

Having lived on a farm and protection against allergic diseases in Australia

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Summary

Background Farmers' children in northern Europe have a lower prevalence of atopy, hay fever and asthma than other children. Farms in Australia differ in scale and operation from those in Europe and the prevalence of allergic diseases in children is higher.

Objective To investigate whether having lived on a farm as a child in Australia is associated with a lower risk of allergic diseases.

Methods Cross-sectional study of children ($n = 1500$) aged 7–12 years from two rural towns: Wagga Wagga in a mixed farming region, and Moree in a crop farming region. Parents answered a questionnaire and children had a skin prick test for atopy.

Results Twenty percent of children had lived on a farm for at least 1 year. The effect of having lived on a farm differed between the towns ($P < 0.001$). It was associated with a lower risk of atopy in Wagga (adjusted odds ratio (aOR) 0.47, 95% confidence interval (CI) 0.32–0.72) but not in Moree (aOR 0.97, 95% CI 0.62–1.53). Children from Wagga were more likely to have lived on a livestock farm than children from Moree (26.1% vs. 9.1%, 95% CI for the difference 8.9–25.4).

Conclusion Having lived on a farm in Australia can confer protection against atopy in children. Further studies are needed to identify possible protective mechanisms associated with farm animals or to establish whether the protective effect is explained by other related exposures.

Keywords: atopy, farming, children, allergic diseases

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Introduction

Studies in Switzerland, Austria, Finland and Germany suggest that living on a farm and having contact with livestock is associated with protection against atopy, hay fever and asthma in children [1–4]. The prevalence of atopy and hay fever has been reported to be reduced by between 31% and 69% in farmers' children. The most favoured hypothesis is that this protection is increased exposure to microbial antigens which may prevent deviation of the immune system towards atopy [2–5]. Animals act as reservoirs for a range of enteric pathogens such as

Campylobacter enteritis and *Escherichia coli* [6,7], and farmers' children may contract more bacterial infections than other children because of greater contact with livestock [8].

If contact with livestock confers protection against allergic diseases, then children who live on farms devoted to crops will not be protected. In fact, the risk of farmers' children developing these diseases may be higher because their exposure to allergens associated with crops will be higher than for other children. There is evidence that adults who work with wheat, barley and other crops are at greater risk of having asthma than the rest of the working population [9].

In New South Wales, Australia, the prevalence of allergic diseases is at least double the prevalence reported for Switzerland, Austria, Finland and Germany [1–4,10].

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Table 1. Odds ratios (unadjusted) for children having allergic sensitization and having lived on a farm

Allergen	Children resident in Moree				Children resident in Wagga Wagga				P-value for difference between towns
	Farm n = 139 %	Non-farm n = 334 %	OR	95% CI	Farm n = 145 %	Non-farm n = 818 %	OR	95% CI	
Positive $\geq$ one allergen	46.0	41.0	1.22	0.82–1.83	29.7	49.0	0.44	0.29–0.64*	<0.001
<i>Dermatophagoides</i>	30.9	28.7	1.11	0.72–1.71	17.9	32.4	0.46	0.29–0.71†	0.006
<i>Lolium</i>	20.9	18.6	1.16	0.71–1.89	15.2	31.3	0.39	0.24–0.63*	0.002
Cat dander	11.5	7.2	1.68	0.86–3.27	2.8	9.9	0.26	0.09–0.72†	0.003
<i>Alternaria</i>	25.2	13.8	2.11	1.29–3.45†	13.8	21.5	0.59	0.35–0.96‡	<0.001
<i>Cladosporium</i>	15.8	8.1	2.14	1.17–3.90‡	7.6	12.7	0.56	0.29–1.08	0.003
Wheat whole grain	4.3	3.6	1.21	0.44–3.28	2.8	4.7	0.58	0.24–1.66	0.33
Grain mill dust	14.3	6.6	2.38	1.24–4.52†	8.3	11.0	0.73	0.39–1.37	0.01
Cotton lint	0.3	0.7	2.41	0.15–38.85	0.7	0.9	0.80	0.10–6.59	0.54

OR, Odds ratio.

* $P < 0.001$; † $P < 0.01$; ‡ $P < 0.05$.

Dermatophagoides pteronyssinus, house dust mite; *Lolium perenne*, rye grass pollen; *Alternaria alternata*, fungus; *Cladosporium cladosporoides*, fungus.

Over 75% of the area of the state is farmed [11]. Beef cattle is the main produce in 40% of farms, sheep in 30% and grain in 30%. We undertook a cross-sectional study of primary school children living in two rural towns. One town was located in a predominantly crop-growing region of New South Wales and the other in a region of livestock and crop farming. We were able to investigate whether children who had lived on a farm had lower risk of atopy, rhinitis or asthma than other children.

Subjects and methods

Study population and study design

A cross-sectional study was undertaken in two rural towns 550 km apart in New South Wales. Moree (149°E, 29°S, population approx. 9000) is located to the north of the state close to the border with Queensland in a major crop-growing region for wheat, barley, grain sorghum, sunflower and cotton [12]. Wagga Wagga (147°E, 35°S, population approx. 50 000) is located to the south of the state close to the border with Victoria. Sixteen percent of the agricultural land around the town is used for cattle and sheep grazing [13].

The study was conducted during July/August (Wagga Wagga) and September (Moree) 1997. Approval for the study was given by the Human Ethics Committee of the University of Sydney. Consent was obtained from the New South Wales Department of School Education, the Catholic Education Office and the Principals of the schools selected to participate. All four primary schools in Moree and 11 of

12 primary schools in west Wagga Wagga participated. The twelfth primary school was excluded because the estimated intake of pupils for 1997 who met the study criteria was <20. Children aged 7–12 years from school years 3, 4, 5 and 6 in Moree and 3, 4 and 5 in Wagga Wagga whose parents gave written consent were included in the study.

Skin prick tests

Sensitization to eight allergens was measured by reactions to skin prick tests on the forearm [14]. The allergens tested were the house dust mite *Dermatophagoides pteronyssinus*, rye grass pollen *Lolium perenne*, cat dander, the fungus *Alternaria alternata* (*tenuis*), the fungus *Cladosporium cladosporoides*, wheat wholegrain, grain mill dust and cotton lint. All allergens were purchased from Hollister-Stier (Bayer Corp., Spokane, WA, USA). Histamine (10 mg/mL) was used as the positive control and a normal saline/glycerol solution as the negative control. Skin wheal size was recorded at 15 min after skin prick as the mean of the length of the long axis to the wheal and the length of its perpendicular. A mean wheal size of ≥ 3 mm was defined as a positive response. Children were classified as atopic if they had a positive response to one or more allergens tested.

Questionnaire

A self-administered questionnaire was distributed to parents. This was a modified version of the Children's Respiratory Questionnaire developed and validated by the

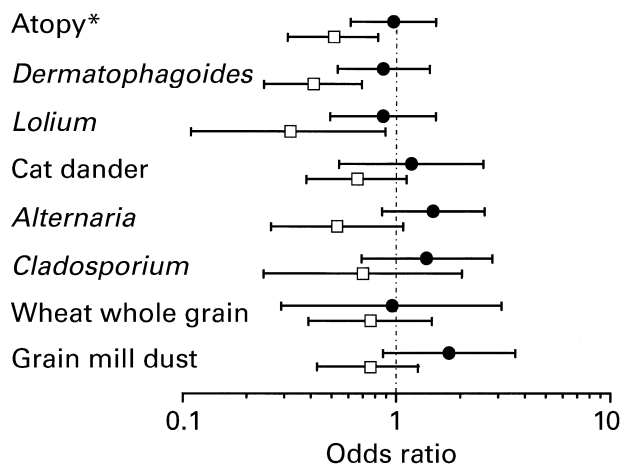


Fig. 1. Adjusted odds ratio for allergic sensitization in farm children. ●, Farm children resident in Moree; □, farm children resident in Wagga Wagga. *Positive to one or more allergens. Adjusted for parental history of asthma and/or rhinitis and/or eczema.

Institute of Respiratory Medicine [15,16]. It included the following question about exposure to farming: 'Has your child ever lived for longer than 12 months on a farm' and if yes 'what crops did the farm grow?'. Possible responses were 'none', 'cotton', 'wheat' and 'other crops'. Children who had lived on a farm for longer than 12 months and whose parents ticked 'none' in response to 'what crops did the farm grow' were classified as having lived on a farm with only livestock. The questions about the child's breathing included 'Has your child ever wheezed?' and, if yes, 'was this in the last 12 months?', 'has your child ever been diagnosed as having asthma by a doctor or at a Hospital', 'is your child's wheezing worse during particular seasons of the year?' and 'has your child ever had attacks of hay fever or nasal allergies?'. The questionnaire also asked about place of birth of the child, allergic diseases in the child's natural parents and the child's current and past exposure to tobacco smoke.

Statistical analysis

χ^2 tests were undertaken to compare the prevalence of allergic sensitization, symptoms and risk factors for respiratory diseases between farm and non-farm children. Logistic regression was used to measure the association between allergic sensitization and respiratory symptoms and having lived on a farm. We tested for differences between towns in the effect of having lived on a farm. Risk factors were added to the model one at a time and only those that made an important difference to the odds ratio were retained in the model. The analyses were undertaken

using STATA (Stata Statistical Software Release 6.0; Stata Corporation 1999; TX, USA). The study had 80% power to detect a two-fold difference in the prevalence of characteristics between farm and non-farm children assuming a lower prevalence of 10% in the farm children.

Results

Sixty-seven percent of parents answered the respiratory symptom questionnaire and gave consent for their child's participation in the study. Of the participating children, 66% had been born in the area in which they resided at the time of the study, and 20% had lived on a farm for at least 1 year. Forty-seven percent of the farm children were male compared with 49% of non-farm children. The mean age for farm children was 9.47 years (SD 1.04) and was 9.35 years (SD 1.09) for non-farm children.

Children from Moree were more likely to have lived on a farm than children from Wagga Wagga (29.6% vs. 15.4%, 95% confidence interval (CI) for the difference 9.5–18.7). Of the children who had lived on farms, more children from Moree had lived on farms that had grown wheat (83.9% vs. 50.9%, 95% CI for the difference 23.1–42.8) and cotton (46.2% vs. 1.9%, 95% CI for the difference 35.8–52.7). However, more children from Wagga Wagga had lived on a farm that had only livestock (26.1% vs. 9.1%, 95% CI for the difference 8.9–25.4).

The prevalence of atopy was 9% lower in children who had lived on a farm ($P = 0.005$) (see Table 1). This was explained by a lower prevalence of sensitization to *Dermatophagoides* and *Lolium* in the farm children. The prevalence of wheeze and use of asthma medicine was also lower in the farm children, although there was no difference in the prevalence of asthma diagnosis (see Table 2). Farm children had less wheezing in spring and winter but there was no difference between the prevalence of hay fever and nasal allergies. A smaller proportion of farm children were of Aboriginal origin and a smaller proportion of their parents smoked (see Table 3).

There were significant differences between the two towns in the association between having lived on a farm and prevalence of atopy (see Table 1). This remained after adjustment for parental history of asthma and/or rhinitis and/or eczema which were the only important confounders (see Fig. 1). In Moree, there was no difference in the prevalence of atopy in farm children compared with non-farm children (adjusted odds ratio (OR) 0.97, 95% CI 0.62–1.53). In Wagga Wagga, the prevalence of atopy was significantly lower in farm children (adjusted OR 0.47, 95% CI 0.32–0.72) compared with non-farm children. In particular, sensitization to *Dermatophagoides* (adjusted

Table 2. Odds ratios (unadjusted) for children having respiratory symptoms and having lived on a farm

Respiratory outcome	Children resident in Moree				Children resident in Wagga Wagga				<i>P</i> -value for difference between towns
	Farm <i>n</i> = 142 %	Non-farm <i>n</i> = 341 %	OR	95% CI	Farm <i>n</i> = 157 %	Non-farm <i>n</i> = 860 %	OR	95% CI	
Ever wheezed	40.6	41.5	0.96	0.65–1.43	33.6	43.8	0.55	0.45–0.93*	0.15
Wheezed in last 12 months	26.6	30.1	0.82	0.53–1.27	20.4	28.4	0.65	0.43–0.98*	0.44
Diagnosed with asthma	43.4	40.6	1.12	0.75–1.66	30.1	40.0	0.65	0.45–0.93*	0.05
Wheezing worse in Spring	10.8	8.5	1.29	0.64–2.59	7.6	15.4	0.45	0.24–0.87*	0.03
Wheezing worse in Summer	6.5	4.8	1.36	0.55–3.38	2.2	5.0	0.43	0.13–1.43	0.13
Wheezing worse in Autumn	4.9	6.6	0.74	0.29–1.91	4.3	5.6	0.76	0.31–1.82	0.97
Wheezing worse in Winter	20.4	11.5	0.50	0.28–0.92*	11.3	16.5	0.65	0.38–1.11	0.54
Ever used asthma medicines	43.4	44.4	0.96	0.65–1.42	36.9	47.5	0.65	0.46–0.92*	0.15
Ever had rhinitis or eczema	46.0	39.2	1.32	0.89–1.97	38.3	45.0	0.76	0.53–1.08	0.04
Rhinitis in last 12 months	36.2	29.7	1.34	0.88–2.05	27.2	36.7	0.64	0.44–0.94*	0.01

OR, Odds ratio.

**P* < 0.05.

OR 0.50, 95% CI 0.31–0.80), and *Lolium* (adjusted OR 0.39, 0.23–0.65) and cat dander (adjusted OR 0.39, 0.23–0.65) was lower. The results were unchanged by restricting the analyses to children born in the town of residence.

There were also significant differences in the prevalence of symptoms between towns. Farm children from Wagga Wagga had a lower risk of hay fever and nasal allergies, wheezing in spring and asthma diagnosis than non-farm children, whereas those from Moree did not. However these differences did not remain after adjustment for atopy or parental history of allergic diseases.

Discussion

We found that having lived on a farm as a child in Wagga Wagga was associated with a 66% reduction in the risk of being atopic but no significant reduction was found in farm children in Moree. We also found a lower risk of diagnosed asthma and rhinitis in farm children from Wagga Wagga but this was not apparent after adjustment for confounding, suggesting that the main influence of farm exposures is on the development of atopy. The findings for farm children from Wagga Wagga are consistent with those reported for farm children in northern Europe [1–4]. However, the

Table 3. Prevalence of risk factors for children having asthma and having lived on a farm

Risk factor	Children resident in Moree				Children resident in Wagga Wagga			
	Farm <i>n</i> = 142 %	Non-farm <i>n</i> = 341 %	95% CI for the Difference	95% CI for the difference	Farm <i>n</i> = 157 %	Non-farm <i>n</i> = 860 %	95% CI for the Difference	95% CI for the difference
Child of Aboriginal origin	2.1	30.6	–28.4	–33.9 to –22.9*	4.5	5.1	–0.7	–4.2–2.9
Bronchitis before child aged 2	16.4	16.5	–0.1	–7.5–7.3	17.7	23.8	–6.1	–12.8–0.6
Tobacco smoked at home	24.1	39.5	–15.4	–24.1 to –6.6†	29.2	26.7	2.5	–5.2–10.3
Father smoked before child aged 2	39.4	44.6	–5.0	–14.7–4.6	33.1	42.1	–9.0	–17.1 to –0.8‡
Mother smoked before child aged 2	32.2	45.6	–13.9	–23.2 to –4.6†	31.4	39.0	–7.6	–15.6–0.4
Father had asthma	24.0	18.6	5.4	–3.4–14.2	20.9	20.6	0.3	–7.1–7.6
Mother had asthma	27.1	28.3	–1.3	–10.6–8.1	25.7	25.9	–0.2	–8.0–7.5
Father had rhinitis or eczema	49.6	38.6	11.0	0.6–21.3‡	40.3	50.3	–10.0	–18.9 to –1.1‡
Mother had rhinitis or eczema	61.0	50.8	10.2	0.3–20.1‡	54.4	59.7	–5.3	–14.0–3.5

**P* < 0.001; †*P* < 0.01; ‡*P* < 0.05.

finding that farm life in Moree was not protective adds a further dimension by highlighting the possible influence of region and suggesting that non-animal farms do not confer protection.

A standard questionnaire was used to measure symptoms and an objective test was used to measure atopy. Selection bias causing a low prevalence of allergic diseases in farmers and their families could have occurred because individuals with allergic diseases may choose not to farm. Studies of adult farmers show that they have a low prevalence of allergic sensitization to animal allergens [17,18]. We adjusted for prevalence of asthma and/or hay fever and/or eczema in parents, but it is likely that some confounding by genotype remains [19].

High concentrations of aeroallergens are produced during harvesting and processing of crops and farm workers are at risk of developing allergies from exposure to these [9,20,21]. Harvesting, for example, can increase fungal spore concentration in the air by 12-fold [22]. Sensitization to grain dust is relatively common in grain handlers [23,24]. However, we found no evidence that farm children had a higher risk for sensitization to the fungus *Alternaria* (which grows on crops), to wheat, to grain mill dust or to cotton.

We found a significant difference in the effect of exposure to farming between Wagga Wagga and Moree. Farm children from Wagga Wagga were afforded protection against atopy whereas those from Moree were not. The overall prevalence of atopy in Wagga Wagga was between 10% and 15% higher than prevalence reported in the studies in northern Europe where atopy was measured [1,2]. However, the size of the protective effect associated with farm life was similar in the two continents: the adjusted ORs for atopy in farm children were 0.52 (95% CI 0.33–0.84) in Austria [2] and 0.34 (95% CI 0.12–0.89) in Switzerland [1]. Studies in Europe have adjusted for presence of allergic diseases in parents, parent education, living and housing conditions, dietary factors, number of siblings, maternal smoking, pet ownership, indoor humidity, study area and heating fuels, and have reported little differences in the crude and adjusted ORs for atopy [1,2].

The study of Austrian farm children found that 'regular contact with livestock or poultry' was the factor most strongly associated with a reduced risk of allergic sensitization in children living on a farm, suggesting that protection against atopy is a result of contact with farm animals [2]. Touching and feeding infected livestock and contact with farm animal faeces have been associated with *C. enteritis*, *E. coli* and *Salmonella typhimurium* infections [6–8], and recent work suggests that exposure to orofaecal and food-borne microbes can prevent the development of atopy [25,26]. As well as being more likely to contact infections from farm animals, farm families are also more

likely to consume foods which have not been subject to the processing requirements of food hygiene legislation.

Differences in farming practice related to animal husbandry between Wagga Wagga and Moree may hold the explanation for the differences in the effect of childhood exposure to farming. Differences in farming practice 10 years ago are of particular interest because animal models suggest that infancy and very early childhood is the period when environmental exposures can influence the acquisition of atopy [27]. The Agricultural Statistics for New South Wales for 1991–92 show that there were more livestock in the Central Murrumbidgee region around Wagga Wagga than there were in the North Central Plain region around Moree [28]. Our data also suggest that children from Wagga Wagga were more likely to live on farms with livestock. However, we did not collect detailed individual data describing the degree to which farm children were exposed to livestock. Interpretation of these data are therefore vulnerable to 'ecological fallacy' and there may be other unidentified factors that explain the differences associated with exposure to farming between the towns.

Farms in northern Europe are usually small, often operated by one family, the majority have livestock which are often housed close to the family living quarters. In 1997, 72% of Swiss farms had cattle [29]. The mean size of cattle farms in Switzerland in 1995 was 23 hectares [30]. In contrast, the median farm size in New South Wales in 1993 was 150–200 hectares for milk cattle and 500–750 hectares for beef cattle [11] and farm animals are rarely housed near family living quarters. But despite these large differences in scale and operation, there appears to be a factor that protects against atopy in both continents.

In conclusion, this study supports the findings from northern Europe that exposure to farm life can be associated with a reduction in the prevalence of atopy. However, the protective effect is not found in all farming regions. The findings for Wagga Wagga were consistent with those from Europe despite large differences between the scale and operation of farms and in the prevalence of allergic diseases. Further studies are needed to identify possible protective mechanisms that are associated with farm animals or to establish whether the protective effect is explained by other related exposures.

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