ASTHMA

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1. Background

According to World Health Organisation (WHO) estimates 300 million people suffer from Asthma, 255, 000 people died of Asthma in 2005 (WHO 2004) and over 80% of Asthma deaths are reported from low and lower-middle income countries (Braman 2006). Asthma creates a substantial burden on individuals and families as it is more often under-diagnosed and under-treated. (Rabe *et al.* 2000; Adachi et *al.* 2002; Lai *et al.* 2003)

In India, an estimated that 57,000 deaths were attributed to Asthma in 2004 (WHO 2004) and it was seen as one of the leading cause of morbidity and mortality in rural India (Smith 2000). Though effective screening, evaluation, and management strategies for Asthma are well established in high-income countries, these strategies have not been fully implemented in India as evidence had previously suggested that Asthma is not to be treated independently but fitted into the general spectrum of respiratory diseases (Krishnakumar 2003). Furthermore, even though medicines that treat Asthma effectively are available at affordable costs, they rarely reach more than one per cent of those who would benefit from it (Krishnakumar 2003).

This factsheet provides a description of Asthma and its natural history; the distribution, prevalence and incidence of Asthma in India as well as its overall burden (including economic burden); risk factors for Asthma, management; and treatment of Asthma, current Asthma policy and a brief review of research programmes in India

Asthma Statistics

Asthma statistics in India (WHO, 2004)

- 57.5 estimated total deaths ('000)
- 5.1 estimated deaths per 100000 population
- 277 DALYs (disability adjusted life-year) per 100,000
- 6.5 age-standardized deaths per 100,000
- 268 age-standardised DALYs per 100,000
- constitutes 0.2% of all deaths and 0.5% of National Burden of Diseases (Smith 2002)

Global Asthma Statistics

- 287,000 (0.5% of total global deaths) deaths, 151,000 men and 136,000 women (WHO, 2004)
- 16,317,000 (1.1% of total) DALYs, 8,856,000 for men and 7,461,000 for women (WHO, 2004)
- 1.8 age -standardized deaths per 100,000 (WHO, 2004)
- 16.7 million deaths in age 15–59 years (WHO, 2004)
- 15 million DALY per year (Masoli *et al.* 2004)
- 19.4 million disability (WHO 2004)
- 6.6 million YLD among men and 1.8 million YLD in high income countries (WHO, 2004)

2. What is Asthma?

The Global Strategy for Asthma Management and Prevention Guidelines define Asthma as 'a chronic inflammatory disorder of the airways associated with increased airway hyper-responsiveness, recurrent episodes of wheezing, breathlessness, chest tightness, and coughing, particularly at night/early morning'. Airway inflammation produces airflow limitation through acute bronchoconstriction, chronic mucus plug formation and airway wall swelling or remodelling (Masoli *et al.* 2004).

There are two general categories for classifying Asthma: extrinsic and intrinsic depending upon the types of stimuli that trigger attacks (www.buteyko.co.nz/asthma/facts)

- Extrinsic Asthma: is caused by a type of immune system response to inhaled allergens such as pollen, animal dander or dust mite particles.
- Intrinsic Asthma: is caused by inhalation of chemicals such as cigarette smoke or cleaning agents, taking aspirin, a chest infection, stress, laughter, exercise, cold air, food preservatives or a myriad of other factors.

3. Natural History of Asthma

Onset of Asthma can occur at any age but children and young adults are the commonly affected age groups and 5-10% cent of children with 'mild' Asthma go on to develop severe Asthma later in life (www.iuatld.org). Although Asthma cannot be 'cured', clinical episodes can largely be prevented and controlled by proper management. Allergic rhinitis and skin allergy may coexist with or precede the onset of Asthma (www.iuatld.org). Environmental exposures during the early years and airway obstruction that develop during this time, in conjunction with genetic susceptibility, are important factors in the development of persistent Asthma in childhood (Table 1). Moreover, reasons for variability in the clinical course of Asthma, persistence in some individuals and progression in others, remains unexplained (Panettieri et *al.* 2008).

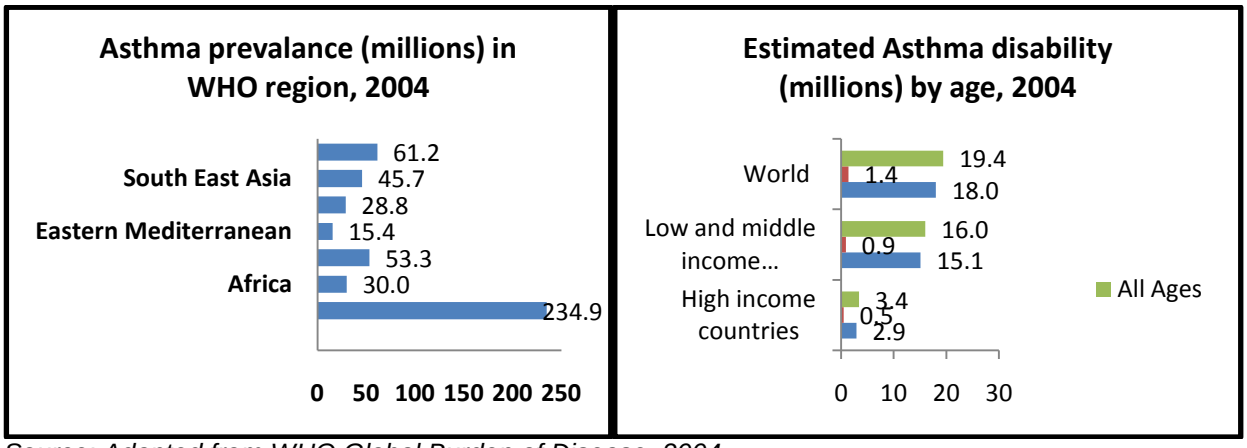
Table 1: Possible antenatal influences on the development of Asthma and allergy

Antenatal influences	Allergy	Asthma
Birth order	+	+
Maternal allergen exposure	+/-	-
Maternal smoking during pregnancy	+/-	++
Obstetric complications	+	+
Elective cesarean section	-	+
Maternal use of antibiotics during pregnancy	+/-	+/-
Maternal diet, PUFA, antioxidants	+/-	+/-
Abbreviations: PUFA: polyunsaturated fatty acids; +: positive association with disease outcome; -: negative association with disease outcome; +/-: equivocal data		

Source: Yeatts *et al.* 2006

4. Global Burden of Asthma

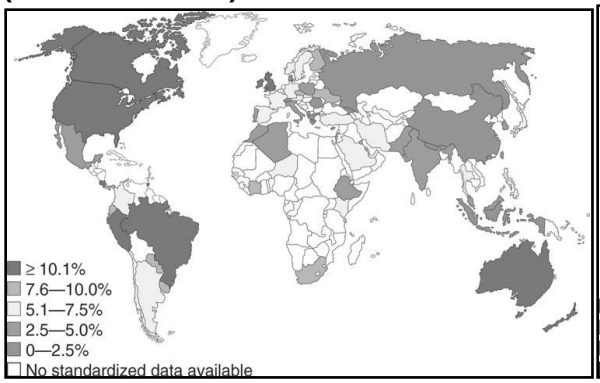
Approximately 300 million people worldwide currently have Asthma, with estimates suggesting that Asthma prevalence increases globally by 50% every decade (Masoli *et al.* 2004). With the projected increase in the proportion of the world's urban population from 45% to 59% in 2025, there is likely to be a marked increase in the number of Asthmatics worldwide over the next two decades. It is estimated that there may be an additional 100 million persons with Asthma by 2025 (Masoli *et al.* 2004).



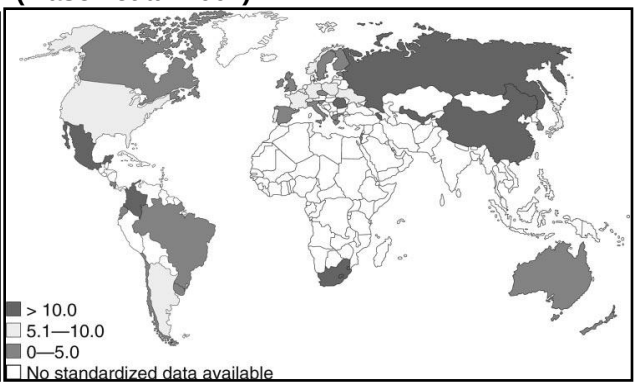
Source: Adapted from WHO Global Burden of Disease, 2004

A wide variation in prevalence rates has been documented: studies of both children and adults have revealed low prevalence rates (2%–4%) in Asian countries (especially China and India) and high prevalence rates (15%–20%) in the United Kingdom, Canada, Australia, New Zealand and other developed countries (ISAAC 1998; Janson *et al.* 2001; Asher *et al.* 2006; Zock *et al.* 2006). The highest Asthma prevalence rates are found in the United Kingdom (>15%) and New Zealand (15.1%) (Masoli *et al.* 2004). In Western Europe, the Asthma prevalence rate has doubled over the last decade (European Lung White Book 2003) and in Japan, the number of Asthma patients treated by medical facilities has tripled over the past 30 years (Masoli *et al.* 2004).

Worldwide prevalence of clinical Asthma (Masoli *et al.* 2004)



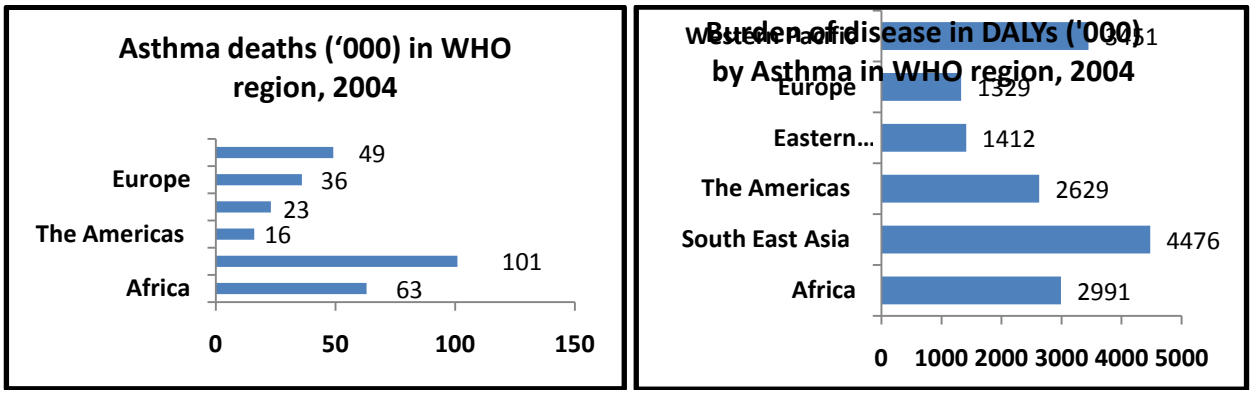
Asthma case fatality rates worldwide (Masoli *et al.* 2004)



In developing regions (Africa, Central and South America, Asia, and the Pacific) however, Asthma prevalence, is rising sharply with increasing urbanisation and westernisation (Masoli *et al.* 2004). High prevalence rates have been reported in Peru (13.0%), Costa Rica (11.9%), and Brazil (11.4%) (Masoli *et*

al. 2004). Most of the Asian countries including India and China, although reporting relatively lower prevalence rates than those in the West, account for a huge burden in terms of absolute numbers of patients (Jindal 2007; Aggarwal *et al.* 2006; Wong and Chan-Yeung 2005).

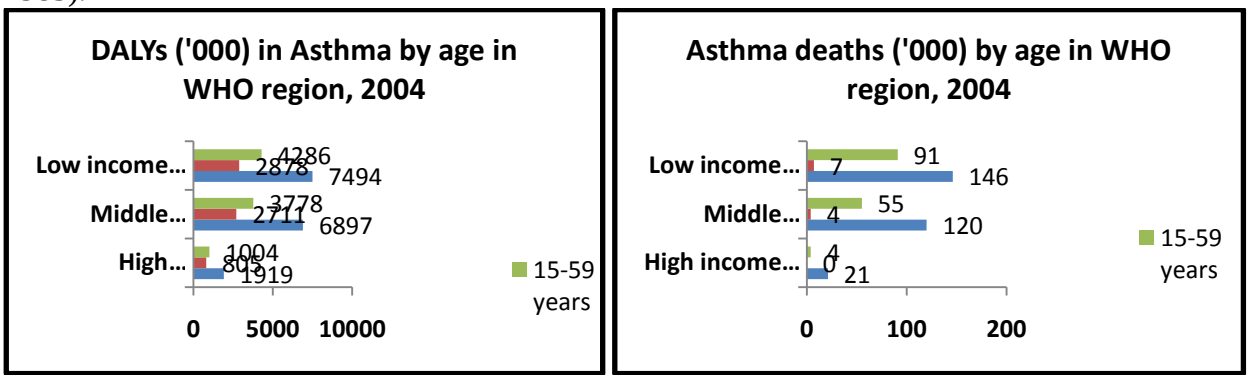
Asthma, relative to other chronic diseases, has lower case fatality rates (0.4% of all deaths) and contributes 1% of the global burden of disease (Masoli *et al.* 2004). Many of the deaths are preventable, but occur either due to lack of suboptimal long-term medical care and/or delay in obtaining help during the final attack (Masoli *et al.* 2004). Overall mortality rates have fallen since the 1980s in the developed world and this may be related to changes in Asthma management, specifically in the increased use of management guidelines and inhaled corticosteroids (Masoli *et al.* 2004).



Source: Adapted from WHO Global Burden of Disease, 2004

5. Economic Burden of Asthma

The number of disability-adjusted life years (DALYs) lost due to Asthma worldwide have currently been estimated at about 15 million per year. (WHO 2004)Worldwide, Asthma accounts for around 1% of all DALYs lost, thus reflecting the high prevalence and severity of Asthma (GINA 2007, Mitchell 1983).

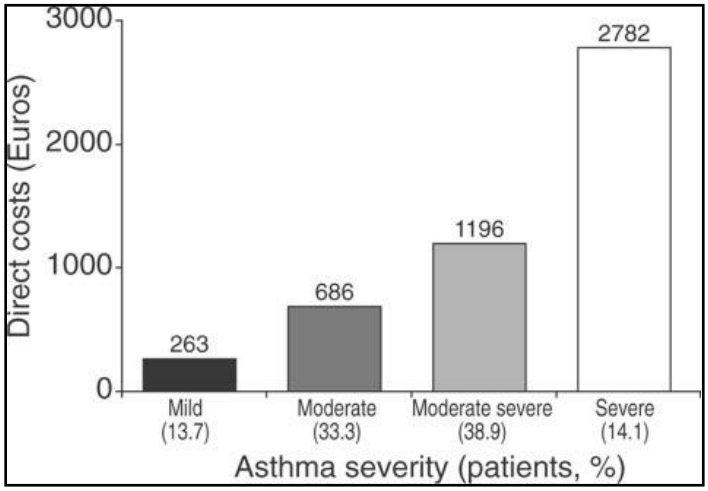


Source: Adapted from WHO Global Burden of Disease, 2004

Globally, the economic costs associated with Asthma exceed those of tuberculosis and HIV/AIDS combined (www.who.int/mediacentre/fact sheets). The economic cost of Asthma is considerable both in terms of direct medical costs (such as hospital admissions and cost of pharmaceuticals) and indirect medical costs (such as time lost from work and premature death). Developed economies can expect to spend 1 to 2% of their health-care budget on Asthma (Masoli *et al.* 2004). Estimates for 1996 indicate

that the financial burden on patients with Asthma in different Western countries ranges from $300 to $1,300 per patient per year (Sullivan *et al.* 1996).

Severe Asthma is associated with disproportionately high costs in comparison with other degrees of Asthma severity, and the economic burden of the disease disproportionately affects those with the moderate to severe Asthma. (see below) (Godard *et al.* 2002)



Source (Godard et al. 2002)

In both Western and developing countries, patients with severe Asthma are responsible for approximately 50% of all direct and indirect costs, even though this patient population represents only 10 to 20% of all Asthma sufferers (Asthma in America 1998; Beasley 2002). By contrast, the 70% of Asthma patients with "mild" disease account for only 20% of total Asthma costs (Beasley 2002). Poor control of Asthma is an important factor in the cost of treating the disease (Van Ganse *et al.* 2002). Asthma exacerbations are costly, especially when they require hospital care. A UK survey found that the cost of treating a person who had experienced an Asthma attack (£381) was more than three and a half times the cost of treating someone whose Asthma was managed without exacerbations (£108) (National Asthma Campaign Asthma Audit 2001; Hoskins *et al.* 2003).

6. Asthma burden in India

There is limited data on Asthma epidemiology from the developing world, including India (Subbarao et al 2009) Although some attempts have been made, studies suffer from several scientific drawbacks including lack of uniformity of methodology and analysis of data (Subbarao et al 2009). Asthma rates are officially low in India, although there is some recent evidence that the true prevalence is higher than previously thought (Aggarwal *et al.* 2006). To date, the total estimated burden of Asthma is an overall prevalence of 3% (30 million patients), and among adults over the age of 15, a median prevalence of 2.4% (Aggarwal *et al.* 2006). Table 2 presents the estimated prevalence rates from various parts of India. For example, In a study from Mumbai, Asthma prevalence in adults aged 20-44 years was reported to be 3.5% using 'clinician diagnosis' and 17% using a very broad definition (which included prior physician diagnosis and/or a positive bronchoprovocation test) (Chowgule *et al.* 1998). The population prevalence of Asthma reported in different field studies is variable and ranges from 2.4-6.4% (Table 2). Among school children higher prevalence rates have been reported (Table 2 and 3).

Table 2: Prevalence of Asthma in adults and children in different studies from India

Study Areas and source	Sample size	Age and setting	Prevalence
Mumbai (Chowgule *et al.*, 1998)	2,313	20-44 yrs Population based	3.5% by physician diagnosis
Chandigarh (Jindal *et al.*, 2000)	2,116	>18 yrs Population based	3.9% (M) 1.3% (F) equal in urban and rural
Chandigarh (Gupta *et al.*, 2001)	9,090	9-20 yrs School based	2.6% (M) 1.9% (F)
Delhi (Chhabra *et al.*, 1999)	18,955	5-17 yrs School based	3.4% (Past wheeze) 11.9% (Current wheeze) 12.8% (M) 10.7% (F)
Ludhiana (Singh *et al.*, 2002)	2,275	1-15 yrs Population based	2.6% (Rural)
Lucknow (Awasthi *et al.*, 2004)	6,000	6-7 and 13-14 yrs School based	6.2% and 7.8% (Wheeze) 2.3% and 3.3% (Asthma)
Multicenter (ISAAC Steering Committee, 1998)	37,171	6-7 and 13-14 yrs School Based	6.0% (Wheeze) 4.5% (Ever Asthma)
Multicentre (ICMR) (Jindal *et al.*, 2005 Unpublished data)	73,605	>15 yrs Population based	2.4% (1.7-3.5% range)
India and 26 states (NFHS-2, 1998-99) (IIPS and ORC Macro 2000)	491,100 household residents	All ages	Prevalence of 2468 per 100,000 for India
India and 29 states (NFHS-3, 2005-06) (IIPS and Macro International 2007)	124,385 women 74,369 men	15-49 years for women and 15-54 for men	Prevalence per 100,000 for India 1696-for women 1627 for men

Source: Aggarwal et al. 2006

Table 3: Prevalence of bronchial asthma in Indian children

Investigators	Study instruments/Study subjects	Total number of study subjects and age group	Prevalence of childhood bronchial asthma (%)
Vishwanathan *et al.1966*	Patna urban population: a random morbidity survey	Children <9 years	0.2%
Multicentric (ISAAC Steering Committee), 1998	ISAAC questionnaire, school based	37,171 (6-7/13-14 years)	6% wheeze and 4.5% ever asthma (frequency 1673)
Chhabra *et al. 1998*	Questionnaire based study	2609 (4-17 years)	15.7% (frequency 410)
Chhabra *et al. 1998*	Questionnaire based study- Delhi, school based	19456 (5-17 years)	3.4% (past wheeze) 2.4% (cold associated) 12.8% (M)10.7% (F) 2.1% (exercise induced) 11.9% (current wheeze) (frequency-2315)
Gupta *et al.2001*	IUATLD based previously standardized	4367 boys (9-20 years)	2.6%

	questionnaire against physician diagnosis, Chandigarh school based		
Gupta *et al.* 2001	IUATLD based previously standardized questionnaire against physician diagnosis, school based	4723 girls (9-20 years)	1.9% (frequency-90)
Singh *et al. 2002*	Ludhiana population based, house survey using modified ATS criteria for diagnosis	2275 rural children 1-15 years	2.6% (frequency-59)
Paramesh, 2002	School survey in 12 schools in the age group 6-15 years	Urban 5570, rural 990, total 6560 (6-15 years) children	Group I school in heavy traffic region and children from affluent families: 19.3% Group II school in heavy traffic region and children from less affluent families: 31.1% Group III school in low traffic region and children from affluent families: 11.2% Overall urban:16.6% Rural:5.7% Weighted average:15% (frequency 834)
Somesekhar and Paramesh, 2002		800, 16-19 years adolescents	
Chakravarthy *et al.2002*	Community based studies children under 12 years simplified version of the ISAAC questionnaire	855	5% (frequency 43)
Singh *et al.2004*	Pretested modified, already validated asthma questionnaire	5-17 years children Urban-872 Rural-758	Urban:11.9%; rural:13.7% Weighted average:12.8% (frequency 72)
Awasthi *et al.2004*	Part of multicentric (ISAAC III) trial in Hindi and English language, Lucknow school based	6000 (6-7/13-14 years)	2.3% (6-7 years) 3.3% 913-14 years) Weighted average:2.8 (Frequency 168)
Mistry *et al.2004*	Validated one page ISAAC questionnaire for Chandigarh	575 (13-14 years)	12.5% (frequency 72)
National Family Health Survey-3, 2005-06	841 per 100000 women age 15-19 years and 941 per 100000 men age 15-19 years	24811 women (15-19 years) 13008 men (15-19 years)	0.9% (frequency 89)
Sharma and Banga, 2007	Rural school based studies, Hindi translated version of Phase III of the ISAAC	Total 8470 4128 (6-7 years) 4342 (13-14 years)	Asthma: 259 (3%) 6-7 years: 150 (3.6%), 13-14 years: 109 (2.5%) Ever wheezer: 437 (5.2%)

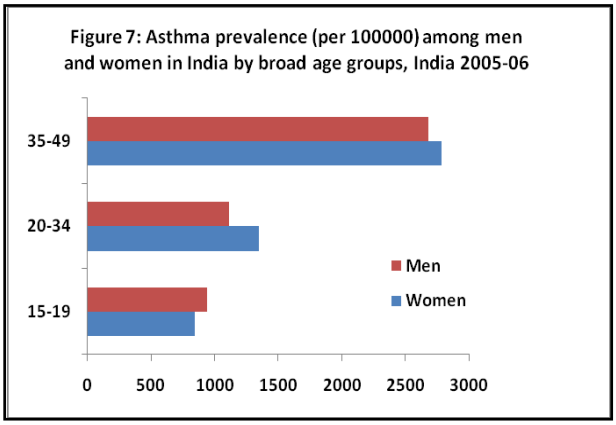
	questionnaires		6-7 years: 232 (5.6%), 3-14 year: 205 94.7%) Last 12 mo wheezers: 300 93.5%); 6-7 years:181 (4.4%); 13-14 years: 119 (2.7%)

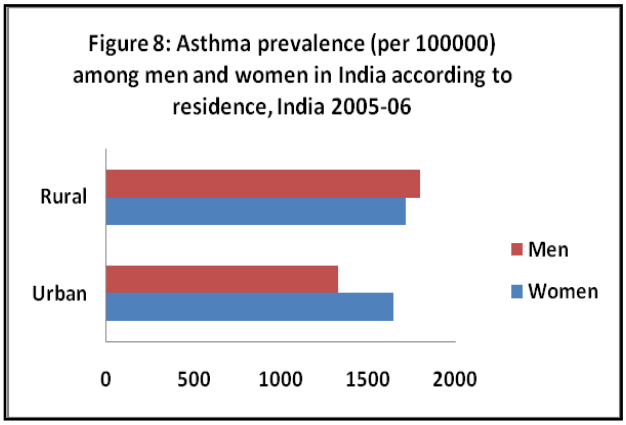
Source: Pal *et al.* 2009

6.1. Asthma prevalence according to National Family Health Survey-3, 2005-06

According to the recently conducted cross sectional nationally representative National Family Health Survey (NFHS)-3, the overall prevalence of asthma among adult men and women in India is similar with 1,696 and 1,627 per 100,000 respectively (IIPS and Macro International 2007). The number of men and women with asthma increases steadily with age (Figure 7). Prevalence of asthma is higher in rural areas (1,719 per 100,000 for women and 1,799 per 100,000 for men) than for urban areas and that it is more common among women than men.

Asthma among men is more prevalent in the lower wealth quintiles than among the higher wealth quintiles Moreover, prevalence is highest among those with less than five years of schooling (2,283 per 100,000 among women and 2,640 among men per 100,000), and among those with no education (1,914 among women per 100,000 and 2,440 among men per 100,000).



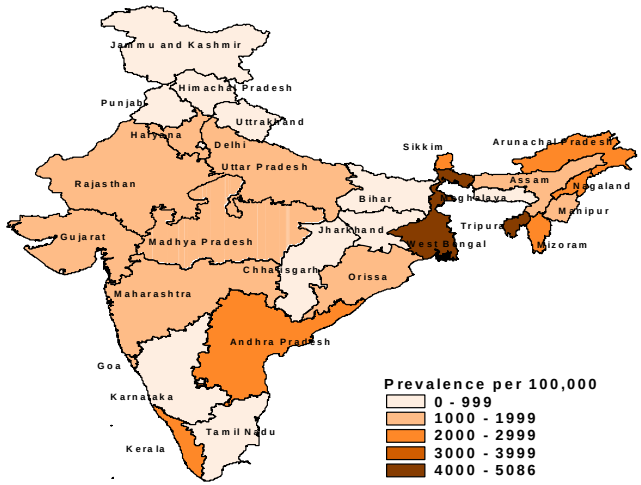


Source: NFHS-3, 2005-06

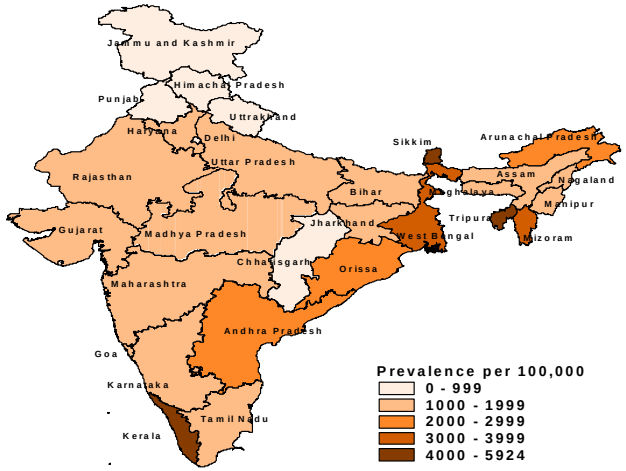
6.2 States differentials in Asthma prevalence

Maps presents the state wise prevalence of asthma in India during 2005-06. The prevalence ranges from 384 per 100,000 in Himachal Pradesh to 5,924 per 100,000 in Tripura among women and from 407 per 100,000 in Jharkhand to 5,086 in Tripura among men. The number of women with asthma exceeds 1,000 per 100,000 in 23 states and is exceptionally high (above 3,000 per 100,000) in five states: West Bengal (3,304), Mizoram (3,563), Kerala (4,037), Sikkim (5,150), and Tripura with the highest prevalence whereas this is true for men in only 2 states; West Bengal and Tripura. Overall, the Northeast Region stands out as the region exhibiting the highest prevalence levels of asthma.

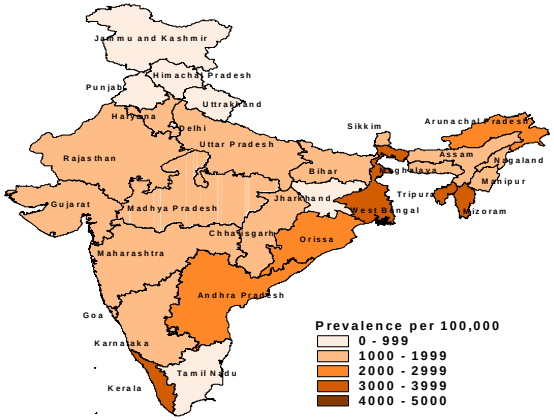
Prevalence of Asthma among Women (15-49 years)
India, 2005-06



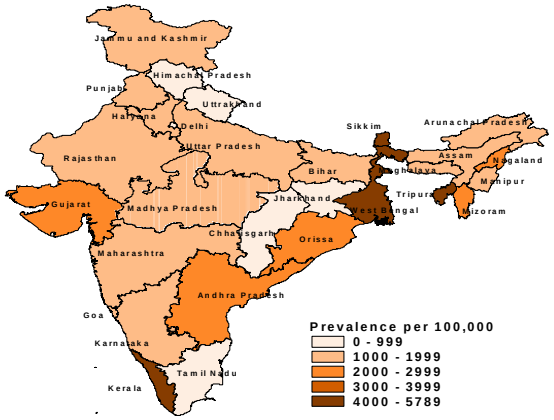
Prevalence of Asthma among Men (15-54 years)
India, 2005-06



Urban Prevalence of Asthma
India, 2005-06



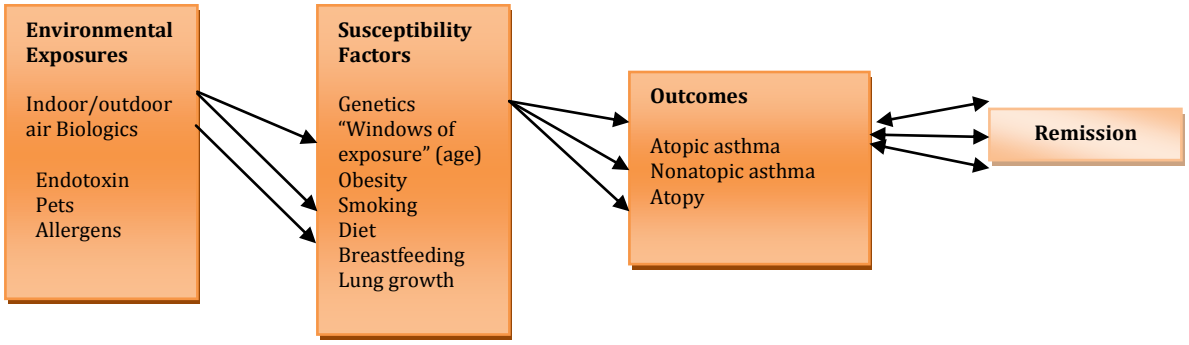
Rural Prevalence of Asthma
India, 2005-06



7. Etiology and Risk factors of Asthma

Asthma comprises a range of heterogeneous phenotypes that differ in presentation, etiology and pathophysiology. The risk factors for each recognised phenotype of Asthma include genetic, environmental and host factors (Burke *et al.* 2003). The conceptual framework for susceptibility factors of Asthma is presented below.

Conceptual framework for susceptibility factors of Asthma



Source: Yeatts *et al.* 2006

Current understanding of the determinants of Asthma have largely been informed through the role of environmental exposures, such as exposure to aeroallergens, indoor and outdoor air pollution, endotoxin, smoking and viral infections (Maddox and Schwartz 2002; Walker *et al.* 2003). The different ways in which tobacco smoke affects asthma are detailed in Table 4. More recently, this knowledge base has been supplemented by considering genetic modifiers of environmental exposures on Asthma expression (Kleeberger and Peden 2005; Weiss 1999). Meanwhile, like most diseases, Asthma also is socially patterned, with lower socio-economic groups, on average, being more burdened (Wright and Fisher 2003). Some suggest that the observed social patterning in Asthma may simply reflect the disproportionate exposure to adverse environmental factors among lower socio-economic groups (O'Neill *et al.* 2003; Weiss and Wagener 1990). Others have proposed the differential exposure to psychosocial stressors as a direct explanation to account for the social disparities in Asthma (Wright and Fisher 2003; Adler *et al.* 1994; Busse *et al.* 1994; Evans 2001; Wright *et al.* 1998). Laboratory as well as prospective population-based studies have shown associations between stress experiences and Asthma expression (Sandberg *et al.* 2000; Wright *et al.* 2002), potentially mediated through physiologic pathways resulting in enhanced IgE expression, enhanced allergen-specific lymphocyte proliferation, and differential cytokine expression in children (Chen *et al.* 2003; Wright *et al.* 2004; Wright *et al.* 2005).

Table 4: Role of tobacco smoke in Asthma occurance

Active Smoking	Passive Smoking (environmental tobacco smo exposure)
Increased bronchial responsiveness	Aggravation and increased prevalence of respirat symptoms
Frequent bronchial irritation symptoms	Bronchial hyper-responsiveness in adults
Increased sensitisation to occupational age	Aggravation of Asthma symptoms
Aggravation of acute episodes	Precipitation of acute episodes
Association with Asthma severity	Risk factor for development of Asthma (children and adults

Source: Adapted from Jindal and Gupta 2004

The risk factors for Asthma include those which are modifiable and non-modifiable. The modifiable ones include tobacco smoking (active and passive), in and outdoor air pollution, urbanisation, obesity, extreme emotional expression, occupation and exposure to risk factors in childhood. The non-modifiable risk factors include family history, genetic factors and prenatal influences. Table 5 presents some of these risk factors with the related odds. For example, living in an urban setting will increase the odds of having Asthma by 34%.

Table 5: Selected risk factors for Asthma in India

Predictors	OR(95%CI)
Location	
Chandigarh	1.000
Delhi	1.026 (0.870-1.211)
Kanpur	1.153 (0.978-1.359)
Bangalore	1.707 (1.483-1.965)
Gender	
Male	1.000
Female	1.435 (1.230-1.675)
Age	
15-24 years	1.000
25-34 years	1.618 (1.289-2.031)
35-44 years	2.819 (2.273-3.496)
45-54 years	4.838 (3.920-5.973)
55-64 years	7.504 (6.037-9.328)
65-74 years	11.332 (9.043-14.202)
>= 75 years	13.472 (10.247-17.711)
Usual residence	
Rural	1.000
Urban	1.342 (1.190-1.514)
Mixed	1.282 (0.928-1.771)
Socio-economic status	
Low	1.000
Middle	0.831 (0.730-0.944)
High	0.717 (0.582-0.883)
Atopy	
History not suggestive of atopy	1.000
History suggestive of atopy	12.304 (11.057-13.691)
Family history of Asthma	
No first degree relative with Asthma	1.000
First degree relative with Asthma	6.104 (5.365-6.946)
Usual smoking habit	
Non smoker	1.000
Cigarette smoker	1.534 (1.231-1.910)
Bidi smoker	1.599 (1.357-1.883)
Smoker of *hookah*/other products	2.227 (1.481-3.350)

Source: Adapted from Aggarwal et al. 2006

Table 6 considers the adjusted odds for the risk of Asthma in women since the odds of having Asthma compared to men in India is 43%.

Table 6: Adjusted ORs and CIs for the risk of Asthma in the women

Variables	Ever-married women		Full sample	
	OR	95%CI	OR	95%CI
Location of the household				
Urban population≥1 million (reference)	1.00		1.00	
Urban population 100000-1 million	1.18	(0.88-1.57)	1.00	(0.86-1.17)
Urban population≤1 million	1.10	(0.85-1.42)	0.94	(0.82-1.07)
Rural area	1.31	(1.02-1.69)	1.04	(0.91-1.18)
Caste				
General (reference)	1.00		1.00	
Scheduled caste	0.80	(0.69-0.93)	0.92	(0.86-0.98)
Scheduled tribe	0.91	(0.77-1.09)	0.81	(0.74-0.89)
Other backward class	0.89	(0.78-1.00)	0.94	(0.88-1.00)
Marital status				
Married (reference)	1.00		1.00	
Widowed	1.56	(1.31-1.86)	1.12	(1.05-1.20)
Divorced	0.91	(0.48-1.73)	1.30	(0.89-1.88)
Separated	1.60	(1.19-2.14)	1.19	(0.92-1.53)
Single			0.89	(0.80-0.98)
Years of schooling				
13 or more (reference)	1.00		1.00	
11-12 (high school)	1.02	(0.70-1.50)	0.97	(0.83-1.14)
9-10 (secondary school)	1.11	(0.80-1.52)	1.06	(0.94-1.20)
6-8 (middle school)	1.32	(0.96-1.82)	1.25	(1.11-1.42)
1-5 (primary school)	1.34	(0.97-1.85)	1.46	(1.29-1.65)
0 (no schooling)	1.44	(1.04-1.99)	1.45	(1.28-1.63)
Standard of living index				
Top quintile (reference)	1.00		1.00	
Third quintile	1.18	(0.98-1.43)	1.23	(1.13-1.34)
Bottom quintile	1.36	(1.08-1.70)	1.46	(1.31-1.61)
Ever smoked				
No (reference)	1.00		1.00	
Yes	1.54	(1.27-1.87)	1.26	(1.20-1.34)
Exposure to tobacco smoke				
No (reference)	1.00		1.00	
Yes	1.10	(1.00-1.22)	1.05	(1.00-1.10)
Housing type				
Pucca (reference)	1.00		1.00	
Semi-pucca	1.15	(1.01-1.32)	1.09	(1.03-1.17)
Kachcha	1.06	(0.91-1.24)	1.12	(1.03-1.20)
People per room				
<1 (reference)	1.00		1.00	
1 to <3	0.91	(0.75-1.11)	0.98	(0.88-1.08)
3 to <5	0.77	(0.62-0.97)	0.98	(0.80-1.00)
≥5	0.77	(0.61-0.99)	0.86	(0.76-0.97)
Body mass index (kg/m2)				
<16	2.14	(1.81-2.53)		
16-17	1.42	(1.19-1.69)		
17-18.5	1.16	(1.01-1.33)		
18.5-23 (reference)	1.00			

23-25	1.30	(1.10-1.54)		
25-30	1.35	(1.13-1.60)		
≥30	1.54	(1.15-2.04)		

Source: Subramanian et al. 2007

To know more about the risk factors for Asthma please click here

8. Prevention of Asthma

8.1 Primary prevention: The goal is to prevent the onset of disease in susceptible individuals. Increasing evidence indicates that allergic sensitisation is the most common precursor to the development of Asthma. (Jones et *al.* 2000; Bousquet *et al.* 2000). Most cases of Asthma are diagnosed and managed at a primary care level. Early commencement of anti-inflammatory therapy, such as inhaled corticosteroids may prevent the progression of the disease. Most patients with mild Asthma have good functional outcome and low healthcare utilisation (Koh and Irving 2007).

8.2 Patient awareness/education: The international community now considers patient education programmes an integral component of Asthma management, along with environmental control and medications (National Asthma education programmer expert panel report 1991). To improve patient awareness and quality of Asthma care delivery, Indian medical staff has called for private practitioners as well as hospital doctors to be included in continuing medical education programmes on Asthma management as well as the provision of separate clinics for Asthma at an Institute level (Bedi and Singh 1994; Gupta and Gupta 2001; Hegde *et al.* 2002). Efficacy of patient education and parental awareness has also been shown to be effective in individual studies from India (Singh *et al.* 2002; Gupta *et al.* 1998; Ghosh *et al.* 1998; Lal *et al.* 1995).

8.3 Lifestyle Modifications: It has been recommended that, people with Asthmas should adopt a healthy life style and should receive adequate guidance by their physician in this regard; and this should include regular balanced diet and avoidance of obesity (Mishra 2004). Short acting beta-2 agonists should be used prior to anticipated exercise, in a patient with exercise-induced Asthma, to alleviate symptoms (Consensus on Guidelines of Management of Clinical Asthma 2005).

8.4 Alternative System of Medicine: A yogic breathing exercise technique, Pranayama, was been shown to reduce in histamine reactivity (Singh *et al.* 1990).

8.5 Secondary prevention: The greatest benefit of Allergen Specific Immunotherapy (SIT) occurs when administered to patients with allergic rhinitis that has been unresponsive to conventional pharmacotherapy or specific environmental control; or in circumstances in which patients do not wish to use medications for prolonged periods of time (Abramson 1999).

8.6 Tertiary prevention: This involves avoidance of allergens (Custovic *et al.* 1998; Strachan and Cook 1998; Chalmers *et al.* 2002; Jindal *et al.* 1997) and nonspecific triggers when Asthma is established. The goal is to prevent exacerbations or illnesses that would otherwise occur on exposure to identified allergens or irritants.

9. Management and Treatment of Asthma

A study presented to the International Conference on Health Care Delivery for Asthma found that only 10% of the Indian population have access to the level of care proposed by international guidelines. The obstacles to Asthma care in India are the costs of care and medications, the socioeconomic disparity within the country, use of multiple languages, cultural issues, and the common use of alternative remedies (Singh 2002).

9.1 Management of Asthma: Although there is no permanent cure for Asthma, the disorder can be adequately controlled with drugs. Under diagnosis and/or inappropriate therapy remain the major cause of Asthma morbidity and mortality. The aims of pharmacological management of Asthma are: the control of day and night symptoms (including exercise-related symptoms), prevention of exacerbations, and achievement of normal (or near normal) lung function with minimal side effects. In general, the goals defined by the Global Initiative for Asthma (GINA 2004) includes:

- Minimal (ideally none) symptoms during day and night.
- Minimal (ideally none) symptoms during exercise.
- Minimal need for reliever medications.
- No exacerbations.
- No limitation of physical activity.
- Maintaining pulmonary function as close to normal as possible.
- Minimal side effects of Asthma medications.
- Prevent development of irreversible airflow obstruction.
- Prevent Asthma-related mortality.

Table 7: Categorisation of severity of Asthma

	Mild	Moderate	Severe
Symptoms disturbing sleep	< Once per week	> Once per week	Daily
Daytime symptoms	< Daily	Daily	Daily
Limitation of accustomed activities	Nil	<1 per week	>1 per week
Use of rescue medication *	<1 dose per day	1-2 doses per day	>2 doses per day
FEV1	Normal	60-80%	<60%
Peak expiratory flow	Normal	60-80%	<60%

Source: Guidelines for management of Asthma at Primary and Secondary Levels of health care in India, 2005

A patient should be placed in the highest category of severity based on any one of the clinical features or lung function test. FEV1 Forced expiratory volume in first second; * Each rescue medication dose = 200 µg inhaled salbutamol = 500 µg terbutaline = 2 mg oral salbutamol = 2.5 mg oral terbutaline.

In India, the recent KAP study on the newer trends in childhood Asthma management in a central Mumbai suburb revealed lesser awareness among family physicians, with no difference based on the number of years in practice. The present modes of information dissemination for family doctors may thus be insufficient and require supplementation and reinforcement (Shahid *et al.* 2007).

9.2 Treatment of Asthma: Because Asthma is a chronic condition, it usually requires continuous medical care (WHO Fact Sheet No 206 2000). Drugs used in Asthma can be divided into two broad

groups i.e. controllers and relievers. Controllers taken on a long-term basis to keep Asthma under control and generally include drugs with anti-inflammatory properties such as inhaled glucocorticoids (Guidelines for management of Asthma at Primary and Secondary Levels of health care in India, 2005). The controller drugs include (in order of preference): inhaled corticosteroids, long-acting inhaled beta-2 agonists, sustained-release theophyllines, leukotriene modifiers, cromones, long-acting oral beta-2 agonists and oral glucocorticoids (Barnes *et al.* 1998; Suissa *et al.* 2000; Szefler *et al.* 2002; O'Byrne *et al.* 2001; Harrison *et al.* 2004).

Relievers are the short and rapid acting bronchodilators, which relieve acute symptoms of Asthma (like cough, dyspnea and wheeze). These include (in order of preference): short-acting inhaled beta-2 agonists, inhaled anticholinergics, short-acting oral beta-2 agonists and short-acting theophylline (Guidelines for management of Asthma at Primary and Secondary Levels of health care in India, 2005; Kips *et al.* 2001; Wallin *et al.* 1995; Li *et al.* 1999; Nelson *et al.* 1998).

Table 8: Equivalent doses of inhaled corticosteroids (in micrograms/day)

Drug	Low-dose ICS		Medium-dose ICS		High-dose ICS	
	Adults	Children	Adults	Children	Adults	Children
Beclomethasone	200-400	100-200	400-1000	200-400	>1000	>400
Budesonide	200-400	100-200	400-800	200-400	>800	>400
Fluticasone	125-250	50-125	250-500	125-250	>500	>250

Source: Guidelines for management of Asthma at Primary and Secondary Levels of health care in India, 2005

Medication inserts for hydrofluoroalkane (HFA) preparations should be carefully reviewed for the correct dosage level. In general, the dose of dry powder inhalers with filler (such as lactose) is double than that of pressurised metered dose inhalers.

10. International Programmes for Prevention and Control of Asthma

WHO recognizes Asthma as a disease of major public health importance and plays a unique role in the co-ordination of international efforts against the disease (WHO Fact Sheet No 206 2000). It argues that international action is needed to:

- increase public awareness of the disease to make sure patients and health professionals recognise the disease and are aware of the severity of associated problems;
- organise and co-ordinate global epidemiological surveillance to monitor global and regional trends in Asthma;
- develop and implement an optimal strategy for its management and prevention (many studies have shown that this will result in the control of Asthma in most patients); and
- stimulate research into the causes of Asthma to develop new control strategies and treatment techniques.

Within this remit the WHO has been active in encouraging the following initiatives:

1. *Non-communicable Disease Network*
(www.who.int/ncdnet)

The World Health Organisation is in the process of establishing the Global Non-communicable Disease Network (NCDnet) to promote collaborative action to support developing countries in addressing non-communicable diseases. The NCDnet is a voluntary collaborative arrangement comprised of United Nations agencies, intergovernmental organisations, academia, research centres, nongovernmental organisations, and the business community, as identified in objective 5 of the 2008-2013 Action Plan for the Global Strategy for the Prevention and Control of Non-communicable Diseases (NCD Action Plan).The overall vision of this collaborative arrangement is to reduce risk, morbidity and mortality related to four shared risk factors (tobacco use, physical inactivity, unhealthy diets, and the harmful use of alcohol) through effective collaboration focused on achieving results in low- and middle-income countries.

2.Global Initiative for Asthma
(www.ginasthma.com)

The Global Initiative for Asthma (GINA), regarded as the most authoritative road map for Asthma care was set up in 1989. The goals of Asthma treatment, as laid out in the GINA workshop report, are shown in Table 9. Though nationwide health plans have succeeded in reducing fatality of respiratory diseases to a certain extent; there is however, a great need for improved and effective area-specific health programmes and social and economic development are mandatory in rural areas to achieve the desired health goals in India (Murthy and Sastry 2005).

Table 9: Goals of Asthma Treatment

Control chronic and nocturnal symptoms
Maintain normal activity, including exercise
Prevent acute episodes of Asthma
Minimise emergency department visits and hospitalisations
Minimal need for reliever medications
Maintain near-normal pulmonary function
Avoid adverse effects of Asthma medications
Source: The GINA workshop report (www.ginasthma.com)

3. WHO Initiative on Allergic Rhinitis and its Impact on Asthma (ARIA)
(www.who.int/respiratory)

WHO is developing a strategy for the prevention of bronchial Asthma through the management of allergic rhinitis. ARIA will broaden the perspectives for primary prevention of bronchial Asthma and will promote better understanding of bronchial Asthma among physicians and patients. The specific goals of ARIA are defined as follows:

- To increase awareness of allergy and allergic diseases as a preventable public health problem among the medical community, public health officials, and the general public;
- To prepare evidence-based guidelines for the prevention and management of allergic rhinitis as a key element of primary prevention of bronchial Asthma;
- To educate physicians and other health care professionals about the relevance of allergic rhinitis to bronchial Asthma; and

- To educate the public about the potentially fatal risks of allergy (anaphylaxis) and Asthma, especially in children, and to encourage greater dialogue with their physicians. Better education and increased dialogue could avoid approximately 25,000 childhood deaths due to Asthma each year

4. WHO strategy for prevention and control of Chronic Respiratory Diseases
(www.who.int/respiratory)

The aim of the WHO chronic respiratory disease programme is to support member States in their efforts to reduce the toll of morbidity, disability and premature mortality related to chronic respiratory disease, and specifically to Asthma and chronic obstructive pulmonary disease (COPD). WHO's programme objectives are:

- Surveillance to map the magnitude of Asthma, analyse its determinants and monitor trends, with emphasis on poor and disadvantaged populations;
- Primary prevention to reduce the level of exposure to common risk factors, particularly tobacco smoke, frequent lower respiratory infections during childhood, and air pollution (indoor, outdoor, and occupational exposure); and
- Identifying cost-effective interventions, upgrading standards and accessibility of care at different levels of the health care system.

In addition, the WHO has set up a ***Global Alliance against Chronic Respiratory Diseases (GARD)*** (www.who.int/gard/en/index.html) which contributes to WHO's work of preventing and controlling chronic respiratory diseases worldwide. The Global Alliance was officially launched on 28 March 2006 in Beijing, People's Republic of China. It is a voluntary alliance of national and international organisations and agencies from many countries. It focuses on the needs of low and middle-income countries and vulnerable populations, and fosters initiatives that are tailored to local needs. The Global Alliance is part of the global work to prevent and control chronic diseases. Because most of the chronic respiratory diseases are under-diagnosed, under-treated and essential medications cannot be accessed in many countries, thus a global effort to improve the diagnosis and the medical care was needed.

Other research bodies working on the area of Asthma is the ***International Union Against Tuberculosis and Lung Disease (IUATLD*** *(www.iuatld.org)* Its remit is to bring innovation, expertise, solutions and support to address health challenges in low and middle-income populations. With nearly 10,000 members and subscribers from 145 countries, The Union has its headquarters in Paris and regional and country offices serving the Africa, Asia Pacific, Europe, Latin America, Middle East, North America and South-East Asia regions. Its scientific departments focus on tuberculosis, HIV, lung health and non-communicable diseases, tobacco control and research. The Union is most widely known for the research that led to the global strategy for treating and controlling tuberculosis. Adopted by the sationWHO in 1993, The Union model is part of the internationally recommended 'Stop TB Strategy' that has been used to treat 32 million people in 202 countries. Drawing on this first success in addressing TB from medical, political, social and organisational perspectives, The Union has since developed programmes addressing TB-HIV, Asthma, pneumonia in children under five years of age, and tobacco control. The emphasis is on providing health solutions for the poor.

11. Global Asthma Research Programmes *(www.theunion.org/asthma-division*) Different Asthma research programmes which are ongoing are as follows:

i. Global Asthma Survey on Practice (GASP):

In 2003, a working group of The Union's Respiratory Disease Scientific Section and scientists from The Union Asthma Division initiated the Global Asthma Survey on Practice (GASP) to assess an audit procedure for use in emergency room situations in 13 centres in 11 countries. Patients with acute severe Asthma were examined and questioned about the severity of their disease and their treatment in the previous four weeks. The study revealed that although new treatments and guidelines have improved Asthma care, they are being poorly implemented. Access to adequate treatment appears to be the critical factor for improving management of Asthma, more adequate training of physicians in public and private settings is also important (Burney *et al.* 2008).

ii. The International Study of Asthma and Allergies in Childhood

(isaac.auckland.ac.nz)

The International Study of Asthma and Allergies in Childhood (ISAAC) was formed in 1991 to facilitate research into Asthma, allergic rhinoconjunctivitis and atopic eczema, and chaired by Professor Innes Asher, head of the Department of Paediatrics, Child and Youth Health at the University of Auckland, New Zealand. A regional coordinator for each region of the world is involved in the ISAAC Steering Committee. ISAAC currently involves almost 100 countries and was conducted in several phases. **ISAAC Phase One** demonstrated for the first time that Asthma is by its scale and frequency a global public health problem that includes sub-Saharan Africa where the average prevalence of Asthma in 1995-1996 had already reached 10% of children between 13 and 14 years old living in big cities. **ISAAC Phase Two** involved more intensive studies in a smaller number of selected centres. It began in 1998 and has enabled internationally standardised comparisons of disease and relevant risk factors. **ISAAC Phase Three** focused on estimations of the trend in the prevalence of Asthma, rhinoconjunctivitis and eczema and has highlighted a continuous increase of Asthma in almost all of the centres in low- and middle-income countries included in this study.

iii. BOLD Study: The overall aim of the study is to establish a worldwide platform for the study of Chronic Obstructive Lung Disease (COPD) mainly within low- and middle-income countries. This platform is used to launch local studies that are standardised in their methods and coordinated in their approach. The BOLD initiative was initially to develop the programme into a longitudinal study. The specific objectives are to measure the prevalence and burden of chronic obstructive lung disease across the world using high quality spirometry, to assess the main causes of the condition in different environments, the burden associated with the disease in relation to impaired quality of life, activity limitation, respiratory symptoms and use of health services and to provide information for input to an economic model of COPD and evaluate the appropriateness of care provided. Since 2009, several centres have been involved including in South Asia (India - *Pune*), South East Asia (the Philippines), Eastern Europe (Estonia -*Tartu*) and Africa (Algeria, Morocco and Tunisia).

12. Asthma Research Programmes in India

Much of the ongoing Asthma research in India is based on "high-risk" cohorts that maximise inclusion of children with a family history of Asthma and recruit primarily children with allergic Asthma. For preventive strategies to be planned and evaluated, basic epidemiologic surveillance data are first needed. In India a few recent initiatives have been launched to address this issue.

i. **ISAAC Trials (isaac.auckland.ac.nz):** The centres in India for the ISAAC trials are available on the provided website.

ii. Asthmatic and allergic disorders mitigation mission *(Dec 2005*): A mitigation mission (SMM 0006) is organised at the all-India level. The participating laboratories under this programme are IGIB, New Delhi; IICT, Hyderabad; CCMB, Hyderabad; ITRC, Lucknow and RRL-Jammu. IICB, Kolkata has been appointed as the coordinating laboratory. Major objectives of this mission include:

- Advanced level research on the target molecules of Asthma like 5-LO (a leukotriene producing enzyme), IgE, phosphodiesterase, etc.
- Extraction, identification and purification of herbal preparations/molecules showing activity on early and late phase pathways of allergic diseases.
- Chemical screening by fingerprinting and purification by gel-permeation, ion-exchange and reverse phase chromatography.
- Screening of promising molecules through in vivo animal models.
- Determination of chemical structure of effective molecules for better performance and chemical synthesis, designing of molecules for better performance and chemical synthesis.
- Identification of new pollens and fungal allergens for creating awareness among masses.

13. Asthma Health Policy

There is every reason to believe that the substantial global burden of Asthma can be dramatically reduced through efforts by individuals, their health care providers, health care organisations, and local and national governments (GINA 2004)

India, along with other developing nation, is facing a the well-documented epidemiological health transition and a "double burden" that sees the arrival of non-communicable diseases with their shared risk factors on top of the persisting heavy load of infectious and communicable diseases (Yusuf *et al.* 2001; Reddy 2003; Reddy 2004; Perel *et al.* 2006), a situation that has been described as 'a race against time' (Leeder *et al.* 2004). Table 10 provides data to suggest that COPD and Asthma are the greatest burdens compared to other non-communicable diseases.

Despite India having devised a national response to address the challenge of the major non-communicable conditions (National Programme for Prevention and Control of Diabetes, Cardiovascular diseases and Stroke, National Cancer Control Programme, National Mental Health Programme, National Programme for control of Blindness, National Programme for Prevention and Control of Deafness) none have been devised for COPD and Asthma. However, the Indian government has been instrumental in introducing legislation which may limit the potential risk factors for Asthma, which includes the passing of the national anti-tobacco legislation in 2008, banning

smoking in public places throughout the country which may therefore have a positive impact on Asthma prevalence and incidence rate (GOI 2008).

Table 10: Disease Burden estimation, 2005

Non-communicable conditions	Estimate of cases/lakh	Projected number 92015) cases/lakh
COPD and Asthma	405.20 (2001)	596.36
Cancers	8.07 (2004)	9.99
Diabetes	310	460
Mental Health	650	800
Blindness	141.07	129.96
CVDs	290 (2001)	640

Source: www.who.int 2005

14. Gaps in Asthma Research Practice in India

There is limited Asthma research currently going on in India and they are far from adequate to address the emerging demand (corresponding increase in disease burden). The major Asthma/COPD related research gaps are as follows:

a) National Asthma surveillance data collection is currently limited, and this presents perhaps the most significant gap in Asthma research in India. Better baseline Asthma data could provide useful information for better risk/resource balance for research and prevention. Most of the research in Asthma in India is regionalised or localised and largely uses hospital based data thus cannot be easily generalised to the entire Indian population. Moreover, most of the Asthma research is on childhood Asthma and thus adult populations are highly neglected in all the different kinds of Asthma related research. Therefore, to measure the extent of the problem in the entire population, there is a need for reliable population-based epidemiological studies in the context of its existing and potential economic impact.

b) Execution of appropriate measures of secondary prevention of Asthma are needed at a greater scale in India. Clinicians and policymakers need better information on how to implement methods that have been shown to prevent morbidity and mortality in Asthma across such a diverse and large population. There is a need to establish evidence based services for effective prevention, diagnosis and care of both adult and childhood Asthma, along with the need to evaluate these health systems in India.

c) Clinical trials are increasingly common in India, but medical registries that document the current state of Asthma in India are lacking. The dearth of such data limits the ability to evaluate effectiveness and penetration of Asthma interventions at the community level.

d) There is an urgent need to identify barriers to effective implementation of Asthma research programmes in India. The educational programmes are not designed with clear objectives and are not suited to the local needs. The strategy, teaching techniques, and content are not appropriate for objectives of programmmes and the audience. The focus should be on skill building and not merely information dissemination.

e) Evaluation and audit of adherence to the national guidelines for Asthma and COPD are required to ensure that appropriate care is provided; and if not, how the situation may be improved.

f) There is need of awareness of Asthma/COPD in India. Awareness programmes may develop means for the self-management of Asthma could be of value to lower resource settings like India, if account were taken of the relevant social and economic settings. The effectiveness of such programmes also need to be evaluated within the Indian context.

g) Finally, for Asthma complications, the current emergency service infrastructure is underdeveloped and has not been studied systematically to understand how Asthma complications may be minimised, particularly in the acute situations.

15. Conclusion

There is a widespread concern that the prevalence and incidence of Asthma is still rising in developed countries, but the economic and humanitarian effects of Asthma are greater in the developing world. The worst affected are children in low-income urban families. Depsite risk factors for asthma have been clearly and consistently identified, much remains unknown as to the fundamental immunologic, genetic and environmental mechanisms underlying the development of this condition and its increased expression, especially in the developed world (Subbarao *et al.* 2009). It is likely that detailed studies of gene-by-environment interactions and of epigenetics will eventually unravel the inconsistencies among the many assumed exposures and outcomes. Reduction in risk, and perhaps even true primary prevention of Asthma, remains elusive but is a key goal of Asthma management (Subbarao *et al.* 2009).

The public health relevance of Asthma, at the global level, is increasingly being recognised (Committee TISoAaAiCIS 1998; Bousquet *et al.* 2005; Gold 2005). While physical environmental factors, supplemented with evidence from gene–environment interaction studies, have advanced our mechanistic understanding of this complex disease, they do not fully account for the substantial social patterning of Asthma (Subramanian *et al.* 2007).

The burden of Asthma in developing countries such as India, is of sufficient magnitude to warrant its recognition as a priority in government health strategies. Particular resources need to be provided to improve the care of disadvantaged groups with high morbidity, including certain racial groups and those who are poorly educated, live in large cities, or are poor. Resources also need to be provided to address preventable factors, such as air pollution, that trigger exacerbations of Asthma. However, there are a number of significant barriers for reducing the burden of Asthma in India, where many patients have limited access to care and essential medications. The GINA has outlined a six-point patient management plan to address the effective handling of the increased number of patients in primary care and the WHO has been instrumental in supporting member states to reduce the burden of chronic disease, Asthma and chronic respiratory disease. Unfortunately, there are no national policies in India to promote the GINA plan. More cooperation is imperative between health-care officials and primary and secondary care providers in order to develop individualised Asthma management programmes that will work at a local level.

References

Abramson M, Puy R, Weiner J. Immunotherapy in asthma: an updated systematic review. Allergy 1999; 54:1022-1041.

Adachi M, Morikawa A, Ishihara K. Asthma insights and reality in Japan (AIRJ). Arerugi 2002; 51:411–420.

Adler N, Boyce T, Chesney M et al. Socioeconomic status and health: the challenge of the gradient. Am Psychol 1994;49:15–24.

Aggarwal AN, Chaudhry K, Chhabra SK, et al. Prevalence and risk factors for bronchial asthma in Indian adults: a multicentre study. Indian J Chest Dis Allied Sci 2006;48:13-22.

Alm B, Erdes L, Mollborg P, et al. Neonatal antibiotic treatment is a risk factor for early wheezing. *Pediatrics* 2008;121:697-702.

Almqvist C, Egmar AC, Hedlin G, et al. Direct and indirect exposure to pets —risk of sensitization and asthma at 4 years in a birth cohort. Clin Exp Allergy 2003; 33: 1190-7.

Annesi-Maesano I, Moreau D, Strachan D. In utero and perinatal complications preceding asthma. Allergy 2001;56:491-7.

Archea C, Yen IH, Chen H, et al. Negative life events and quality of life in adults with asthma. Thorax 2007;62:139-46.

Asher MI, Montefort S, Bjorksten B, et al., ISAAC Phase Three Study Group. Worldwide time trends in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in childhood: ISAAC Phases One and Three repeat multicountry cross-sectional surveys. Lancet 2006;368:733-43.

Asthma in America: a landmark survey. GlaxoSmithKline,1998. Available at: http://www.asthmainamerica.com.

Asthma insights and reality in Europe: the Asthma Insights and Reality in Europe (AIRE) Study. Available at: www.asthma.ac.psiweb.com

Awasthi S, Kalra E, Roy S, Awasthi S. Prevalence and risk factors of asthma and wheeze in school-going children in Lucknow, North India. Indian Pediatrics 2004; 41: 1205-1210.

Bager P, Melbye M, Rostgaard K, et al. Mode of delivery and risk of allergic rhinitis and asthma. J Allergy Clin Immunol 2003;111:51-6.

Bakerly ND, Moore VC, Vellore AD, et al. Fifteen-year trends in occupational asthma: data from the Shield surveillance scheme. Occup Med (Lond) 2008; 58:169-74.

Barbee RA, Kaltenborn W, Lebowitz MD, et al. Longitudinal changes in allergen skin test reactivity in a community population sample. J Allergy Clin Immunol 1987; 79:16-24.

Barnes PJ, Pedersen S, Busse WW. Efficacy and safety of inhaled corticosteroids. New developments. Am J Respir Crit Care Med 1998; 157: S1-S53.

Beasley R. The burden of asthma with specific reference to the United States. J Allergy Clin Immunol 2002; 109(5 Suppl):S482–S489

Becklake MR, Kauffmann F. Gender differences in airway behaviour over the human life span. Thorax 1999;54:1119-38.

Bedi RS, Singh HJ. Socio-economic factors affecting inhaler therapy compliance in asthma. Lung India 1994; 12:25-26.

Behera D, Chakrabarti T, Khanduja KL. Effect of exposure to domestic cooking fuels in bronchial asthma. Indian J Chest Dis Allied Sci 2001; 43:27-31.

Behera D, Jindal SK. Respiratory symptoms in Indian women using domestic cooking fuels. Chest 1991;100:385–8.

Benn CS, Thorsen P, Jensen JS, et al. Maternal vaginal microflora during pregnancy and the risk of asthma hospitalization and use of antiasthma medication in early childhood. J Allergy Clin Immunol 2002;110:72-7.

Bergmann RL, Diepgen TL, Kuss O, et al. Breastfeeding duration is a risk factor for atopic eczema. Clin Exp Allergy 2002;32:205-9.

Bernsen RM, de Jongste JC, van der Wouden JC. Birth order and sibship size as independent risk factors for asthma, allergy, and eczema. Pediatr Allergy Immunol 2003; 14:464-9.

Beuther DA and Sutherland ER. Overweight, Obesity, and Incident Asthma. A Meta-analysis of Prospective Epidemiologic Studies. American Journal of Respiratory and Critical Care Medicine Vol 175. pp. 661-666, (2007)

Bjornson CL, Mitchell I. Gender differences in asthma in childhood and adolescence. J Gend Specif Med 2000;3:57-61.

Bousquet J, Bousquet PJ, Godard P, Davers JP. The public health implications of asthma. Bull World Health Organ 2005;83:548–54.

Bousquet J, Yssel H, Vignola AM. Is allergic asthma associated with delayed fetal maturation or the persistence of conserved fetal genes? Allergy 2000; 55: 1194-1197.

Braman Sidney S. The Global Burden of Asthma Chest 2006;130;4S-12S.

Bröms K, D Norbäck, M Eriksson, C Sundelin, and K Svärdsudd. Effect of degree of urbanisation on age and sex-specific asthma prevalence in Swedish preschool children. BMC Public Health. 2009; 9: 303.

Bronnimann S, Burrows B. A prospective study of the natural history of asthma. Remission and relapse rates. Chest 1986;90:480-4.

Burke W, Fesinmeyer M, Reed K, et al. Family history as a predictor of asthma risk. Am J Prev Med 2003;24:160-9.

Burney P, Potts J, Aït-Khaled N, Sepulveda RM et al. A multinational study of treatment failures in asthma management. Int J Tuberc Lung Dis 2008; 12: 13-18.

Burney PGJ, Britton JR, Chinn S, et al. Descriptive epidemiology of bronchial reactivity in an adult population: Results from a community study. Thorax 1987;42:38–44.
Burney PGJ. Epidemiology. In: Clark TJH, Godfrey S, Lee TH, Thomsom NC (eds). Asthma. London: Panther Publishers Private Limited; 2002:197–223.
Busse WJ, Kiecolt-Glaser J, Coe C, et al. Stress and asthma: NHLBI Workshop Summary. Am J Respir Crit Care Med 1994;151:249–52.
Camargo CA Jr, Weiss ST, Zhang S, et al. Prospective study of body mass index, weight change, and risk of adult-onset asthma in women. Arch Intern Med 1999;159: 2582-8.
Campo P, Kalra HK, Levin L, et al. Influence of dog ownership and high endotoxin on wheezing and atopy during infancy. J Allergy Clin Immunol 2006; 118: 1271-8.
Castro-Giner F, Kogevinas M, Mächler M, et al. 2008. TNFA -308G>A in two international population-based cohorts and risk of asthma. ERJ 32 (2): 350-361
Castro-Giner F, Nino Künzli, Bénédicte Jacquemin et al. 2009 Traffic-Related Air Pollution, Oxidative Stress Genes, and Asthma (ECHRS). EHP 117(12): 1919-1924
Celedón JC, Litonjua AA, Ryan L, et al. Day care attendance, respiratory tract illnesses, wheezing, asthma, and total serum IgE level in early childhood. Arch Pediatr Adolesc Med 2002;156:241-5.
Chalmers GW, Macleod KJ, Little SA, et al. Influence of cigarette smoking on inhaled corticosteroid treatment in mild asthma. Thorax 2002 Mar; 57: 226-230.
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.
Chen CH, Xirasagar S, Lin HC. Seasonality in adult asthma admissions, air pollutant levels, and climate: a population-based study. J Asthma 2006;43:287-92.
Chen E, Fisher EB, Bacharier LB, Strunk RC. Socioeconomic status, stress, and immune markers in adolescents with asthma. Psychosom Med 2003;65:984–92.
Chen Y, Dales R, Stewart P, et al. Hospital readmissions for asthma in children and young adults in Canada. Pediatr Pulmonol 2003;36:22-6.
Chen Y, Stewart P, Johansen H, et al. Sex difference in hospitalization due to asthma in relation to age. J Clin Epidemiol 2003;56:180-7.
Chhabra SK, Gupta CK, Chhabra P, Rajpal S. Prevalence of bronchial asthma in school children in Delhi. J Asthma 1998; 35:291-296.
Chhabra SK, Gupta CK, Chhabra P, Rajpal S. Risk factors for development of bronchial asthma in children in Delhi. Ann Allergy Asthma Immunol 1999; 83:385-390.
Chowgule RV, Shetye VM, Parmar JR, et al. Prevalence of respiratory symptoms, bronchial hyperreactivity, and asthma in a megacity. Results of the European Community Respiratory Health Survey in Mumbai (Bombay). Am J Respir Crit Care Med 1998;158: 547-554.
Claudio L, Tulton L, Doucette J, et al. Socioeconomic factors and asthma hospitalization rates in New York City. J Asthma 1999;36:343-50.
Cline MG, Burrows B. Distribution of allergy in a population sample residing in Tucson, Arizona. Thorax 1989;44:425-31.
Clinical practice guidelines on bronchial asthma in adults. J Assoc Physicians India 2002; 50: 461-501.
Committee TISoAaAiCIS. Worldwide variation in prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and atopic eczema: ISAAC. Lancet 1998;351:1225–32.
Consensus Guidelines on management of childhood asthma in India. Indian Pediatr 1999; 36: 157-164.
Crawford WA, Beedham CG. The changing demographic pattern in asthma related to sex and age. A study of 13,651 patients on sodium cromoglycate (Intal). Med J Aust 1976;1:430-4.
Custovic A, Simpson A, Woodcock A. Importance of indoor allergens in the induction of allergy and elicitation of allergic disease. Allergy 1998; 53: 115-20.
De M. Asthmatic and allergic disorders mitigation mission. CURRENT SCIENCE, 2005; 89 (10).
de Marco R, Locatelli F, Cerveri I, et al. Incidence and remission of asthma: a retrospective study on the natural history of asthma in Italy. J Allergy Clin Immunol 2002; 110:228-35.
de Marco R, Locatelli F, Sunyer J, et al. Differences in incidence of reported asthma related to age in men and women. A retrospective analysis of the data of the European Respiratory Health Survey. Am J Respir Crit Care Med 2000; 162:68-74.
Dell S, To T. Breastfeeding and asthma in young children: findings from a population-based study. Arch Pediatr Adolesc Med 2001;155:1261-5.
Devereux G, Turner SW, Craig LC, et al. Low maternal vitamin E intake during pregnancy is associated with asthma in 5-year-old children. Am J Respir Crit Care Med 2006;174:499-507.

Dezateux C, Stocks J, Dundas I, et al. Impaired airway function and wheezing in infancy: the influence of maternal smoking and a genetic predisposition to asthma. Am J Respir Crit Care Med 1999;159:403-10.
Diaz-Sanchez D, Tsien A, Fleming J, Saxon A. Combined diesel exhaust particulate and ragweed allergen challenge markedly enhances human in vivo nasal ragweed-specific IgE and skews cytokine production to a T helper cell 2-type pattern. J Immunol 1997;158:2406-13.
Dodge RR, Burrows B. The prevalence and incidence of asthma and asthma-like symptoms in a general population sample. Am Rev Respir Dis 1980;122:567-75.
Donahue JG, Weiss ST, Livingston JM, et al. Inhaled steroids and the risk of hospitalization for asthma. JAMA 1997;277:887-91.
Eder W, Ege MJ, von Mutius E. The asthma epidemic. N Engl J Med 2006;355:2226-35.
El-Sharif N., Z. Abdeen, R. Qasrawi, G. Moens, and B. Nemery. Asthma prevalence in children living in villages, cities and refugee camps in Palestine. Eur Respir J 2002; 19:1026-1034.
Ernst P, Demissie K, Joseph L, et al. Socioeconomic status and indicators of asthma in children. Am J Respir Crit Care Med 1995;152:570-5.
Ernst P, Ghezzo H, Becklake MR. Risk factors for bronchial hyperresponsiveness in late childhood and early adolescence. Eur Respir J 2002;20:635-9.
Erzen D, Carriere KC, Dik N, et al. Income level and asthma prevalence and care patterns. Am J Respir Crit Care Med 1997;155:1060-5.
European lung white book. Brussels, Belgium: European Respiratory Society and the European Lung Foundation, 2003.
Evans D, Levinson MJ, Feldman CH, et al. The impact of passive smoking and emergency room visits of urban children with asthma. Am Rev Respir Dis 1987;135:567–72.
Evans G. Environmental stress and health. In: Baum A, Revenson T, Singer J (eds). Handbook of Health Psychology. Mahwah, NJ: Lawrence Erlbaum Associates Inc., 2001. pp. 365–85.
Evans GW, Kantrowitz E. Socioeconomic status and health: the potential role of environmental risk exposure. Annu Rev Public Health 2002;23:303-31.
Friedlander SL, Jackson DJ, Gangnon RE, et al. Viral infections, cytokine dysregulation and the origins of childhood asthma and allergic diseases. Pediatr Infect Dis J 2005;24(Suppl):S170-6.
Galanter J, Choudhry S, Eng C, et al. ORMDL3 gene is associated with asthma in three ethnically diverse populations. Am J Respir Crit Care Med 2008;177:1194-200.
Gdalevich M, Mimouni D, Mimouni M. Breast-feeding and the risk of bronchial asthma in childhood: a systematic review with meta-analysis of prospective studies.J Pediatr 2001;139:261-6.
Gerritsen J, Koëter GH, Postma DS, et al. Prognosis of asthma from childhood to adulthood. Am Rev Respir Dis 1989;140:1325-30.
Ghosh CS, Ravindran P, Joshi M, Stearns SC. Reductions in hospital use from self management training for chronic asthmatics. Soc Sci Med 1998; 46:1087-1093.
Gilliland FD, Islam T, Berhane K, et al. Regular smoking and asthma incidence in adolescents. Am J Respir Crit Care Med 2006;174:1094-100.
Global Initiative for Asthma. GINA workshop report: global strategy for asthma management and prevention. Available at:http://www.ginasthma.com/wr_clean.pdf. 2004
Global Strategy for Asthma Management and Prevention, Global Initiative for Asthma (GINA) 2007. Available from: http://www.ginasthma.org.
Godard P, Chanez P, Siraudin L, et al. Costs of asthma are correlated with severity: a 1-yr prospective study. Eur Respir J 2002; 19:61–67
Godden DJ, Ross S, Abdalla M, et al. Outcome of wheeze in childhood. Symptoms and pulmonary function 25 years later. Am J Respir Crit Care Med 1994;149:106-12.
Gold DR, Wright R. Population disparities in asthma. Annu Rev Public Health 2005;26:89–113.
Goldberg S, Israeli E, Schwartz S, et al. Asthma prevalence, family size, and birth order. Chest 2007;131:1747-52.
Gold DR. Environmental tobacco smoke, indoor allergens, and childhood asthma. Environ Health Perspect 2000;108 Suppl 4:643-51.
Goodman DC, Stukel TA, Chang CH. Trends in pediatric asthma hospitalization rates: regional and socioeconomic differences. Pediatrics 1998;101:208-13.
Government of India (GOI). Prohibition of smoking in public places rules 2008. Joint Secretary, Ministry of Health & Family Welfare, Government of India Press, New Delhi, India.
Groban MD, Evans RM, Edgren B, et al. Clinical benefits and cost reduction associated with a comprehensive asthma management programme at a managed care organization. Dis Manage Health Outcomes 1998;4:93-100.
Guidelines for management of asthma at primary and secondary levels of healthcare in India (2005). WHO-GOI collaborative programme (2004-2005).

Gupta D, Aggarwal AN, Chaudhary J, Jindal SK. Domestic fuel combustion and morbidity from asthma amongst nonsmoking women. Lung India 1999; 17:10-14.
Gupta D, Aggarwal AN, Kumar R, Jindal SK. Prevalence of bronchial Asthma and association with environmental tobacco smoke exposure in adolescent school children in Chandigarh, North India. J Asthma 2001; 38: 501-507
Gupta PP, Gupta KB. Awareness about the diseases in asthma patients receiving treatment from physicians at different levels. Indian J Chest Dis Allied Sci 2001; 43: 91-95.
Gupta SK, Mazumdar KS, Gupta S, Mazumdar AS, Gupta S. Patient education programme in bronchial asthma in India: why, how, what and where to communicate? Indian J Chest Dis Allied Sci 1998; 40:117-124.
Gupta, PP and KB Gupta: Awareness about the disease in asthma patients receiving treatment from physicians at different levels. Indian J Chest Dis allied Sci 2001; 43: 91-95.
Gustafsson PM, Kjellman B. Asthma from childhood to adulthood: course and outcome of lung function. Respir Med 2000;94:466-74.
Halfon N, Newacheck PW. Childhood asthma and poverty: differential impacts and utilization of health services. Pediatrics 1993;91:56-61.
Hamman RF, Halil T, Holland WW. Asthma in schoolchildren. Demographic associations and peak expiratory flow rates compared in children with bronchitis. Br J Prev Soc Med 1975; 29:228-38.
Hancox RJ, Milne BJ, Poulton R, et al. Sex differences in the relation between body mass index and asthma and atopy in a birth cohort. Am J Respir Crit Care Med 2005;171:440-5.
Harrison TW, Oborne J, Newton S, Tattersfield AE. Doubling the dose of inhaled corticosteroid to prevent asthma exacerbations: randomised controlled trial. Lancet 2004; 363: 271-275.
Hasan MM, Gofin R, Bar-Yishay E. Urbanization and the risk of asthma among schoolchildren in the Palestinian Authority. J Asthma. 2000; 37(4):353-60.
Hegde SC, Shah PB, Mahashur AA. Awareness regarding occupational asthma amongst general practitioners - a critical evaluation. Indian J Occup Environ Med 2002; 6:16-20.
Henriksen AH, Holmen TL, Bjermer L. Sensitization and exposure to pet allergens in asthmatics versus non-asthmatics with allergic rhinitis. Respir Med 2001; 95:122-9.
Holberg CJ, Elston RC, Halonen M, et al. Segregation analysis of physiciandiagnosed asthma in Hispanic and non-Hispanic white families. A recessive component? Am J Respir Crit Care Med 1996;154:144-50.
Hoskins G, McCowan C, Neville RG, Thomas GE, Smith B, Silverman S. Risk factors and costs associated with an asthma attack. Thorax 2000; 55: 19–24.
Holt PG. Potential role of environmental factors in the etiology and pathogenesis of atopy: a working model. Environ Health Perspect 1999;107 Suppl 3:485-7.
Huss K, Adkinson NF Jr, Eggleston PA, et al. House dust mite and cockroach exposure are strong risk factors for positive allergy skin test responses in the Childhood Asthma Management Programme. J Allergy Clin Immunol 2001;107:48-54.
Hyndman SJ, Williams DR, Merrill SL, et al. Rates of admission to hospital for asthma. BMJ 1994;308:1596-600.
Illi S, von Mutius E, Lau S, et al. Perennial allergen sensitisation early in life and chronic asthma in children: a birth cohort study. Lancet 2006;368:763-70.
International Institute for Population Sciences (IIPS) and Macro International. 2007. National Family Health Survey (NFHS-3), 2005-06: India: Volume I. Mumbai: IIPS.
International Institute for Population Sciences and ORC Macro. (2000) National Family Health Survey (NFHS-2), 1998-99: India. Mumbai: International Institute for Population Sciences.
International Union Against Tuberculosis and Lung Diseases (IUATLD). Fact sheet: Asthma a world-wide problem. Available from www.iuatld.org.
Peroni DG, Pietrobelli A and Boner AL. Asthma and obesity in childhood: on the road ahead. International Journal of Obesity (2010) 34, 599–605; doi:10.1038/ijo.2009.273
International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee.Worldwide variation in prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and atopic eczema: ISAAC. Lancet 1998;351:1225-32.
Jaakkola MS, Ieromnimon A, Jaakkola JJ. Are atopy and specific IgE to mites and molds important for adult asthma? J Allergy Clin Immunol 2006;117:642-8.
James AL, Palmer LJ, Kicic E, et al. Decline in lung function in the Busselton Health Study: the effects of asthma and cigarette smoking. Am J Respir Crit Care Med 2005;171:109-14.
Janson C, Anto J, Burney P, et al. The European Community Respiratory Health Survey: What are the main results so far? European Community Respiratory Health Survey II. Eur Respir J 2001;18:598-611.
Jedrychowski W, Galas A, Whyatt R, et al. The prenatal use of antibiotics and the development of allergic disease in one year old infants. A preliminary study. Int J Occup Med Environ Health 2006;19:70-6.

Jindal SK, Gupta D, Aggarwal AN, Jindal RC, Singh V. Study of the prevalence of Asthma in adults in north India using a standardized field questionnaire. J Asthma 2000; 37: 345-351

Jindal SK, Gupta D, Chattopadhyay S, Kumar L. Environmental tobacco smoke exposure precipitates acute exacerbations in nonsmoker asthmatics. Lung India 1997; 15:168-172.

Jindal SK, Gupta D, Singh A. Indices of morbidity and control of asthma in patients exposed to environmental tobacco smoke. Chest 1994; 106:746-749.

Jindal SK, Gupta D. The relationship between tobacco smoke and bronchial asthma. Indian J Med Res 120: 2004: 443-453.

Jindal SK, Jha LK, Gupta D. Bronchial hyper-responsiveness of women with asthma exposed to environmental tobacco smoke. Indian J Chest Dis Allied Sci 1999; 41:75-82.

Jindal SK. Bronchial asthma: the Indian scene. Curr Opin Pulm Med 2007; 13 : 8-12.

Johnston FH, Webby RJ, Pilotto LS, et al. Vegetation fires, particulate air pollution and asthma: a panel study in the Australian monsoon tropics. Int J Environ Health Res 2006;16:391-404.

Jones CA, Holloway JA, Warner JO. Does atopic disease start in foetal life? Allergy 2000; 55: 2-10.

Joseph CL, Havstad SL, Ownby DR, et al. Racial differences in emergency department use persist despite allergist visits and prescriptions filled for anti-inflammatory medications. J Allergy Clin Immunol 1998;101:484-90.

Joshi P, Shaw A, Kakakios A, et al. Interferon-gamma levels in nasopharyngeal secretions of infants with respiratory syncytial virus and other respiratory viral infections. Clin Exp Immunol 2003;131:143-7.

Kanner RE, Connett JE, Altose MD, et al. Gender difference in airway hyperresponsiveness in smokers with mild COPD. The Lung Health Study. Am J RespirCrit Care Med 1994;150:956-61.

Kao CC, See LC, Yan DC, et al. Time trends and seasonal variations in hospital admissions for childhood asthma in Taiwan from 1990 to 1998. Asian Pac J Allergy Immunol 2001;19:63-8.

Karmaus W, Arshad H, Mattes J. Does the sibling effect have its origin in utero? Investigating birth order, cord blood immunoglobulin E concentration, and allergic sensitization at age 4 years. Am J Epidemiol 2001;154:909-15.

Kero J, Gissler M, Gronlund MM, et al. Mode of delivery and asthma — is there a connection? Pediatr Res 2002;52:6-11.

Kinra S, Davey SG, Jeffreys M, et al. Association between sibship size and allergic diseases in the Glasgow Alumni Study. Thorax 2006;61:48-53.

Kips JC, Pauwels RA. Long-acting inhaled beta(2)-agonist therapy in asthma. Am J Respir Crit Care Med 2001; 164: 923-932.

Kjellman B, Hesselmar B. Prognosis of asthma in children: a cohort study into adulthood. Acta Paediatr 1994;83:854-61.

Kleeberger SR, Peden D. Gene-environment interactions in asthma and other respiratory diseases. Annu Rev Med 2005;56:383–400.

Klinnert MD, Mrazek PJ, Mrazek DA. Early asthma onset: the interaction between family stressors and adaptive parenting. Psychiatry 1994;57:51-61.

Knox RB, Suphioglu C, Taylor P, et al. Major grass pollen allergen Lol p 1 binds to diesel exhaust particles: implications for asthma and air pollution. Clin Exp Allergy 1997;27:246-51.

Koenig JQ. Air pollution and asthma. J Allergy Clin Immunol 1999;104:717-22.

Kogevinas M, Zock JP, Jarvis D, et al. Exposure to substances in the workplace and new-onset asthma: an international prospective population-based study (ECRHS-II). Lancet 2007;370:336-41.

Koh MS. Irving LB. The natural history of asthma from childhood to adulthood. International Journal of Clinical Practice. 2007;61(8):1371-1374.

Kozyrskyj AL, Ernst P, Becker AB. Increased risk of childhood asthma from antibiotic use in early life. *Chest* 2007;131:1753-9.

Krishnakumar A. The silent tormentor . Frontline. 2003;20(17):August 16 – 29.

Kull I, Almqvist C, Lilja G, et al. Breast-feeding reduces the risk of asthma during the first 4 years of life. J Allergy Clin Immunol 2004;114:755-60.

Kummeling I, Stelma FF, Dagnelie PC, et al. Early life exposure to antibiotics and the subsequent development of eczema, wheeze, and allergic sensitization in the first 2 years of life: the KOALA Birth Cohort Study. *Pediatrics* 2007;119:e225-31.

Lai CK, De Guia TS, Kim YY, et al. Asthma control in the Asia-Pacific region: the Asthma Insights and Reality in Asia-Pacific Study. J Allergy Clin Immunol 2003; 111:263–268.

Laitinen T, Räsänen M, Kaprio J, et al. Importance of Genetic Factors in Adolescent Asthma A Population-based Twin-family Study. Am. J. Respir. Crit. Care Med. 1998;157(4):1073-1078.

Lal A, Kumar L, Malhotra S. Knowledge of asthma among parents of asthmatic children. Indian Pediatr 1995; 32:649-55.

Lau S, Nickel R, Niggemann B, et al. The development of childhood asthma: lessons from the German Multicentre Allergy Study (MAS). Paediatr Respir Rev 2002; 3:265-72.

Lau S, Illi S, Sommerfeld C, et al. Early exposure to house-dust mite and cat allergens and development of childhood asthma: a cohort study. Multicentre Allergy Study Group. Lancet 2000;356:1392-7.

Lawrence S, Beasley R, Doull I, et al. Genetic analysis of atopy and asthma as quantitative traits and ordered polychotomies. Ann Hum Genet 1994;58:359-68.
Le Souëf PN, Sears MR, Sherrill D. The effect of size and age of subject on airway responsiveness in children. Am J Respir Crit Care Med 1995;152:576-9.
Leeder S, Raymond S, Greenberg H, Liu H, Esson K. A Race Against Time: The Challenge of Cardiovascular Disease in Developing Economies. The Earth Institute, Columbia University; New York: 2004.
Lehrer PM, Isenberg S, Hochron SM. Asthma and emotion: a review. J Asthma 1993;30:5-21.
Leung R, Ho P. Asthma, allergy, and atopy in three South-east Asian populations. Thorax 1994;49:1205-10.
Lemanske RF Jr, Jackson DJ, Gangnon RE, et al. Rhinovirus illnesses during infancy predict subsequent childhood wheezing. J Allergy Clin Immunol 2005; 116: 571-7.
Lewis S, Butland B, Strachan D, et al. Study of the aetiology of wheezing illness at age 16 in two national British birth cohorts. Thorax 1996;51:670-6.
Lewis S, Richards D, Bynner J, et al. Prospective study of risk factors for early and persistent wheezing in childhood. Eur Respir J 1995;8:349-56.
Leynaert B, Bousquet J, Henry C, et al. Is bronchial hyperresponsiveness more frequent in women than in men? A population-based study. Am J Respir Crit Care Med 1997;156:1413-20.
Li X, Ward C, Thien F, Bish R, Bamford T, Bao X, et al. An antiinflammatory effect of salmeterol, a long acting beta (2) agonist, assessed in airway biopsies and bronchoalveolar lavage in asthma. Am J Respir Crit Care Med 1999; 160: 1493-1499.
Lin RY, Rehman A. Clinical characteristics of adult asthmatics requiring intubation.J Med 1995;26:261-77.
Litonjua AA, Carey VJ, Weiss ST, et al. Race, socioeconomic factors, and area of residence are associated with asthma prevalence. Pediatr Pulmonol 1999;28:394-401.
Litonjua AA, Rifas-Shiman SL, Ly NP, et al. Maternal antioxidant intake in pregnancy and wheezing illnesses in children at 2 y of age. Am J Clin Nutr 2006; 84: 903-11.
Lødrup Carlsen KC. The Environment and Childhood Asthma (ECA) Study in Oslo: ECA-1 and ECA-2. Pediatr Allergy Immunol 2002;13(Suppl 15):29-31.
Lowe LA, Simpson A, Woodcock A, et al. Wheeze phenotypes and lung function in preschool children. Am J Respir Crit Care Med 2005;171:231-7.
Macaubas C, de Klerk NH, Holt BJ, et al. Association between antenatal cytokine production and the development of atopy and asthma at age 6 years. Lancet 2003; 362: 1192-7.
Maddox L, Schwartz DA. The pathophysiology of asthma. Annu Rev Med 2002;53:477–98.
Mandhane PJ, Greene JM, Cowan JO, et al. Sex differences in factors associated with childhood- and adolescent-onset wheeze. Am J Respir Crit Care Med 2005; 172:45-54.
Martindale S, McNeill G, Devereux G, et al. Antioxidant intake in pregnancy in relation to wheeze and eczema in the first two years of life. Am J Respir Crit Care Med 2005;171:121-8.
Martinez FD, Holt PG. Role of microbial burden in aetiology of allergy and asthma. Lancet 1999;354 (Suppl 2):SII12-5.
Martinez FD, Wright AL, Taussig LM, et al. Asthma and wheezing in the first six years of life. The Group Health Medical Associates. N Engl J Med 1995;332:133-8.
Masoli M, Fabian D, Holt S, et al. Global Initiative for Asthma (GINA) program: the global burden of asthma: executive summary of the GINA Dissemination Committee report. Allergy 2004; 59:469–478.
Matricardi PM, Franzinelli F, Franco A, et al. Sibship size, birth order, and atopy in 11,371 Italian young men. J Allergy Clin Immunol 1998;101:439-44.
McCreanor J, Cullinan P, Nieuwenhuijsen MJ, et al. Respiratory effects of exposure to diesel traffic in persons with asthma. N Engl J Med 2007;357:2348-58.
McKeever TM, Lewis SA, Smith C, et al. The importance of prenatal exposures on the development of allergic disease: a birth cohort study using the West Midlands General Practice Database. Am J Respir Crit Care Med 2002;166:827-32.
Meurer JR, George V, Subichin S, et al. Asthma severity among children hospitalized in 1990 and 1995. Arch Pediatr Adolesc Med 2000;154:143-9.
Mihrshahi S, Ampon R, Webb K, et al. The association between infant feeding practices and subsequent atopy among children with a family history of asthma. Clin Exp Allergy 2007;37:671-9.
Milama J, McConnella R, Yaoa L, Berhanea K, Jerretta M, Richardsona J. Parental Stress and Childhood Wheeze in a Prospective Cohort Study. Journal of Asthma, 2008;45(4): 319 – 323.
Miller JE. The effects of race/ethnicity and income on early childhood asthma prevalence and health care use. Am J Public Health 2000;90:428-30.
Mishra V. Effect of indoor air pollution from biomass combustion on prevalence of asthma in the elderly. Environ Health Perspect 2003; 111: 71–78.

Mishra, V. 2004. Effect of Obesity on Asthma among Adult Indian Women. International Journal of Obesity 28: 1048-1058.
Mistry R, Wickramasingha N, Ogston S, et al. Wheeze and urban variation in South aisa. Eur J Pediatr 2004;163:145-7
Mitchell EA. Increasing prevalence of asthma in children. NZ Med J 1983;96:463–4.
Mitchell EA. International trends in hospital admission rates for asthma. Arch Dis Child 1985; 60:376–378
Moffatt MF, Kabesch M, Liang L, et al. Genetic variants regulating ORMDL3 expression contribute to the risk of childhood asthma. Nature 2007;448:470-3.
Mohamed N, Ng'ang'a L, Odhiambo J, Nyamwaya J, Menzies R. Home environment and asthma in Kenyan schoolchildren: a case–control study. Thorax 1995; 50: 74–78. | PubMed |
Morrison SJ. The prevalence of asthma and wheezing in children. Br J Dis Chest 1976;70:73–7.
Mrazek DA, Klinnert M, Mrazek PJ, et al. Prediction of early-onset asthma in genetically at-risk children. Pediatr Pulmonol 1999;27:85-94.
Murthy KJR and JG Sastry. Economic burden of asthma. NCMH Background Papers: Burden of Disease in India. 2005.
Nafstad P, Magnus P, Jaakkola JJ. Risk of childhood asthma and allergic rhinitis in relation to pregnancy complications. J Allergy Clin Immunol 2000;106:867-73.
Nel AE, Diaz-Sanchez D, Ng D, Hiura T, Saxon A.Enhancement of allergic inflammation by the interaction between diesel exhaust particles and the immune system. J Allergy Clin Immunol 1998;102:539-54.
Nafstad P, Samuelsen SO, Irgens LM, et al. Pregnancy complications and the risk of asthma among Norwegians born between 1967 and 1993. Eur J Epidemiol 2003; 18:755-61.
National Asthma Campaign Asthma Audit. The National Asthma Audit: assessing the burden of asthma. Asthma J 2001; 6: Suppl., 1–11.
National Heart, Lung, and Blood Institute. National asthma Education program- Expert Panel Report. Guidelines for the diagnosis and management of asthma. J allergy Clin Immunol 1991, 88 (suppl): 425-534.
Nelson JA, Strauss L, Skowronski M, et al. Effect of long-term salmeterol treatment on exercise-induced asthma. N Engl J Med 1998; 339: 141-146.
Neville RG, Pearson MG, Richards N, et al. A cost analysis on the pattern of asthma prescribing in the UK. Eur Respir J 1999;14:605-9.
Nicolai T, Illi S, Tenborg J, et al. Puberty and prognosis of asthma and bronchial hyper-reactivity. Pediatr Allergy Immunol 2001;12:142-8.
Nouwen A, Freeston MH, Labbe R, Boulet LP. Psychological factors associated with emergency room visits among asthmatic patients. Behav Modif 1999;23:217-33.
O'Neill MS, Jerrett M, Kawachi I et al. Health, wealth and air pollution: advancing theory and methods. Environ Health Perspect 2003;111:1861–70.
Ober C, Hoffjan S. Asthma genetics 2006: the long and winding road to gene discovery.Genes Immun 2006;7:95-100.
O'Byrne PM, Barnes PJ, Rodriguez-Roisin R, et al. Low dose inhaled budesonide and formoterol in mild persistent asthma: the OPTIMA randomized trial. Am J Respir Crit Care Med 2001; 164: 1392-1397.
Oosterlee A, Drijver M, Lebret E, Brunekreef B. Chronic respiratory symptoms in children and adults living along streets with high traffic density. Occup Environ Med 1996;53:241-7.
Oddy WH, de Klerk NH, Sly PD, et al. The effects of respiratory infections, atopy, and breastfeeding on childhood asthma. Eur Respir J 2002;19:899-905.
Oddy WH. Breastfeeding and asthma in children: findings from a West Australian study. Breastfeed Rev 2000;8:5-11.
Oswald H, Phelan PD, Lanigan A, et al. Childhood asthma and lung function in mid-adult life. Pediatr Pulmonol 1997;23:14-20.
Pal R, Dahal S, Pal S. Prevalence of Bronchial asthma in Indian children. Indian Journal of Community Medicine. 2009;34 (4): 310-316.
Panettieri RA, Ronina Covar, Evalyn Grant, Elizabeth V. Hillyer, Leonard Bacharier. Natural history of asthma: Persistence versus progression—does the beginning predict the end? Patient Education and Counseling 2008; 121(3):607-613.
Paramesh H. Air pollution and child health. Academy Today, January 2001.
Paramesh H. Epidemiology of asthma in India. Indian J Ped 2002;69:309–12.
Pearce N, Pekkanen J, Beasley R. How much asthma is really attributable to atopy? Thorax
1999;54:268-72.
Pearson RS. Asthma in Barbados. Clin allergy 1973;3:289-97.
Peat JK, Salome CM, Sedgwick CS, Kerrebijn J, Woolcock AJ. A prospective study of bronchial hyperresponsiveness and respiratory symptoms in a population of Australian schoolchildren. Clin Exp Allergy 1989;19:299-306.
Peckham C, Butler N. A national study of asthma in childhood. J Epidemiol Community Health 1978;32:79-85.
Perel P, Casas JP, Ortiz Z, Miranda JJ. Noncommunicable diseases and injuries in Latin America and the Caribbean: time for action. PLoS Medicine 2006;3:e344.
Phelan PD, Robertson CF, Olinsky A. The Melbourne Asthma Study: 1964–1999. J Allergy Clin Immunol 2002;109:189-94.

Pistelly R. Wood smoke and asthma: a controversial issue. Am J Respir Crit Care Med 1997; 155: A941.
Platts-Mills TA. Role of allergens in asthma and airway hyperresponsiveness: relevance to
immunotherapy and allergen avoidance. In: Kaliner MA, Persson CG, eds. Asthma: its pathology and treatment. New York: Marcel Dekker; 1991.
Pokharel PK, Kabra SK, Kapoor SK, Pandey RM. Risk factors associated with bronchial asthma in school going children of rural Haryana. Indian J Pediatr 2001; 68:103-106.
Prescott SL, King B, Strong TL, et al. The value of perinatal immune responses in predicting allergic disease at 6 years of age. Allergy 2003;58:1187-94.
Rabe KF, Vermeire PA, Soriano JB, et al. Clinical management of asthma in 1999: the Asthma Insights and Reality in Europe (AIRE) study. Eur Respir J 2000; 16:802–807.
Reddy KS. 2003. Prevention and Control of Non-Communicable Diseases: Status and Strategies. Working paper No. 104. Indian Council for Research on International Economic Relations, New Delhi.
Reddy KS. Cardiovascular disease in non-Western countries. The New England Journal of Medicine 2004;350:2438–2440.
Reddy TS, Guleria R, Sinha S, Sharma SK, Pande JN. Domestic cooking fuel and lung functions in healthy non-smoking women. Indian J Chest Dis Allied Sci 2004; 46: 85-90.
Rietveld S, van Beest I, Everaerd W. Stressinduced breathlessness in asthma. Psychol Med 1999;29:1359-66.
Roche WR. Inflammatory and structural changes in the small airways in bronchial asthma. Am J Respir Crit Care Med 1998;157:S191-4.
Romieu I, Torrent M, Garcia-Esteban R, et al. Maternal fish intake during pregnancy and atopy and asthma in infancy. Clin Exp Allergy 2007;37:518-25.
Roorda RJ, Gerritsen J, van Aalderen WM, et al. Follow-up of asthma from childhood to adulthood: influence of potential childhood risk factors on the outcome of pulmonary function and bronchial responsiveness in adulthood. J Allergy Clin Immunol 1994;93:575-84.
Rutten-van Molken MP, van Doorslaer EK, Rutten FF. Economic appraisal of asthma and COPD care: a literature review 1980-91. Soc Sci Med 1992;35:161-75.
Sandberg S, Paton JY, McCann DC, et al. The role of acute and chronic stress in asthma attacks in children. Lancet 2000;356:982–87.
Salvi SS, Frew A, Holgate S. Is diesel exhaust a cause for increasing allergies? Clin Exp Allergy 1999;29:4-8.
Saxena S. Dayal V . Emergency Enviornment. Monitor. 1997. 93-102.
Schaub B, Lauener R, von Mutius E. The many faces of the hygiene hypothesis. J Allergy Clin Immunol 2006;117:969-77.
Schaubel D, Johansen H, Mao Y, et al. Risk of preschool asthma: incidence, hospitalization, recurrence, and readmission probability. J Asthma 1996;33:97-103.
Schwartz J, Weiss ST. Relationship of skin test reactivity to decrements in pulmonary function in children with asthma or frequent wheezing. Am J Respir Crit Care Med 1995;152:2176-80.
Sears MR, Burrows B, Flannery EM, et al. Atopy in childhood. I. Gender and allergen related risks for development of hay fever and asthma. Clin Exp Allergy 1993; 23:941-8.
Sears MR, Burrows B, Flannery EM, et al. Relation between airway responsiveness and serum IgE in children with asthma and in apparently normal children. N Engl J Med 1991;325:1067-71.
Sears MR, Greene JM, Willan AR, et al. A longitudinal, population-based, cohort study of childhood asthma followed to adulthood. N Engl J Med 2003; 349:1414-22.
Sears MR, Greene JM, Willan AR, et al. Long-term relation between breastfeeding and development of atopy and asthma in children and young adults: a longitudinal study. Lancet 2002;360:901-7.
Sears MR, Herbison GP, Holdaway MD, et al. The relative risks of sensitivity to grass pollen, house dust mite and cat dander in the development of childhood asthma. Clin Exp Allergy 1989;19:419-24.
Sears MR, Holdaway MD, Flannery EM, et al. Parental and neonatal risk factors for atopy, airway hyper-responsiveness, and asthma. Arch Dis Child 1996;75:392-8.
Sears MR. Growing up with asthma. BMJ 1994;309:72-3.
Segal R, Ried LD, Mackowiak J. Cost of asthma illnesses: emergency department visits without admission. Pharm Pract Manag Q 1995; 15: 72–82.
Selroos O, Pietinalho A, Lofroos AB, et al. Effect of early vs late intervention with inhaled corticosteroids in asthma. Chest 1995;108:1228-34.
Shahid S, Bhinder GS, Dhanjal JK. Knowledge, Attitudes and Practices (KAP) of Primary care physicians of Central Mumbai Suburbs about childhood asthma. The Internet Journal of asthma, allergy and Immunology 2007;6(1).
Shabaraya RK, Vishnusharma A, Rajendran SD, Suresh B. Impact of patient education on pulmonary function outcomes in Asthmatic patients IJHP, 2008; 45: 16-19.

Sharma SK, Banga A. Prevalence and risk factors for wheezing in children from rural areas of North India. Allergy Asthma Proc 2007;28:647-53

Sherrill D, Sears MR, Lebowitz MD, et al. The effects of airway hyperresponsiveness, wheezing, and atopy on longitudinal pulmonary function in children: a 6-year follow-up study. Pediatr Pulmonol 1992;13:78-85.

Sigurs N, Gustafsson PM, Bjarnason R, et al. Severe respiratory syncytial virus bronchiolitis in infancy and asthma and allergy at age 13. Am J Respir Crit Care Med 2005;171:137-41.

Simpson A, Custovic A. Pets and the development of allergic sensitization. Curr Allergy Asthma Rep 2005;5:212-20.

Singh D, Sobti PC, Arora V, Soni RK. Epidemiological study of asthma in rural children. Indian J Community Med 2002; 27:167-170.

Singh H, Soni RK, Gill PJS. Epidemiological and risk factors in childhood bronchial asthma. Indian J Community Med 1998; 23:42-44.

Singh RB. Symposium: international conference on health care delivery for asthma. Asthma in India. Proceedings of the 58th annual Meeting of the American academy of allergy, Asthma and Immunology; March 1-6, New York, NY:2002.

Singh V, Khandelwal R, Bohra S, Gupta R, Gupta BS. Evaluation of communication skills of physicians about asthma. J Assoc Physicians India 2002; 50:1266-1269.

Singh V, Wisniewski A, Britton J, Tattersfield A. Effect of yoga breathing exercises (Pranayama) on airway reactivity in subjects with asthma. Lancet 1990; 335: 1381-1383.

Singh M, Singh SP, Singh K, et al. Prevalence of bronchial asthma among school children in urban and rural areas. Chest 2004;126:762S

Skobeloff EM, Spivey WH, St Clair SS, et al. The influence of age and sex on asthma admissions. JAMA 1992;268:3437-40.

Smith KR. National Burden of disease in India from indoor air pollution. 2000. Proc Natl Acad Sci USA. Nov 21, 97(24). 13286-93.

Smith KR. 2002. Indoor air pollution in developing countries: recommendations for research. Int J Indoor Environ Health 12:1–7.

Somasekhar AR, Paramesh H. Prevalence of under-diagoned asthma in adolescents. Proceedings of XXXIX National Conference of Indian Academy of Pediatrics; Bangalore, India:2002.

Sporik R, Holgate ST, Platts-Mills TA, Cogswell JJ. Exposure to house-dust mite allergen (Der p I) and the development of asthma in childhood. A prospective study. N Engl J Med 1990;323:502-7.

Steering committee of the International study of asthma and allergies in childhood (ISAAC). World wide prevalence of symp-toms of asthma, allergic rhinoconjunctivitis and atopic asthma. Lancet 1998; 351:1221-1232.

Stein RT, Holberg CJ, Sherrill D, et al. Influence of parental smoking on respiratory symptoms during the first decade of life: the Tucson Children's Respiratory Study. Am J Epidemiol 1999;149:1030-7.

Stick SM, Burton PR, Gurrin L, et al. Effects of maternal smoking during pregnancy and a family history of asthma on respiratory function in newborn infants. Lancet 1996;348:1060-4.

Strachan DP, Anderson HR, Limb ES, et al. A national survey of asthma prevalence, severity, and treatment in Great Britain. Arch Dis Child 1994;70:174-8.

Subbarao P, Mandhane PJ, Sears MR. Asthma: epidemiology, etiology and risk factors, CMAJ 2009. DOI:10.1503/cmaj.080612

Subramanian SV, Ackerson LK, Subramanyam MA, Wright RJ. Domestic Violence is associated with adult and childhood asthma prevalence in india. International Journal of Epidemiology 2007; 36: 569-579.

Subramanian SV, Kennedy MH (2009) Perception of Neighborhood Safety and Reported Childhood Lifetime Asthma in the United States (U.S.): A Study Based on a National Survey. PLoS ONE 4(6): e6091. doi:10.1371/journal.pone.0006091

Suissa S, Ernst P, Benayoun S, Baltzan M, Cai B. Low-dose inhaled corticosteroids and the prevention of death from asthma. N Engl J Med 2000;343:332-6.

Sullivan S, Elixhauser A, Buist AS, et al. National Asthma Education and Prevention Program working group report on the cost effectiveness of asthma care. Am J Respir Crit Care Med 1996; 154:S84–S95

Szefler SJ, Martin RJ, King TS, et al. Significant variability in response to inhaled corticosteroids for persistent asthma. J Allergy Clin Immunol 2002; 109: 410-418.

Takkouche B, Gonzalez-Barcala FJ, Etminan M, et al. Exposure to furry pets and the risk of asthma and allergic rhinitis: a meta-analysis. Allergy 2008;63:857-64.

Tariq SM, Arshad SH, Matthews SM, et al. Elevated cord serum IgE increases the risk of aeroallergen sensitization without increasing respiratory allergic symptoms in early childhood. Clin Exp Allergy 1999;29:1042-8.

Tariq SM, Hakim EA, Matthews SM, et al. Influence of smoking on asthmatic symptoms and allergen sensitisation in early childhood. Postgrad Med J 2000; 76:694-9.

Tashkin DP, Altose MD, Bleecker ER, et al. The Lung Health Study: airway responsiveness to inhaled methacholine in smokers with mild to moderate airflow limitation. The Lung Health Study Research Group. Am Rev Respir Dis 1992;145:301-10.

Tavendale R, Macgregor DF, Mukhopadhyay, et al. A polymorphism controlling ORMDL3 expression is associated with asthma that is poorly controlled by current medications. J Allergy Clin Immunol 2008;121:860-3.

Taylor DR, Fergusson DM, Milne BJ, et al. A longitudinal study of the effects of tobacco and cannabis exposure on lung function in young adults. Addiction 2002;97: 1055-61.
Tetrault JM, Crothers K, Moore BA, et al. Effects of marijuana smoking on pulmonary function and respiratory complications: a systematic review. Arch Intern Med 2007;167:221-8.
The International study of asthma and allergies in childhood (ISAAC) steering committee. World wide prevalence of symptoms of asthma, allergic rhino-conjunctivitis and atopic asthma. Lancet 1998; 351:1225-1235.
The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee. Worldwide variations in the prevalence of asthma symptoms: the International Study of Asthma and Allergies in Childhood (ISAAC). Eur Respir J 1998; 12: 315-35.
To T, Dick P, Feldman W, et al. A cohort study on childhood asthma admissions and readmissions. Pediatrics 1996;98:191-5.
Trawick DR, Holm C, Wirth J. Influence of gender on rates of hospitalization, hospital course, and hypercapnea in high-risk patients admitted for asthma: a 10-year retrospective study at Yale-New Haven Hospital. Chest 2001;119:115-9.
Van Ganse E, Laforest L, Pietri G, et al. Persistent asthma: disease control, resource utilisation and direct costs. Eur Respir J 2002; 20: 260–267.
Vishwanathan R, Prasad M, Thakur AK, et al. Epidemiology of asthma in urban population: A random morbidity survey. J Indian Med Assoc 1966;46:480-3
Von Behren J, Kreutzer R, Smith D. Asthma hospitalization trends in California,1983-1996. J Asthma 1999;36:575-82.
von Mutius E. The environmental predictors of allergic disease. J Allergy Clin Immunol 2000;105:9-19.
von Mutius E, Martinez FD, Fritzsch C, Nicolai T, Roell G, Thiemann HH. Prevalence of asthma and atopy in two areas of West and East Germany. Am J Respir Crit Care Med 1994;149:358-64.
Vonk JM, Boezen HM.Predicting adult asthma in childhood. Curr Opin Pulm Med. 2006 Jan;12(1):42-7.
Walker BJ, Stokes LD, Warren R. Environmental factors associated with asthma. J Natl Med Assoc 2003;95:152–66.
Wallin A, Sandstrom T, Soderberg M, et al. The effects of regular inhaled formoterol, budesonide, and placebo on mucosal inflammation and clinical indices in mild asthma. Am J Respir Crit Care Med 1999; 159: 79-86.
Weinberg E. G. Urbanization and childhood asthma: An African perspective; Journal of Allergy and Clinical Immunology; 2000;105(2):224-231.
Wieringa MH, Weyler JJ, Van Bastelaer FJ, et al. Higher asthma occurrence in an urban than a suburban area: role of house dust mite skin allergy. Eur Respir J 1997;10:1460-6.
Weiss KB, Sullivan SD. The health economics of asthma and rhinitis. I. Assessing the economic impact. J Allergy Clin Immunol 2001;107:3-8.
Weiss KB, Wagener DK. Changing patterns of asthma mortality: identifying target populations at high risk. J Am Med Assoc 1990;264:1683–87.
Weiss KG, Sullivan SD, Lyttle CS. Trends in the cost of illness for asthma in the United States. J Allergy Clin Immunol 2000;106:493-9
Weiss ST, Sparrow D, O'Connor GT. The interrelationship among allergy, airways responsiveness, and asthma. J Asthma 1993;30:329-49.
Weiss ST. Gene by environment interactions and asthma. Clin Exp Allergy 1999;29(suppl 2):96–99.
WHO Fact Sheet No206; Revised January 2000 (available at https://apps.who.int/inf-fs/en/fact206.html)
www.who.int/respiratory/asthma/en
www.asthma. ac.psiweb.com
www.asthmainamerica.com).
Wickman M, Ahlstedt S, Lilja G, et al. Quantification of IgE antibodies simplifies the classification of allergic diseases in 4-year-old children. A report from the prospective birth cohort study – BAMSE. Pediatr Allergy Immunol 2003;14:441-7.
Wilkins K, Mao Y. Trends in rates of admission to hospital and death from asthma among children and young adults in Canada during the 1980s. CMAJ 1993; 148:185-90.
Willemsen G, van Beijsterveldt TCEM, van Baal CGCM, et al. Heritability of selfreported asthma and allergy: a study in adult Dutch twins, siblings and parents.Twin Res Hum Genet 2008;11:132-42.
Willers SM, Devereux G, Craig LC, et al. Maternal food consumption during pregnancy and asthma, respiratory and atopic symptoms in 5-year-old children. Thorax 2007; 62:773-9.
Williams H, McNicol KN. Prevalence, natural history, and relationship of wheezy bronchitis and asthma in children. An epidemiological study. BMJ 1969;4:321-5.
Wong GWK, Chan-Yeung M. Asthma epidemiology. In: Ip M, Chan-Yeung M, Lam WK, Zhong NS, editors. Respirator medicine: an Asian perspective, 1st ed. Hong Kong SAR China: Hong Kong University Press; 2005 p. 3-23.
World Health Organization. The global burden of disease: 2004 update. Geneva, WHO, 2008. Available at www.who.int/evidence/bod
World Health Organization. WHO factsheet 206: bronchial asthma. Available at: www.who.int/mediacentre/factsheets/fs206/en.

Wright AL, Holberg CJ, Taussig LM, et al. Maternal asthma status alters relation of infant feeding to asthma in childhood. Adv Exp Med Biol 2000;478:131-7.
Wright R, Rodriguez M, Cohen S. Review of psychosocial stress and asthma: an integrated biopsychosocial approach. Thorax 1998;53:1066–74.
Wright RJ, Cohen RT, Cohen S. The impact of stress on the development and expression of atopy. Curr Opin Allergy Clin Immunol 2005;5:23–9.
Wright RJ, Cohen S, Carey V, et al. Parental stress as a predictor of wheezing in infancy: a prospective birth-cohort study. Am J Respir Crit Care Med 2002; 165:358-65.
Wright RJ, Fisher EB. Putting asthma into context: community influences on risk, behavior, and intervention. In: Kawachi I, Berkman LF (eds). Neighborhoods and Health. New York: Oxford University Press, 2003.
Wright RJ, Wright RO, Finn P et al. Chronic caregiver stress and IgE expression, allergen-induced proliferation, and cytokine profiles in a birth cohort predisposed to atopy. Am J Allergy Clinl Immunol 2004;113:1051–57.
www.asthma.partners.org
www.buteyko.co.nz/asthma/facts/types.cfm
Xu B, Pekkanen J, Hartikainen AL, et al. Caesarean section and risk of asthma and allergy in adulthood. J Allergy Clin Immunol 2001;107:732-3.
Xu X, Niu T, Christiani DC, et al. Occupational and environmental risk factors for asthma in rural communities in China. Int J Occup Environ Health 1996; 2: 172–176.
Yeatts K, Sly P, Shore S, et al. A Brief Targeted Review of Susceptibility Factors, Environmental Exposures, Asthma Incidence, and Recommendations for Future Asthma Incidence Research; Environmental Health Perspectives. 114(4). 2006.
Yusuf S, Reddy S, Ounpuu S, Anand S. Global burden of cardiovascular diseases: Part I: general considerations, the epidemiologic transition, risk factors, and impact of urbanization. Circulation. 2001;104(22):2746-53.
Zannolli R, Morgese G. Does puberty interfere with asthma? Med Hypotheses 1997; 48:27-32.
Zock JP, Heinrich J, Jarvis D, et al. Distribution and determinants of house dust mite allergens in Europe: the European Community Respiratory Health Survey II. J Allergy Clin Immunol 2006;118:682-90.