

Review article

Is atopy a protective or a risk factor for cancer? A review of epidemiological studies

Objective: There is an ongoing debate whether there is a link between a history of atopy and cancer risk. The purpose of this paper is to review the published epidemiological studies on the association between atopy and the risk of cancers.

Methods: Through an electronic search (January 1986–April 2004) with an additional review of cited references, we identified studies with quantitative data on the relation of atopy (irrespective of its definition or subtype) to cancer (different cancer sites).

Results: The protective effect of atopy in colorectal cancer has been observed consistently in the case–control studies, but not in cohort studies. A consistent inverse association between self-reported atopy and glioma risk has been shown, but there is absence of such an association for meningioma. In most studies, the risk of leukaemia, in particular childhood leukaemia, tends to be lower among people with a history of atopy. Studies, which looked at, the association between atopic diseases and risk of cancers of pancreatic, breast, lymphoma showed varying outcomes. Most studies on the atopy–pancreatic cancer relation suggested an inverse association. For lymphoma, most studies have shown no substantial association. Overall evidence indicates an increased risk of lung cancer among persons with a history of asthma.

Conclusion: Despite the mixed results, the emerging picture from most of the currently available epidemiological data indicate that atopic disease is associated with a reduced risk for cancer. Further research should focus on a more carefully defined ‘atopy’ status and manifestation of different atopic diseases, to advance our understanding of the role that allergies might play in the risk of developing cancer.

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The prevalence of atopic disorders has been increasing over recent decades. It has been speculated that atopy influences other aspects of health besides the allergic response, such as insulin-dependent diabetes mellitus, cardiovascular disease and cancer (1). With regards to cancer, atopy has been postulated to play either a protective role or to be a risk factor owing to enhanced or deficient immune surveillance.

Epidemiological studies published before 1985 generally supported a decreased risk of cancer with atopy (2). Of these, 11 studies found an inverse association, three studies showed no association and two studies reported an increase risk. This paper reviews the growing epidemiological evidence of the relationship between atopy and cancer risk since 1985.

Methods

MEDLINE was searched electronically from January 1986 to April 2004 to obtain all publications with quantitative data on

the association between atopy (irrespective of its definition or subtype) and risk of cancer. We included the term allergy, because this has often been used as overlapping the atopic diseases. The articles were identified using the key words ‘atopy, allergy, asthma, hay fever or dermatitis’ and ‘cancer, neoplasm’. A manual search was also performed through checking the cited references in the publications that were retrieved. In total, 66 studies were identified. The articles were grouped according to cancer sites; if more than one cancer site was studied, the relevant information was abstracted and allocated to the respective site/type. We then tabulated the results in terms of associations between atopy (including subtypes of atopy) and cancer in terms of relative risks (RR) or odds ratios (OR).

Results

All the studies that we identified are summarized in Tables 1–9, grouped according to the cancer sites/types. We found more than one publication with original, quantitative data on the association of atopy with, respectively, colorectal cancer, pancreatic cancer, breast

Table 1. Studies of association between atopy and colorectal cancer (in alphabetical order)

Reference	Study, country	Types of study	Number of cases	Exposure	Relative risk (RR)/odds ratio (OR) (95% CI)
(3)	Kune et al. (1988), Australia	Case-control; population-based	715	Asthma Allergies or hay fever	0.9 (0.6–1.3) 0.8 (0.7–1.0)
(4)	La Vecchia et al. (1991), Italy	Case-control; hospital-based	1078	Drug allergy	0.6 (0.4–0.9) (colon) 0.6 (0.4–1.0) (rectum)
(6)	McWhorter (1988), United States	Cohort	45	Allergy	1.7 (0.9–3.1)
(7)	Mills et al. (1992), United States	Cohort	196	Allergy	1.0 (0.7–1.3) (colon) 0.9 (0.5–1.4) (rectum)
(5)	Negri et al. (1999), Italy	Case-control; hospital-based	2053	Allergy	0.9 (0.7–1.1) (colon) 0.6 (0.4–0.9) (rectum)
(8)	Talbot-Smith et al. (2003), Australia	Cohort	82	Asthma: M/F Hay fever: M/F Atopy: M/F	0.4 (0.1–3.2)/0.4 (0.1–2.8) 0.8 (0.2–2.7)/1.1 (0.5–2.5) 0.3 (0.0–2.8)/1.4 (0.4–4.0)

cancer, lung cancer, brain cancer, leukaemia, non-Hodgkin lymphoma (NHL). In addition, we identified a rest-group of other cancer sites, often in the context of studies that did not *a priori* define a specific cancer site or type, but looked at cancer in general.

Colorectal cancer

An inverse association between atopic disease and colorectal cancer risk has been observed consistently in the case-control studies (Table 1). Asthma, hay fever or allergic disease in general were observed to be protective factors in a population-based case-control study on 715 cases of colorectal cancer in Australia (3). A hospital-based case-control study in the Greater Milan area included 1078 cases and 1501 controls (4); the OR among patients with drug allergy was 0.6 [95% confidence interval (CI): 0.4–0.9] for colon cancer, and 0.6 (95% CI: 0.4–1.0) for cancer of the rectum.

Another hospital-based study in Italy from 1992 to 1996 (5) also suggested a protective role of allergic disorders for colorectal cancer. The cases were 1225 patients with newly diagnosed histologically confirmed colon cancer and 728 cases of cancer of the rectum. The 4154 control subjects were matched for age and sex. Among persons with a history of any allergy, the risk for colon cancer was 0.9 (95% CI: 0.7–1.1) and for rectal cancer was 0.6 (95% CI: 0.4–0.9). The study did not distinguish between different types of allergies and used self-reported information on the history of atopy; this may have introduced a certain degree of misclassification.

In contrast, cohort studies do not clearly confirm atopy as a protective factor for colorectal cancer. A prospective study using the data of the first National Health and Nutrition Examination Survey (NHANES I) reported for any type of allergy an RR for colorectal cancer of 1.7 (95% CI: 0.9–3.1) based on 45 cases, but the small numbers precluded a meaningful analysis (6). Another cohort study of more than 34 000 Seventh-day Adventists

in California found an RRH of 1.0 (95% CI: 0.7–1.3) for colon cancer ($n = 138$) and 0.9 (95% CI: 0.5–1.4) for cancer of the rectum ($n = 58$) (7). The cohort study based on the Busselton Health Survey (8) did not a priori focus on colorectal cancer, but found among men a protective, although nonsignificant, trend for asthma, hay fever and 'any atopy'.

Pancreatic cancer

The studies, which looked at the association between atopic disease and risk for pancreatic cancer, had varying outcomes (Table 2). A case-control study in the United States (9) found that previous allergic disease resulted in a 60% risk reduction (OR 0.4, 95% CI: 0.2–0.7). Another population-based case-control study in the USA found the OR to be 0.7 (95% CI: 0.4–1.1) among those with a history of asthma (10) and also a Canadian case-control study suggested that there was a protective effect (but not statistically significant) of a history of hay fever, eczema and asthma (11).

A case-control study in the Netherlands, which recruited 176 cases and 487 matched controls also reported a decrease in the risk of pancreatic cancer in association with 'allergy' (OR 0.6, 95% CI: 0.4–0.9) (12). The risk was not significantly decreased for eczema when the subcategories of 'allergy' were examined separately. A case-control study in Athens (13) detected an inverse association between asthma and pancreatic cancer risk, with a RR of 0.3 ($P = 0.3$). A history of various allergic reactions resulted in a slight, nonsignificant reduction among Californian Seventh-day Adventists (14).

A lower risk of pancreatic cancer was detected in a population-based case-control study in China (108 cases and 275 matched controls) among those who reported a history of any type of allergy (OR 0.6, 95% CI: 0.4–1.1) (15).

The combined history of any allergic condition was associated with a decreased risk (OR 0.7, 95%

Table 2. Studies of association between atopy and pancreatic cancer (in alphabetical order)

Reference	Study, country	Types of study	Number of cases	Exposure	Relative risk (RR)/ odds ratio (OR) (95% CI)
(12)	Bueno de Mesquita et al. (1992), the Netherlands	Case-control; population-based	176	Allergy	0.6 (0.4–0.9)
				Eczema	0.8 (0.4–1.3)
				Asthma, hay fever and other allergy	0.4 (0.2–0.8)
(15)	Dai et al. (1995), China	Case-control; population-based	108	Allergy	0.6 (0.4–1.1)
				Drug	1.1 (0.5–2.4)
				Food	0.3 (0.0–2.6)
				Contact dermatitis	0.5 (0.1–1.7)
				Urticaria	0.5 (0.2–1.3)
				Asthma	1.0 (0.3–3.2)
				Allergic rhinitis	0.3 (0.1–1.4)
(18)	Farrow and Davis (1990), United States	Case-control; population-based	148	Medication	1.7 (1.0–3.0)
				Food	2.1 (0.8–5.5)
				Plant	0.7 (0.3–1.8)
				Animal	1.2 (0.4–3.4)
(9)	Gold et al. (1985), United States	Case-control; hospital-based	201	Allergy	0.4 (0.2–0.7)
(17)	Holly et al. (2003), United States	Case-control; population-based	532	Allergy	0.8 (0.6–1.0)
				Eczema	0.7 (0.5–0.9)
				Dust	0.7 (0.5–0.9)
				Plants	0.8 (0.6–1.0)
				Mould	0.5 (0.3–0.8)
				Animal	0.7 (0.5–0.9)
				Insect bite/sting	0.7 (0.4–1.0)
				Food	0.7 (0.5–1.1)
(11)	Jain et al. (1991), Canada	Case-control; population-based	249	Hay fever	0.5 (0.2–1.3)
				Eczema	0.7 (0.3–1.5)
				Asthma	0.5 (0.2–1.7)
				Other allergies	1.3 (0.7–2.3)
(13)	Kalapothaki et al. (1993), Athens	Case-control; hospital-based	181	Asthma	0.33 ($P = 0.28$)
(19)	La Vecchia et al. (1990), Italy	Case-control; hospital-based;	247	Drug	1.0 (0.6–1.6)
(10)	Mack et al. (1986), United States	Case-control; population-based	490	Asthma	0.7 (0.4–1.1)
				Eczema	0.2 (0.1–0.5)
				Allergy	0.6 (0.4–0.8)
(6)	McWhorter (1988), United States	Cohort study	11	Allergy	1.7 (0.5–5.8)
(14)	Mills et al. (1988), United States	Cohort	40	Hay fever	0.9 (0.2–3.6)
				Asthma	0.7 (0.2–1.9)
				Poison ivy	1.0 (0.4–2.3)
				Bee sting	0.4 (0.1–3.2)
				Medication	0.7 (0.1–6.0)
				Chemicals	1.5 (0.4–6.3)
(16)	Silverman et al. (1999), United States	Case-control; population-based	484	Allergy	0.7 (0.5–0.9)
				Hay fever	0.6 (0.5–0.9)
				Asthma	1.0 (0.6–1.5)
				Eczema	1.1 (0.7–1.9)
				Animal	0.5 (0.2–1.1)
				Insect bite/sting	0.8 (0.6–1.2)
				Dust or mould	0.6 (0.3–1.1)
				Drug	1.4 (1.0–1.9)
				Household products	1.5 (0.8–2.9)

CI: 0.5–0.9) in a case-control study in the USA of 484 cases pancreatic cancer and 2099 controls (16). This study indicated lower risks for those with a history of hay fever (OR 0.6, 95% CI: 0.5–0.9), allergy to animals (OR 0.5, 95% CI: 0.2–1.1), dust/moulds (OR 0.6, 95% CI: 0.3–1.1) and stings (OR 0.8, 95% CI: 0.6–1.2). Nevertheless, the investigators suggested that these

associations may be due to the chance, as no significant differences were found between cases and controls for asthma, eczema and several other types of allergies.

A large population-based case-control study conducted in the San Francisco Bay area between 1994 and 2001 was supportive of a protective effect of a history of

Table 3. Studies of association between atopy and breast cancer (in alphabetical order)

Reference	Study, country	Types of study	Number of cases	Exposure	Relative risk (RR)/odds ratio (OR) (95% CI)
(20)	Eriksson et al. (1995), Sweden	Cohort	7 premenopausal	Atopy	4.8 (1.9–9.9)
(22)	Hedderson et al. (2003), United states	Case-control; population-based	747	Allergy	1.3 (0.9–1.8) (<35 years) 0.8 (0.6–1.0) (>35 years)
(6)	McWhorter (1988), United States	Cohort	34	Allergy	1.2 (0.6–2.4)
(7)	Mills et al. (1992), United States	Cohort	215	Asthma	1.2 (0.7–2.0)
				Hay fever	1.3 (1.0–1.9)
				Allergy	1.2 (0.9–1.6)
(21)	Petroianu et al. (1995), Brazil	Case-control; neighbourhood	49	Allergy	Not given
(8)	Talbot-Smith et al. (2003), Australia	Cohort	86	Asthma	1.1 (0.5–2.6)
				Hay fever	0.9 (0.5–1.7)
				Atopy	1.4 (0.6–3.4)
(2)	Vena et al. (1985), United States	Case-control; population-based	1835	Asthma	1.0 ($P > 0.05$)
				Hay fever	0.9 ($P > 0.05$)
				Other allergy	0.8 ($P > 0.05$)

Table 4. Studies of association between atopy and lung cancer (in alphabetical order)

Reference	Study, country	Types of study	Number of cases	Exposure	Adjust for smoking	Relative risk (RR)/odds ratio (OR) (95% CI)
(24)	Alavanja et al. (1992), United States	Case-control; population-based	618	Asthma	Yes	1.3 (0.8–2.1)
(35)	Boffetta et al. (2002), Sweden	Cohort	713	Asthma	No	1.6 (1.5–1.7)
(27)	Brenner et al. (2001), China	Case-control; population-based	886	Asthma	Yes	2.1 (1.5–3.0)
(32)	Brownson and Alavanja (2000), United States	Case-control; population-based	676	Asthma	Yes	1.1 (0.7–1.7)
(36)	Huovinen et al. (1997), Finland	Cohort	471	Asthma	Yes	3.2 (1.4–7.3)
(37)	Lange et al. (1996), Denmark	Cohort	315	Asthma	Yes	1.3 (0.7–2.3)
(26)	Mayne et al. (1999), United States	Case-control; population-based	437	Asthma	Yes	2.1 (1.0–4.1) 1.1 (0.5–2.6) (nonsmoking)
(7)	Mills et al. (1992), United States	Cohort	62	Allergy	Yes	1.2 (0.4–3.3)
(30)	Osann et al. (2000), United States	Case-control; population-based	217	Asthma and hay fever	Yes	0.5 (0.3–1.0)
(33)	Osann (1991), United States	Case-control; population-based	98	Asthma	Yes	4.8 (1.0–22.8)
(8)	Talbot-Smith et al. (2003), Australia	Cohort	37	Asthma: M/F Hay fever: M/F Atopy: M/F	Yes	1.1 (0.2–9.1)/1.0 (0.1–7.5) 0.6 (0.1–4.9)/1.5 (0.4–5.3) 0.3 (0.0–2.5)/0.9 (0.1–9.9)
(29)	Reynolds and Kaplan (1987), United states	Case-control; population-based	60	Asthma	Yes	6.3 ($P < 0.01$)
(23)	Vena et al. (1987), United States	Case-control; population-based	1052	Asthma: M/F	No	1.6 ($P < 0.05$)/1.7 ($P < 0.05$)
(34)	Vesterinen et al. (1993), Finland	Cohort	648	Asthma	No	1.3 (1.2–1.4)
(31)	Wu et al. (1988), United States	Case-control; population-based	336	Asthma	Yes	1.0 (0.5–2.1)
(25)	Wu et al. (1995), United states	Case-control; population-based	412	Asthma	Yes	1.7 (1.1–2.5)

allergic conditions (OR 0.8, 95% CI: 0.6–1.0) (17). Similar patterns in risk reduction were observed for common allergies, such as for house dust (OR 0.7, 95% CI: 0.5–0.9), cats (OR 0.6, 95% CI: 0.4–0.9), plants (OR 0.8, 95% CI: 0.6–1.0) and mould (OR 0.5, 95% CI: 0.3–0.8). Trends of risk reduction were seen with increasing

number of allergies ($P < 0.001$) and severity of allergic symptoms ($P = 0.003$).

In contrast, a population-based case-control study among men living in Washington suggested an increased risk for pancreatic cancer with medication allergy (OR 1.7, 95% CI: 1.0–3.0), food allergy (OR 2.1, 95% CI: 0.8–5.5) or

Table 5. Studies of association between atopy and adult primary brain tumour (in alphabetical order)

Reference	Study, country	Types of study	Cases	Allergy	Asthma	Hay fever	Eczema
(44)	Brenner et al. (2002), United States	Case-control; hospital-based	489 glioma	0.7 (0.5–0.9)	0.6 (0.4–0.9)	1.0 (0.7–1.4)	0.8 (0.5–1.3)
			197 meningioma	1.0 (0.7–1.4)	0.8 (0.5–1.4)	0.9 (0.6–1.5)	0.8 (0.4–1.5)
			96 acoustic neuroma	1.0 (0.6–1.6)	1.3 (0.7–2.5)	2.4 (1.4–4.0)	0.9 (0.3–2.5)
(39)	Cicuttini et al. (1997), Australia	Case-control; population-based	416 glioma	Not given	0.8 (0.5–1.2)	Not given	0.9 (0.5–1.4)
(38)	Hochberg et al. (1990), United States	Case-control; population-based	160 astrocytomas	0.6 (0.4–1.0)	Not given	Not given	Not given
(40)	Ryan et al. (1992), Australia	Case-control; population-based	110 glioma	0.5 (0.3–0.9)	0.4 (0.1–1.2)	Not given	0.2 (0.1–0.9)
			60 meningioma	1.1 (0.6–2.0)	1.1 (0.4–2.8)	Not given	0.6 (0.2–1.7)
(41)	Schlehofer et al. (1992), Germany	Case-control; population-based	115 glioma	0.7 (0.5–1.0)	Not given	Not given	Not given
			81 meningioma				
			30 acoustic neuroma				
(42)	Schlehofer et al. (1999), Germany	Case-control; population-based	1178 glioma	0.6 (0.5–0.7)	0.8 (0.6–1.0)	Not given	0.6 (0.5–0.9)
			331 meningioma	0.9 (0.7–1.2)	0.8 (0.5–1.4)		0.7 (0.4–1.1)
(45)	Schwartzbaum et al. (2003), Sweden	Cohort	I, 37 glioma	0.5 (0.2–1.1)	Not given	0.8 (0.3–2.1)	0.5 (0.2–1.5)
			41 meningioma	0.8 (0.4–1.7)		0.9 (0.4–2.2)	0.7 (0.3–1.7)
			II, 42 glioma	1.1 (0.5–2.5)	Not given	Not given	Not given
			26 meningioma	2.4 (1.1–5.5)			
(43)	Wiemels et al. (2002), United States	Case-control; population-based	405 glioma	0.5 (0.3–0.7)	Not given	Not given	Not given

Table 6. Studies of association between atopy and leukaemia (in alphabetical order)

Reference	Study, country	Types of study	Number of cases	Exposure	Relative risk (RR)/odds ratio (OR) (95% CI)
(50)	Cooper et al. (1996), United States	Case-control; population-based	811	Asthma: AML/ALL	0.7 (0.5–1.2)/0.9 (0.4–1.9)
				Eczema: AML/ALL	1.1 (0.6–2.0)/1.7 (0.7–4.2)
				Hay fever: AML/ALL	1.0 (0.7–1.4)/1.0 (0.6–1.8)
(46)	Linnet et al. (1986), United States	Case-control; hospital-based	342	Hay fever	0.5 (0.3–1.0)
				Eczema	0.7 (0.3–1.5)
				Asthma	1.1 (0.5–2.6)
				Hives	0.7 (0.3–1.6)
				Drug	0.7 (0.4–1.0)
(48)	Linnet et al. (1987), United States	Case-control; hospital-based	100	Allergy	1.0 (0.5–2.3)
(52)	Nishi and Miyake (Japan), 1989	Case-control; hospital-based	63	Atopy	0.3 (0.1–0.8)
(53)	Petridou et al. (1997), Greece	Case-control; hospital-based	153	Allergy	0.4 (0.1–1.4)
(55)	Schuz et al. (2003), Germany	Case-control; population-based	1294	Hay fever: ALL/AML	0.5 (0.3–0.7)/1.0 (0.5–2.1)
				Neurodermatitis: ALL/AML	0.5 (0.3–0.7)/0.8 (0.4–1.7)
				Asthma: ALL/AML	0.6 (0.3–1.4)/
				Contact eczema: ALL/AML	0.6 (0.4–1.0)/0.8 (0.3–2.1)
				Hives: ALL/AML	1.1 (0.6–2.9)/
				Food or drug: ALL/AML	0.8 (0.6–1.2)/0.6 (0.2–1.9)
				Other: ALL/AML	0.6 (0.3–1.1)/0.9 (0.3–3.3)
(47)	Severson et al. (1989), United States	Case-control; population-based	98	Allergy	0.4 (0.2–0.6)
				Bee/insect stings	0.2 (0.1–0.6)
				Food	0.2 (0.1–0.4)
(51)	Spector et al. (2004), United States	Case-control; population-based	180	Asthma	1.6 (0.9–2.9)
				Eczema	1.1 (0.6–2.0)
				Atopy or hives	2.2 (1.2–4.2)
(54)	Wen et al. (2000), United States	Case-control; population-based	1842	Asthma	0.8 (0.6–1.0)
				Hay fever	0.6 (0.5–0.8)
				Food and drug	0.7 (0.6–0.8)
				Eczema	0.7 (0.5–0.9)
				Hives	0.9 (0.7–1.2)
				Allergy	0.7 (0.6–0.8)
(49)	Zheng et al. (1993), China	Case-control; population-based	486	Asthma: ALL	0.5 (0.1–4.2)
				Eczema: ALL	1.7 (0.7–4.5)

AML, acute myelocytic leukaemia; ALL, acute lymphoblastic leukaemia; CI, confidence interval.

animal allergy (OR 1.2, 95% CI: 0.4–3.4) (18). A nonsignificantly elevated risk was reported among persons in the NHANES I follow-up study, but this was based on only 11

cases of pancreatic cancer (6). No association of pancreatic cancer with drug allergy (OR 0.9, 95% CI: 0.6–1.5) was observed in a case-control study in Italy (19).

Table 7. Studies of association between atopy and NHL (in alphabetical order)

Reference	Study, country	Types of study	Histology	Number of cases	Exposure	Relative risk (RR)/ odds ratio (OR) (95% CI)
(57)	Bernstein and Ronald (1992), United States	Case-control; population-based	NHL	619	Eczema: M/F Nuts/berries: M/F Insect bite/sting: M/F	0.6 (0.3–1.2)/0.6 (0.3–1.2) 0.5 (0.2–1.0)/0.8 (0.5–1.4) 0.9 (0.4–1.8)/0.6 (0.4–1.0)
(66)	Briggs et al. (2002), United States	Case-control; population-based	NHL	952	Medication Food Plants Dust Animal Insect bite or sting Allergy	1.0 (0.7–1.4) 1.1 (0.7–1.6) 1.0 (0.8–1.3) 0.9 (0.7–1.2) 1.1 (0.7–1.7) 1.1 (0.5–2.8) 1.0 (0.8–1.2)
(60)	Cartwright et al. (1988), UK	Case-control; hospital-based	NHL	437	Eczema dermatitis	1.6 (1.1–2.4)
(61)	Doody et al. (1992), United States	Case-control; population-based	NHL	100	Hay fever Eczema	0.5 (0.2–1.2) 1.9 (0.6–5.8)
(20)	Eriksson et al. (1995), Sweden	Cohort	NHL	2	Atopy Intermediate Nonatopic Asthma Hives Rhinitis	3.8 (0.5–13.8) 3.4 (0.4–12.2) 1.7 (0.2–6.3) 1.0 (0.0–5.8) 0.0 (0.0–13.6) 2.9 (0.8–7.5)
(62)	Fabbro-Peray et al. (2001), France	Case-control; population-based	NHL	445	Asthma Eczema Hives	0.8 (0.5–1.3) 0.5 (0.3–0.7) 1.7 (1.2–2.2)
(63)	Franceschi et al. (1989), Italy	Case-control; hospital-based	NHL	208	Allergy	1.0 (0.6–1.5)
(58)	Holly et al. (1997), United States	Case-control; population-based	NHL	1593	Allergy: HIV+/HIV– Animals: HIV+/HIV– Dust: HIV+/HIV– Food: HIV+/HIV– Plants: HIV+/HIV–	0.5 (0.3–0.8)/0.3 (0.2–0.6) 0.5 (0.2–1.3)/0.4 (0.1–1.5) 0.3 (0.1–0.7)/0.4 (0.1–1.6) 0.9 (0.4–1.8)/0.3 (0.1–0.9) 0.3 (0.2–0.6)/0.5 (0.2–1.1)
(59)	Holly et al. (1999), United States	Case-control; population-based	NHL	1281	Medication: M/F Food: M/F Plants: M/F Dust: M/F Animal: M/F Hives: M/F Asthma: M/F	1.0 (0.8–1.3)/0.8 (0.6–0.9) 1.0 (0.7–1.3)/0.8 (0.6–1.0) 0.6 (0.4–0.8)/0.5 (0.4–0.7) 0.9 (0.6–1.3)/0.7 (0.5–1.0) 0.5 (0.3–0.8)/0.7 (0.5–1.1) 1.2 (0.9–1.5)/0.6 (0.5–0.8) 0.9 (0.6–1.2)/0.8 (0.5–1.2)
(64)	La Vecchia et al. (1992), Italy	Case-control; hospital-based	NHL	177	Allergy	1.0 (0.6–2.1)
(6)	McWhorter (1988), United States	Cohort	Lymphoma, leukaemia, myeloma combined	20	Allergy Hives Hives (≥5 years)	3.8 (1.6–9.5) 7.9 (3.1–19.9) 9.3 (3.7–22.6)
(7)	Mills et al. (1992), United States	Cohort	Lymphoma	46	Allergy Bee sting Chemicals Medication Poisonous plants Asthma Hay fever	1.7 (1.0–3.1) 1.1 (0.4–3.7) 1.3 (0.3–5.4) 1.6 (0.8–3.1) 1.5 (0.8–3.0) 0.4 (0.0–2.5) 1.0 (0.4–2.3)
(8)	Talbot-Smith et al. (2003), Australia	Cohort	Lymphoma	20	Asthma: M/F Hay fever: M/F Atopy: M/F	1.6 (0.2–13.4)/not given 0.9 (0.1–6.9)/0.9 (0.1–7.3) 0.5 (0.1–5.8)/1.3 (0.1–20.5)
(56)	Tielsch et al. (1987), United States	Case-control; hospital-based	NHL	109	Allergy	0.8 (0.5–1.3)
(65)	Vineis et al. (2000), Italy	Case-control; population-based	NHL	1388	Allergies Hay fever Eczema	0.9 (0.7–1.3) 0.7 (0.5–1.0) 1.1 (0.9–1.6)

NHL, non-Hodgkin lymphoma; CI, confidence interval.

Table 8. Studies of association between atopy and other cancer sites (in alphabetical order)

Reference	Study, country	Cancer sites	Types of study	Number of cases	Exposure	Odds ratio (OR) (95% CI)
(68)	Dai et al. (1997), China	Oesophageal	Case-control; population-based	275	Allergic Drug allergy Food allergy Contact dermatitis Urticaria Asthma Allergic rhinitis	0.6 (0.4–0.9) 0.8 (0.4–1.6) 0.7 (0.2–2.3) 0.2 (0–0.9) 0.4 (0.2–0.9) 1.1 (0.5–3.1) 0.8 (0.3–1.9)
(67)	Hallquist et al. (1994), Sweden	Thyroid	Case-control; population-based	180	Asthma or allergy	0.4 (0.2–0.9)

Table 9. Studies of association between atopy and all cancer sites combined (in alphabetical order)

Reference	Study, country	Types of study	Number of cases	Exposure	Relative risk (RR)/odds ratio (OR) (95% CI)
(20)	Eriksson et al. (1995), Sweden	Cohort	87	Atopy Asthma Rhinitis Urticaria	1.1 (0.6–1.7) 1.3 (0.9–1.8) 1.1 (0.8–1.5) 1.7 (1.0–2.8)
(6)	McWhorter (1988), United States	Cohort	341	Hives Asthma Hay fever Food allergy Other allergies	1.4 (1.0–2.2) 1.1 (0.6–1.7) 1.2 (0.8–1.7) 1.4 (0.9–2.2) 1.4 (1.0–1.9)
(7)	Mills et al. (1992), United States	Cohort		Asthma: M/F Hay fever: M/F Allergy: M/F	0.8 (0.5–1.3)/1.0 (0.7–1.3) 1.1 (0.8–1.4)/1.2 (0.9–1.4) 1.1 (0.9–1.5)/1.0 (0.9–1.2)
(34)	Vesterinen et al. (1993), Finland	Cohort	3842	Asthma: M/F	1.1 (1.1–1.2)/1.0 (1.0–1.1)
(2)	Vena et al. (1985), United States	Case-control; population-based	13 665	Asthma: M/F Hay fever: M/F Hives: M/F Other allergies: M/F	1.0/0.9 ($P > 0.05$) 1.0/0.9 ($P > 0.05$) 0.8/0.8 ($P < 0.05$) 0.7/0.7 ($P < 0.05$)

Breast cancer

For breast cancer, inconsistent results appeared from five studies on all cancer sites and ‘allergy’ (Table 3). A prospective cohort study of Seventh-day Adventists demonstrated a slightly nonsignificantly increased risk of breast cancer among women who reported any history of allergy (RR 1.2, 95% CI: 0.9–1.6) (7). In the NHANES I prospective follow-up study, a history of any allergy was associated with a similar RR estimate of 1.2 (95% CI: 0.6–2.4), but this study included only 34 breast cancer cases (6). One prospective study, which used positive skin prick testing (SPT) as criteria for atopy, found that a history of atopy was a risk factor for premenopausal breast cancer [Standardized Incidence Ratio (SIR) 4.8, 95% CI: 1.9–9.9] but not for postmenopausal breast cancer (20). This study was able to more precisely ascertain the presence of an allergic response, it was however limited to only seven incident premenopausal breast cancer cases and no postmenopausal cases. On the contrary, a retrospective study in the USA found no association with breast cancer among women who had a history of allergy (2). In the

Busselton cohort, the investigators did not find an increase in risk associated with a history of asthma or hay fever, although there was a nonsignificant risk of 1.4 with atopy (8). Petroianu et al. (21) found that the prevalence of atopy was reduced in 49 breast cancer patients, but they were unable to control for potential confounding factors.

A recent population-based case-control study, with the specific aim to examine the association between atopy and breast cancer among young USA women (22), found that a history of allergies was associated with a reduced risk of breast cancer for women older than 35 (OR 0.8, 95% CI: 0.6–1.0), but not for women 35 years or younger (OR 1.3, 95% CI: 0.9–1.8).

Lung cancer

With a few exceptions, epidemiological studies indicate that people with a history of allergic disease have an elevated risk of lung cancer (Table 4). Five case-control studies (23–27), presenting data limited to subjects who had never smoked, have found risks of lung cancer associated with asthma to be in the range of 1.1–2.7.

Pooling the results from these five case-control studies by Santillan et al. (28) resulted in a RR of 1.8 (95% CI: 1.3–2.3). The analysis of the data from studies, which controlled for smoking history gave a pooled estimate of 1.7 (95% CI: 1.3–2.2) (28).

Among people who reported a history of asthma, the risk estimates for nonsmokers and smokers were 1.6 and 1.7 respectively (23). A study in California found that asthma was associated with (statistically significant) increased risk among men, but not in women, after adjusting age and smoking (29). Another population-based case-control study found the OR to be 1.2 (95% CI: 0.8–2.1) for Missouri women smokers, after adjusting age and smoking history (24). Among nonsmokers, asthma emerged as a significant risk factor (OR 2.7, 95% CI: 1.4–5.4). A similar finding was observed among lifetime nonsmoking women in five metropolitan areas of the USA (25): the adjusted OR was 1.7 (95% CI: 1.1–2.5) in those with a history of asthma. A study in 98 female cases of small cell lung cancer and 204 controls in the USA reported that those with a history of asthma exhibited a significantly higher risk (smoking- and other risk factor-adjusted OR 4.8, 95% CI: 1.0–22.8) of lung cancer (30). A study from Gansu, China supports the elevated risk: Brenner et al. (27) reported an OR of 2.0 (95% CI: 0.9–4.2) among nonsmokers and 2.1 (95% CI: 1.5–3.0) after adjusting for smoking history.

A case-control study in New York (26), of 437 nonsmoking cases and the same number of population controls, found no association among nonsmokers (OR 1.1, 95% CI: 0.5–2.6), although an elevated risk was reported after adjusting for smoking history (OR 2.1, 95% CI: 1.0–4.1). No increased risk of lung cancer was found in white women in Los Angeles with a personal history of asthma after adjusting age and smoking history (31), and no significant differences were found between cases and controls for a history of asthma in a case-control study in Missouri (32) (OR 1.1, 95% CI: 0.7–1.7).

Women were studied in a Californian nested case-control study of participants in a multiphasic health screening (33): among the 217 case-control pairs, there was a reduced risk for lung cancer among women with asthma or hay fever (OR 0.5, 95% CI: 0.3–1.0).

Most prospective cohort studies among asthmatic patients have consistently demonstrated a higher risk of lung cancer. Approximately 78 000 Finnish asthmatic patients were studied through the linkage of two registries (34): the risk for lung cancer was increased (SIR of 1.3 among men and 1.7 among women). In an average 8.5-years of follow up of Swedish patients with a hospital-discharge diagnosis of asthma (35), the SIR was 1.6 (95% CI: 1.5–1.7).

A higher risk of death from lung cancer among asthma patients was reported in prospective studies in Finland and in Denmark; a prospective study based on a Finnish

twin cohort found that the risk of death due to lung cancer was increased in men with asthma [hazard ratio (HR) adjusted for smoking 3.2, 95% CI: 1.4–7.3] (36), while a slight nonsignificant increase in the risk of death from lung cancer was observed in a prospective study in Copenhagen (37). Inconsistent results appeared from the Busselton Health Survey (8), indicating no clear association with asthma or hay fever.

Brain cancer

Epidemiological studies conducted since 1990 have been fairly consistent in demonstrating an inverse association between self-reported allergic conditions and glioma risk, while there was absence of such an association between allergic conditions and meningioma (Table 5). Atopic disease was investigated in relation to glioblastoma in a case-control study in Boston: there was an inverse association with medical treatment for allergies of any kind (RR 0.6, 95% CI: 0.4–1.0) (38). In 1999, a German group published a multicentre international case-control study (1178 cases of glioma) that included data from the Cicuttini et al. (39), Ryan et al. (40) and their own (41) studies and five additional study centres (42). When the data sets from these eight centres are presented separately, an inverse association is demonstrated in seven, of which five are statistically significant. In a combined analysis of the data from the eight study centres, the OR was 0.4 (95% CI: 0.5–0.7) for people with a history of allergy. A similar pattern was seen with specific allergic conditions, such as asthma and eczema.

Two case-control studies (43, 44) carried out in the USA in 2002 contained detailed information on allergens, allergic symptoms, age at diagnosis, and duration of allergic conditions and pointed to a strong negative association between allergic conditions and glioma risk. Wiemels et al. (43) reported an OR of 0.5 (95% CI: 0.3–0.7) for a history of any allergy. Most allergies were protective: significant inverse associations were observed for pollen, dairy and nut allergies. A linear trend of decreasing risk with increasing numbers of allergies, but not with numbers of symptoms or reported severity of allergy, was demonstrated in this study. In a hospital-based case-control study of 489 cases of glioma, Brenner et al. (44) found that a previous allergic history was associated with a significantly decreased risk of 30% (OR 0.7, 95% CI: 0.5–0.9). A similar pattern of risk reduction was seen in persons with asthma (OR 0.6, 95% CI: 0.4–0.9).

Additional evidence for protection against glioma afforded by allergy was provided by prospective studies in three cohorts based on Swedish twins, hospital discharges and cancer registries (45). It demonstrated a lower risk of glioma among people with a history of allergy, with a HR of 0.5 (95% CI: 0.2–1.0) in cohort I and 0.5 (95% CI: 0.1–1.9) for high-grade (III and IV) glioma in cohort II.

Leukaemia

Atopic disease seems to be associated with a decreased risk of leukaemia (Table 6). The USA-based study of 342 cases of chronic lymphocytic leukaemia and the same number of controls reported that there was no significant association with any specific type of allergy (46). However, the study identified a 'dose-response' protective effect of allergic disorders in general ($P = 0.04$), which agreed with the findings of another USA population-based case-control study (47). The latter reported a decreased risk of acute myelocytic leukaemia among those with a history of any type of allergy (OR 0.4, 95% CI: 0.2–0.6).

Three studies (48–50) found no association of allergic disorders with multiple myeloma and adult leukaemia. The multiple myeloma study was a hospital-based case-control study that examined 100 cases and the same number of controls (OR 1.0, 95% CI: 0.5–2.3) (48), while one of the studies for adult leukaemia was a population-based case-control study in China, involving 486 cases and 502 healthy controls (49). The other case-control study on adult leukaemia in the USA found no association with hay fever or eczema, but a nonsignificant elevated risk in persons with asthma (50).

The negative association between atopy and the risk of childhood leukaemia is fairly consistent, except one study in the USA (51). A case-control study in Hokkaido, Japan, found that a significant inverse association was present between atopy and risk of non-T cell acute lymphoblastic leukaemia of children (ALL) (OR 0.3, 95% CI: 0.1–0.6) (52). Another hospital-based case-control study of 153 childhood leukaemia cases reported that previous hospitalization for allergic disease was associated with a nonsignificant risk reduction of 60% (OR 0.4, 95% CI: 0.1–1.4) (53).

A large recent study in the United States of children (1842 cases and 1986 controls) found that ever having had any allergic condition was associated with (a statistically significant) 30% decreased risk of ALL (54). The estimates were similar for specific allergic conditions, namely, asthma, hay fever, food and drug allergy and eczema. There was a linear trend of decreasing risk with an increase in total number of specific allergies. The study also noted an inverse association of ALL with a history of any allergic disorder among any of the siblings of the subjects (OR 0.9, 95% CI: 0.8–1.0). The results from this study are limited, however, by the lack of information on the age at onset of allergic disorders, making it difficult to determine the time sequence of the association between the allergic disorder and ALL.

The protective effect of atopy in childhood ALL was further confirmed in a more recent case-control study carried out in Germany (55). The study found that a significant inverse association with childhood ALL was present among children with hay fever (OR 0.5, 95% CI: 0.3–0.7), atopic dermatitis (OR 0.5, 95% CI: 0.3–0.7) or

contact eczema (OR 0.6, 95% CI: 0.4–1.0), but not in children with a history of hives. There was also a reduced risk among children whose parents or sibling had an atopic disease.

More recently, a study in the USA presented a stark contrast to previous findings of a protective association of allergy with childhood ALL (51). There was a significant elevated risk of ALL among children with atopy or hives whose diagnosis of atopy was made before the year of the matched case's ALL diagnosis (OR 2.2, 95% CI: 1.2–4.2), which was even higher if atopy was diagnosed within the year before the matched case's ALL diagnosis (OR 3.8, 95% CI: 1.0–14.3).

Non-Hodgkin's lymphoma

A history of allergy or allergy-related conditions has been widely studied as a potential risk factor for NHL, but the results are inconsistent (Table 7). Tielsch et al. (56) demonstrated that a history of allergy resulted in a slight, nonsignificant reduction of NHL (OR 0.8, 95% CI: 0.5–1.3). In a population-based case-control study in Los Angeles County, NHL risks were investigated separately for men and women in relation to 15 different allergy groups, including pollen/dust, animals, insect bites/stings and several categories of food (57). A lower risk of NHL was only recorded with allergy to nuts and berries among men, and allergy to insect bites/stings among women. In a study among HIV-positive and HIV-negative homosexual men, a significant decrease in risk was found for NHL, particularly in the HIV-negative group with allergy (58). Allergic conditions were investigated in relation to NHL among homosexual men and women in another study by the same author (59): significant risk reductions were associated with allergy to plants, allergy to animals among homosexual men. Among women there was a significantly decreased risk associated with hives, but in homosexual men there was a nonsignificantly increased OR of 1.2.

A hospital-based case-control study in the Yorkshire Health Region found a significant risk of 1.6 (95% CI: 1.1–2.4) for people who had a history of eczema/dermatitis (60). A nonsignificant elevated risk was observed for eczema, but not for hay fever, in the USA study (61). In a population-based case-control study in France, people who reported a history of hives were at higher risk of NHL (OR 1.7, 95% CI: 1.2–2.2); on the other hand, people who reported a history of asthma or eczema had reduced risks (62). In the USA, the already mentioned prospective study among 34 198 Seventh-day Adventists (7) found that there was a significant association with a history of allergy (RR 1.7, 95% CI: 1.0–3.1). In this study, allergy to chemicals, medication and plants was associated with increased risk of NHL. A prospective study in Sweden among 6593 SP tested patients found an elevated, but not statistically significant, risk among atopic subjects and among people with a history of

rhinitis (20). The most striking association was based on prospective data from NHANES I (6): in a combined analysis of risk for lymphoma, leukaemia and myeloma, the RR was 7.9 (95% CI: 3.1–19.9) for any history of doctor-diagnosed hives, and was even higher if there was a 5-year history of hives (RR 9.3, 95% CI: 3.7–23.6).

In two case-control studies in Italy, there was no association with a history of allergy (63, 64). In another study in Italy, no association was found with history of allergy, but a positive association was recorded with eczema and a negative association with hay fever (65). No significant associations between a general history of allergy and overall NHL risk (OR 1.0, 95% CI: 0.8–1.2), as well as the risks for major NHL subtypes (follicular, diffuse, small cell lymphocytic and immunoblastic), were noted in a case-control study of 952 NHL cases (66). The Busselton cohort study in which atopy was defined by SPT reported no significant association (8).

Other cancer sites

Other cancer sites that have been investigated in relation to atopic disorders include the thyroid, oesophagus, prostate and ovary (Table 8). A Swedish population-based case-control study (67) reported a thyroid cancer risk for those with a history of allergy or asthma of 0.4 (95% CI: 0.2–0.9). A study of oesophageal cancer in Shanghai showed a reduced risk among persons with a history of allergy (OR 0.6, 95% CI: 0.4–0.9) (68).

Some cohort studies have examined the risk of a wide variety of individual cancers and specific allergies (Table 9). The complex results showed that the association between atopy and cancer depends on the specific allergy and specific organ site under consideration. A retrospective study of 13 665 cancer cases and 4079 controls in the United States found an inverse association of a history of hives and other allergy-related diseases with cancer risk (2). Similar patterns in risk reduction were observed for oral cancer, cancers of lung, digestive system, urinary system among males and reproductive system among females.

A 10-year follow-up study by McWhorter (6) reported that a history of allergy increased the risk of cancer by 40% (OR 1.4, 95% CI: 1.1–1.8). The definition of allergy that was used in this study was quite broad and included 'asthma, hay fever, hives, food allergy or other allergies'.

The Californian Seventh-day Adventists cohort study indicated no overall increased risk of developing cancer in association with allergy (7). There was a positive association of several allergies with prostate cancer and with breast cancer (as reviewed above), as well as lymphatic and haematopoietic cancers. There was, however, a suggestive inverse relation between several allergies and ovarian cancer.

The Finnish cohort study of 78 000 asthmatic patients demonstrated a significant increased risk of cancer in men (SIR 1.1, 95% CI: 1.1–1.2), whereas no excess in risk was seen in women (34).

The Swedish cohort study of 6593 patients with allergen skin test reactivity, reported no overall increased cancer risk (20). The Busselton Health Survey 1981–99 examined the association of atopy and allergy with newly diagnosed cancers (8). Atopy increased the risk of prostate cancer [OR 2.5 (95% CI: 1.0–5.9) for any atopy, and OR 2.9 (95% CI: 1.3–6.7) for SPT positivity to house dust mite], while there were no associations with breast and lung cancer and lymphoma. There were nonsignificant trends of a protective effect on colorectal cancer, and nonsignificant increased risks of leukaemia and melanoma.

Discussion

The biological plausibility of the association between atopic disease and cancer risk has been acknowledged. When atopy is regarded as a hyperreactive state of the immune system, it is usually assumed to reflect a shift in the T-lymphocyte response away from the Th1 towards a Th2 dominated activity, although coexistence of Th1-mediated diseases and Th2-induced disorders have been demonstrated (69, 70). The mechanism of the possible role of atopy in the risk of cancer is unclear. Theoretically, the hyperreactive state might be accompanied by an enhanced immune-surveillance, thus decreasing the chance of proliferation of aberrant cells; the reduced risk of childhood leukaemia and brain tumours could be an example. On the contrary, it can also be argued that the atopic state is responsible for a (sub)chronic state of inflammation, which might enhance the risk of cancer in such tissues; this might be the reason for the increased risk of lung cancer in asthmatics.

Eosinophiles are a source of numerous cytokines and growth factors, thus in principle they can display both proinflammatory and anti-inflammatory activities as well as immunoregulatory ones (71). Atopic disease is often accompanied by eosinophilia. In a recent review (71) 'new' roles for eosinophils in cancer have been described and it was mentioned that tissue or blood eosinophilia is correlated with a better tumour prognosis. However, we could not identify epidemiological studies, which have considered the amount of eosinophils in patients with atopic diseases as a covariable in the association with cancer.

Epidemiological studies have investigated the association between atopic disease and several types of cancer, demonstrating either a protective role of atopy for certain types of cancer, or acting as a risk factor for other cancer types. The varying results highlight the problems associated with the potential effects of recall bias in the retrospective studies, as well as the problems associated

with the small number of subjects with a specific subtype of atopy and/or 'allergy' and cancer types in prospective studies. Patients with cancer may suffer from immunosuppression that will lead to attenuation of allergic symptoms. Most studies have a case-control design, which might have examined effects of cancer on the immune system or allergic symptoms. For example, a study on childhood leukaemia could not find whether the allergic disorders preceded the development of leukaemia or were less prevalent as a consequence because of the lack of information on the age at onset of allergic disorder (54). Prospective cohort studies are more reliable in the determination of the temporal relationship between exposure and disease. In colorectal cancer, the cohort studies do not indicate a protective effect, in contrast to the case-control studies. In breast cancer the four cohort studies tend to point towards increased cancer risk. All the six cohort studies on lung cancer in asthmatics support the tendency to increased risk. Of the 25 studies on haematological malignancies, four had a cohort design; the results of the cohort studies are as inconsistent as the case-control studies.

Differences in the definition of atopy, lack of objective measures of atopy, restricted selection of patients or outcomes, and failure to control for important cancer risk factors such as smoking, are also important issues to consider in the interpretation of these studies. A major problem is the variability between the studies in the definition of atopy: very few studies separate atopy (as defined by SPTs) from allergy (8, 20), while many studies include urticaria, and some studies include contact dermatitis (a type 4 immunological reaction) or drug reactions (4, 15). Instead of a symptom-based definition of atopy and/or allergy, only two studies have used a positive SPT as marker for atopy in their data analysis, while no analysis has been based on specific immunoglobulin E (IgE) as marker. A Swedish cohort study was based on individuals who were SP tested in 1976–89 (20). The study indicated an increased risk for breast cancer and lymphoma. The Busselton cohort study defined atopy as a positive reaction to one or more SPTs; allergy was defined as having been diagnosed with asthma or hay fever (8). In this study, atopy was associated with significant increased risk for prostate cancer risk and there was a trend towards a protective effect on colorectal cancer and increased risk of leukaemia and melanoma.

As indicated above, several papers acknowledge that bias, especially recall bias in the retrospective studies, may play a role. A prospective study in Finland has looked at cancer incidence among asthmatic patients, who may have more frequently contact with the health care system than the general population (34). Consequently, the raised risk estimates in the cases of lung cancer might be due to increased cancer detection in

these patients. In addition, the effects of changes in lifestyle (smoking, diet, reproductive behaviour) caused by asthmatic disease on cancer morbidity have to be considered as potential risk modifiers. Another example is the large Californian cohort study conducted in Seventh-day Adventists (7): the associations are observed in a population that is generally highly educated, with a greater awareness of personal health. Because they avoid tobacco and alcohol and tend to adhere to a vegetarian life-style for religious reasons, they are a special low-risk group for cancer development (14).

The association between atopy and cancer could be due to confounding by factors that are associated with both conditions. Sustained smoking has been found to be inversely associated with the development of allergic sensitivities (72, 73). Therefore, failure to control for smoking may obscure possible relationships between manifestations of atopic disease and cancer, especially cancers that are associated with smoking (e.g. lung cancer). In colorectal cancer confounding may play a role because of the negative association between smoking and colitis ulcerosa (a risk factor for colorectal cancer). Confounding by failure to take alcohol consumption into account may play a role in the studies looking at the role of atopy and breast cancer: alcohol consumption is a risk factor for this type of cancer, while alcohol intake has been hypothesized to the incidence of SPT reactivity and IgE levels (74, 75).

In view of the large heterogeneity of the studies reviewed in this paper, it is not surprising that meta-analysis has only been performed in one study on asthma and risk of lung cancer (28). The combined results from case-control studies, which limited the analysis to never smokers, showed a significant increased risk among asthmatics. The pattern of results observed across studies either controlling for smoking or not is consistent. A study of glioma, which pooled the data from different centres, indicated a protective effect of allergic conditions (41).

Conclusion

Despite the mixed results, the emerging picture from most of the currently available epidemiological data indicate that atopic diseases may be associated with an increased risk for lung cancer. In spite of methodological problems, the studies conducted thus far seem to point towards a reduced risk for pancreatic cancer, childhood leukaemia and brain tumours. Further research should focus on a more carefully defined and documented status of 'atopy' and different atopic diseases, to advance our understanding of the role that atopy and its associated allergies might play in the risk of developing cancer.

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