (Paris)* 2000;**32**:159–163.
89. Behbehani NA, Abal A, Syabbalo NC, Abd Azeem A, Shareef E, Al-Momen J. Prevalence of asthma, allergic rhinitis, and eczema in 13- to 14-year-old children in Kuwait: an ISAAC study. *International Study of Asthma and Allergies in Childhood. Ann Allergy Asthma Immunol* 2000;**85**:58–63.
90. El-Sharif NA, Nemery B, Barghuthy F, Mortaja S, Qasrawi R, Abdeen Z. Geographical variations of asthma and asthma symptoms among schoolchildren aged 5 to 8 years and 12 to 15 years in Palestine: the International Study of Asthma and Allergies in Childhood (ISAAC). *Ann Allergy Asthma Immunol* 2003;**90**:63–71.
91. Janahi IA, Bener A, Bush A. Prevalence of asthma among Qatari schoolchildren: International Study of Asthma and Allergies in Childhood, Qatar. *Pediatr Pulmonol* 2006;**41**:80–86.
92. Netuveli G, Hurwitz B, Sheikh A. Lineages of language the diagnosis of asthma. *J R Soc Med* 2007;**100**:19–24.
93. Haahtela T, Klaukka T, Koskela K, Erhola M, Laitinen LA. Asthma programme in Finland: a community problem needs community solutions. *Thorax* 2001;**56**:806–814.
94. Manning PJ, Goodman P, O'Sullivan A, Clancy L. Rising prevalence of asthma but declining wheeze in teenagers (1995–2003): ISAAC protocol. *Ir Med J* 2007;**100**:614–615.
95. Harangi F, Lorinczy K, Lazar A, Orkenyi M, Adonyi M, Sebok B. Prevalence of childhood asthma in Baranya County, Hungary, between 2003 and 2006. *Orvosi Hetilap* 2007;**148**:1643–1648.
96. Abramidze T, Gotua M, Rukhadze M, Gamkrelidze A. Prevalence of asthma and allergies among adolescents in Georgia: comparison between two surveys. *Georgian Medical News* 2007;**???**:38–41.
97. Urrutia I, Aguirre U, Sunyer J, Plana E, Muniozguen N, Martinez-Moratalla J, et al. Changes in the prevalence of asthma in the Spanish cohort of the European Community Respiratory Health Survey (ECRHS-II). *Archivos de Bronconeumologia* 2007;**43**:425–430.
98. Endre L, Lang S, Vamos A, Bobvos J, Paldy A, Farkas I et al. Increase in prevalence of childhood asthma in Budapest between 1995 and 2003: correlation with air pollution data and total pollen count. *Orvosi Hetilap* 2007;**148**:211–216.

Appendix

Table 1. Studies removed because they were not in English ($n = 4$)

Study	Where/language	Age	Measure	Magnitude	Conclusion
Harangi et al. (2007) (95)	Hungary/Hungarian	6–7 and 13–14 years	International Study of Asthma and Allergies in Childhood (ISAAC) phase III	There was a significant increase in the frequency of 'wheezing in the last 12 months' (2006: 9.6%; 2003: 6.8%)	During the observation period of 3 years, there was a significant increase in 'wheezing in the last 12 months'
Abramidze et al. (2007) (96)	Georgia/Georgian	13–14 years	ISAAC questionnaire 1996 and 2003	The mean prevalence increased steadily for current wheezing from 3.6% to 5.6% ($P = 0.0001$)	Asthma prevalence is increasing
Urrutia et al. (2007) (97)	Spain/Spanish	After 9 or 10 years	European Community Respiratory Health Survey	The frequency of diagnosed asthma rose from 4% to 7% ($P < 0.05$). The rate of reported asthma rose annually by 0.34% (95% confidence interval [CI], 0.20–0.48%), while diagnosed asthma rose by 0.26% (95% CI, 0.13–0.39%) and treated asthma by 0.16% (95% CI, 0.07–0.25%)	Increased prevalence rates of asthma diagnosis and treatment have been detected, but the rates of reported symptoms have remained similar, consistent with the assumption that more persons are being classified as asthmatics
Endre et al. (2007) (98)	Hungary/Hungarian	In children, 15 years and under	Cross-sectional survey. Questionnaire in 1995, 1999 and 2003	The increase between 1995 and 1999, and between 1999 and 2003 was highly significant ($P < 0.0001$)	On the basis of the results of more than 100 thousand children, the authors conclude that between 1995 and 2003, the proportion of asthmatic children increased by 50% in Budapest, while the air pollution did not deteriorate, and the pollen concentration from sensitizing plants did not increase