

# Prevalence of wheezing and atopic diseases in Austrian schoolchildren in conjunction with urban, rural or farm residence

Elisabeth Horak · Bernhard Morass · Hanno Ulmer · Jon Genuneit ·  
Charlotte Braun-Fahrländer · Erika von Mutius; on behalf of the GABRIEL Study Group

Received: 3 March 2014 / Accepted: 18 June 2014 / Published online: 22 July 2014  
© Springer-Verlag Wien 2014

## Summary

**Background** A large number of studies have consistently shown that children growing up on a farm have a reduced prevalence of allergic disorders. The GABRIEL Advanced Study was conducted in five rural areas of southern Germany, Switzerland, Austria and Poland to shed light on the protective ‘farm effect’ on asthma and atopic disease. Whereas, the GABRIEL Advanced Study focussed on rural children only, the present study incorporates data from Innsbruck town children also.

**Methods** A screening questionnaire was developed to identify children with and without atopic disease within their living environment. Children were stratified into *farm children, rural children and Innsbruck-town chil-*

*dren*. Within the farming environment, regular exposure to the following key factors of interest was predefined: the animal shed, the hay loft and farm milk. Wheezing in the past 12 months (W12), doctor-diagnosed (dd)-asthma, dd-allergic rhinitis and dd-atopic dermatitis were evaluated by using standardized questions from the International Study of Asthma and Allergies in Childhood (ISAAC).

**Results** Farm children with regular exposure showed a lower risk for W12 (odds ratios (OR)=0.3; 95 % confidence interval (CI) 0.2–0.5), dd-asthma (OR=0.4; 95 % CI 0.2–0.9) and dd-hay fever (OR 0.2; 95 % CI 0.1–0.4). The protective effect of regular exposure extended to rural children but included W12 and dd-hay fever only. Multivariate logistic regression analysis for children being regularly exposed revealed protective attributes for the animal shed, the hay loft and farm milk.

**Conclusion** These data show that *regular exposure* to a farming environment protects against wheezing, asthma and hay fever. Regarding wheezing and hay fever, this effect was not restricted to children living on a farm but also notable in rural children with regular farm contact.

**Keywords** Asthma · Atopic disease · Wheezing · Farming

E. Horak, MD, PD (✉)  
Department of Pediatrics, Division of Pediatric Cardiology and Pulmonology, Innsbruck Medical University,  
Anichstr. 35, 6020 Innsbruck, Austria  
e-mail: Elisabeth.Horak@uki.at

B. Morass  
Department of Pediatrics, Division of Pediatric Cardiology and Pulmonology, Innsbruck Medical University, Innsbruck, Austria

H. Ulmer  
Department of Medical Statistics, Informatic and Health Economics, Innsbruck Medical University,  
Innsbruck, Austria

J. Genuneit  
Institute of Epidemiology and Medical Biometry, Ulm University,  
Ulm, Germany

C. Braun-Fahrländer  
Swiss Tropical and Public Health Institute, University Basel,  
Basel, Switzerland

E. von Mutius  
University Childrens Hospital,  
Munich, Germany

**Prävalenz von Wheezing und atopischen Erkrankungen bei österreichischen Schulkindern im städtischen, ländlichen oder bäuerlichen Umfeld**

## Zusammenfassung

**Hintergrund** In den letzten Jahren konnten zahlreiche Studien zeigen, dass Kinder, die am Bauernhof aufwachsen, seltener an atopischen Erkrankungen leiden. Die GABRIEL Advanced Multicenterstudie, durchgeführt in Deutschland, Schweiz, Österreich und Polen, hat sich zum Ziel gesetzt mögliche protektive Faktoren betref-

fend den „Bauernhof-Effekt“ aufzudecken. Während die GABRIEL Advanced Studie ausschließlich die am Land lebenden Kinder inkludierte, wurden in der vorliegenden Arbeit auch die Daten von Stadtkindern (Innsbruck) in die Analyse mit einbezogen.

**Methodik** Mittels Screening-Fragebogen wurden Kinder je nach Lebensraum in *Bauernhofkinder*, *Landkinder* und *Innsbruck-Stadtkinder* stratifiziert und dieser Lebensraum dann mit der Prävalenz atopischer Erkrankungen korreliert. Am Bauernhof wurden als mögliche protektive Faktoren regelmäßiger Kontakt zu Tierstall und/oder Futterscheune (Heustall) und der regelmäßige Konsum von Bauernhofmilch prädefiniert. Die Prävalenz von ärztlich diagnostiziertem (doctor diagnosed=dd) Asthma, dd-allergischer Rhinitis, dd atopischer Dermatitis, als auch Wheezing in den letzten 12 Monaten (W12), wurden mittels standardisiertem ISAAC Fragebogen erhoben.

**Ergebnisse** Bauernhofkinder mit regelmäßiger Exposition zu Tierstall, Futterscheune oder regelmäßigem Konsum von Bauernhofmilch hatten ein deutlich geringeres Risiko für W12 (OR=0,3; 95 % CI 0,2–0,5), dd-Asthma (OR=0,4; 95 % CI 0,2–0,9) und dd-allergischer Rhinitis (OR 0,2; 95 % CI 0,1–0,4). Der protektive Effekt einer regelmäßigen Exposition erstreckte sich auch auf Landkinder, allerdings beschränkt auf W12 und dd-allergische Rhinitis. Auch die multivariate logistische Regressionsanalyse zeigte protektive Attribute für Stall, Scheune als auch für Bauernhofmilch, mit jedoch unterschiedlichem Potential auf die einzelnen Outcomeparameter.

**Schlussfolgerung** Die vorliegenden Daten bestätigen, dass regelmäßige Bauernhofexposition im Kindesalter sich protektiv auf Wheezing, Asthma und allergische Rhinitis auswirkt. Dieser Effekt zeigte sich nicht nur für die am Bauernhof lebenden Kindern, sondern erstreckte sich auch auf Kinder im ländlichen Umfeld mit regelmäßigem Bauernhofkontakt.

**Schlüsselwörter** Asthma · Atopie · Wheezing · Bauernhof

## Introduction

Asthma and atopic diseases are caused by interaction between genetic susceptibility and environmental conditions and has become increasingly common in industrialised societies across the world. Recent data showed that rural environments, in particular farming, are strongly protective against atopic diseases, and increasing urbanisation may be an important factor contributing to the rise in asthma prevalence [1, 2].

This report exclusively concentrates on the results of the questionnaires from the GABRIEL Advanced Study-Phase I in Tyrol, an alpine federation state of Austria with approximately 700.000 inhabitants, whereof 120.000 live in the capital town Innsbruck. The GABRIEL Advanced Study was conducted in five rural areas of southern Germany, Switzerland, Austria and Poland to shed light on the protective ‘farm effect’ on asthma and atopic dis-

ease. Phase I was conducted for participant recruitment taking into account environmental factors and symptoms. Whereas, the GABRIEL Advanced Study focussed on rural children only, the present study includes also data from Innsbruck town children. For details of the GABRIEL Advanced Study design, we refer to the recent publication of Genuneit et al. [3].

## Patients, materials and methods

A screening questionnaire was developed to identify children with and without atopic disease within their living environment. Children were stratified into *farm children* (living on a farm), *rural children* (not living on a farm) and *Innsbruck-town children* (not living on a farm) based on their residence at the time of the survey. Within the farming environment key factors of interest were pre-defined: the animal shed, the hay loft and farm milk.

Wheezing in the past 12 months (W12), doctor-diagnosed (dd)-asthma, dd-allergic rhinitis and dd-atopic dermatitis were evaluated by using standardised questions from the International Study of Asthma and Allergies in Childhood (ISAAC) [4]. Additionally, we used a somewhat broader ‘asthma’ definition, containing wheezing in the past 12 months or use of an asthma spray ever or recurrent wheezy bronchitis or a doctor diagnosis of asthma.

The term *regular exposure*, defined by regular contact to particular areas/agents within the farm, was evaluated by the following questions:

Has your child ever spent time with animals in an animal shed regularly (at least once a week for a period of 6 months minimum)?

Has your child ever spent time in a hay loft regularly (at least once a week for a period of 6 months minimum)?

Has your child ever drunk farm milk directly from a farm regularly (at least once a week for a period of 6 months minimum)?

In the first step, we asked the school authority for their support and generated a list of all primary schools within Tyrol, Austria. The parents of all children visiting primary school were invited to complete a short questionnaire regarding their living environment, regular farm contact and symptoms/diagnoses of wheezing, asthma, allergic rhinitis and atopic dermatitis. We mailed the questionnaires to the schools, the teachers distributed and collected them after completion by the parents and sent them back to the study centre in a pre-stamped parcel.

The study was approved by the Ethical Committee, and informed consent was given from all participants.

## Statistical analysis

Prevalence of allergic diseases was analysed using contingency tables. Chi-square tests were calculated to assess dependencies between disease prevalence and exposure variables such as gender, age, family history,

urban, rural or farm residence, etc. In addition, univariate (unadjusted) and multivariate (adjusted) logistic regression analyses were performed to estimate odds ratios (OR) and their 95% confidence intervals (95% CI) for disease prevalence in relation to exposure variables. *P* values <0.05 were considered to indicate statistical significance. Statistical analysis was performed utilizing SPSS 15.0 and STATA 10.0 for Windows.

## Results

Ninety-one percent (355/390) primary schools in Tyrol supported the study, participating and non-participating schools were scattered evenly across Tyrol [3]. School participation rate within Innsbruck town was 81%.

The percentage of participating children by district (Tyrol is divided in nine districts) was fairly constant approximately 63%, being lowest for Innsbruck town (55%) and highest for Landeck district (67%).

In summary, 17,180 parents (63%) responded to the questionnaire whereof 13% live on a farm, 79% live in more or less rural areas of Tyrol and 8% live in Innsbruck, the capital city of Tyrol.

Analysing participation by parental education revealed that 22% of the parents had a high school degree. When comparing the data with data from Statistic Austria 2011, age group 30–39 years of age, 19% of the population in Austria have a high school degree (<http://www.statistik.gv.at>). Therefore, families with higher education are not seriously over-represented in the present study.

Detailed demographic data of the population are provided in Table 1. The mean age was 8.4 years (SD ± 1.2), 50% were male. Reported prevalence of any positive family history for atopic disease was 47% in town children, 44.5% in rural children and 33% in farm children.

In general, farming style in Tyrol is rather traditional and the farms are small with 15–30 or less cattle per farm. The main farming types were livestock (67%) and dairy farming (64%), followed by pig keeping (35%), poultry (34%) and rabbits (28%). The main fodder used on the farms were loose hay (86%), grass (73%), grass silage (38%), feed grain (35%) and pressed hay (31%). A total of 23% of the farms were not run by the parents themselves.

*Regular exposure* to either the animal shed, hay loft or farm milk was reported by 90% of the farm children, 22% of the rural children and 7% of the Innsbruck-town children. Farm children with a positive family history for atopic diseases had less *regular exposure* than those with a negative family history (86 versus 93%, *p* < 0.001).

For the entire study population, the prevalence data are as follows: W12 10.3%, dd-asthma 3.4%, dd-hay fever 10.6% and dd-atopic dermatitis 13.9%. Prevalence and unadjusted odds ratios for wheezing and atopic diseases in children with and without *regular exposure* are shown in Table 2. Farm children with *regular exposure* had the lowest prevalence rates whereas unexposed farm children showed the same or an even higher prevalence than Innsbruck-town children.

**Table 1** Demographic data of the study population

	<i>n</i>	%
Total number of participants	17,180	
Male	8536/16,963	50.3
Farm children	2094/16,534	12.7
Rural children	13084/16,534	79.1
Innsbruck-town children	1356/16,534	8.2
Family history of asthma	1666/16,621	10.0
Family history of hay fever	5054/16,570	30.5
Family history of atopic dermatitis	2902/16,544	17.5
Family history any atopic disease	7108/16,452	43.2
Mother smoking ever	8813/15,925	55.3
Father smoking ever	7160/15,975	44.8
Mother high school degree	3659/16,355	22.4
Father high school degree	3583/16,093	22.3

Farm children with regular exposure had a significantly lower risk for W12, dd-asthma, 'asthma' and dd-hay fever. The protective effect of regular exposure extended to rural children but was statistically significant for W12 and dd-hay fever only; no significant effect was notable in Innsbruck-town children.

Multivariate logistic regression analysis for children being regularly exposed revealed protective attributes for the animal shed, the hay loft and for farm milk (Table 3). The protective effect of drinking raw farm milk included dd-asthma and dd-hay fever; regular exposure to the hay loft was protective for 'asthma' and dd-hay fever; regular exposure to the animal shed was protective for dd-asthma and dd-hay fever.

## Discussion

Over the past 10 years, not only epidemiological studies in Europe but also in Australia, Canada and USA constantly documented a lower prevalence of wheezing and atopic diseases in children living in rural areas or growing up on a farm [5–7]. The present study again confirms the protective properties of living on a farm and drinking farm milk against current wheezing, asthma and hay fever.

However, the protective effect of living on a farm was restricted to farm children with *regular exposure* to the animal shed, hay loft or farm milk. Farm children without *regular exposure* to those environments showed an even higher prevalence for W12, dd-hayfever and dd-atopic dermatitis as Innsbruck-town children. The protective effect of the farm environment extended to rural children with *regular exposure* but was not significant in Innsbruck-town children. The finding that the protective effect is not restricted to children living on a farm but is also seen in rural children with regular contact to a farming environment was first reported by Riedler et al. [8].

Our findings suggest that the protective effect of the farm environment is caused by a surrogate of factors,

**Table 2** Prevalence and unadjusted odds ratios (OR), 95% confidence intervals (CI) for asthma and atopic diseases in Innsbruck-town children, rural children and farm children with and without 'regular exposure' to the animal shed, hay loft or farm milk

	Town			Rural			Farm		
	No exposure (n=1205) %	Exposure (n=91) %	OR (95% CI)	No exposure (n=9841) %	Exposure (n=2840) %	OR (95% CI)	No exposure (n=191) %	Exposure (n=1851) %	OR (95% CI)
W12	10.8	8.9	0.8 (0.4–1.7)	11.2	9.7	<b>0.8*</b> <b>(0.7–1.0)</b>	13.8	5.2	<b>0.3**</b> <b>(0.2–0.5)</b>
dd-asthma	4.7	4.5	1.0 (0.3–2.7)	3.6	3.3	0.9 (0.7–1.2)	3.7	1.4	<b>0.4*</b> <b>(0.2–0.9)</b>
'asthma'	21.3	17.6	0.8 (0.4–1.4)	17.4	16.6	0.9 (0.8–1.0)	19.9	8.8	<b>0.4**</b> <b>(0.3–0.6)</b>
dd-hay fever	10.0	10.0	1.0 (0.5–2.0)	12.2	9.3	<b>0.7**</b> <b>(0.6–0.8)</b>	13.8	3.8	<b>0.2**</b> <b>(0.1–0.4)</b>
dd-atopic dermatitis	13.3	12.4	0.9 (0.5–1.8)	14.2	14.9	1.0 (0.9–1.2)	16.4	12.1	0.7 (0.5–1.0)

W12 wheezing in the past 12 months, dd doctor-diagnosed  
\* $p < 0.05$ , \*\* $p < 0.001$

**Table 3** Multivariate logistic regression analysis<sup>a</sup> for children having 'regular exposure' (n=4782); odds ratios (OR), 95% confidence intervals (CI)

	Wheezing in the past 12 months	Doctor-diagnosed asthma	'Asthma'	Doctor-diagnosed hay fever	Doctor-diagnosed atopic dermatitis
Female sex	<b>0.7 (0.6–0.9)*</b>	<b>0.4 (0.3–0.6)**</b>	<b>0.6 (0.5–0.8)**</b>	<b>0.5 (0.4–0.6)**</b>	0.9 (0.8–1.1)
Family history of atopic disease	<b>1.8 (1.4–2.2)**</b>	<b>2.6 (1.8–3.8)**</b>	<b>1.8 (1.6–2.2)**</b>	<b>3.0 (2.4–3.8)**</b>	<b>3.3 (2.7–3.9)**</b>
Contact animal shed	0.9 (0.6–1.1)	<b>0.5 (0.3–0.9)*</b>	0.9 (0.7–1.1)	<b>0.6 (0.4–0.8)*</b>	0.8 (0.7–1.1)
Contact hay loft	0.8 (0.6–1.2)	0.8 (0.5–1.3)	<b>0.7 (0.5–0.9)**</b>	<b>0.7 (0.5–1.0)*</b>	0.9 (0.7–1.1)
Drinking raw milk	0.8 (0.6–1.1)	<b>0.6 (0.4–0.9)*</b>	0.8 (0.6–1.0)	<b>0.7 (0.5–0.9)*</b>	1.0 (0.8–1.2)
Mother smoking ever	0.8 (0.7–1.0)	0.8 (0.5–1.1)	0.8 (0.7–1.0)	1.0 (0.8–1.3)	0.9 (0.7–1.1)

<sup>a</sup>Models were adjusted for all variables listed in the table  
\* $p < 0.05$ , \*\* $p < 0.001$

whereupon *regular exposure* over a longer time period plays a critical role. It seems that the key factors on the farm, which enable to activate our immune system towards the right direction, are scattered somewhere within the animal shed, hay loft and farm milk. Exposure to animals, the hay loft or the consumption of farm milk might represent different relevant sources with different protective properties. Despite this, not all farming environments seem to protect uniformly against wheezing disorders, asthma and atopic diseases. An interesting and detailed observation was published by the Parsifal Study Team [9], and there is worldwide effort to identify important environmental compounds as well as gene-environment interactions.

When comparing the presented prevalence data from 2008 with data from a study conducted in 1997 in Austria/Salzburg neighbouring Tyrol, it is notable that the prevalence regarding W12 and atopic diseases in farm children has increased within this period: W12 increased from 4.7 to 5.2%; dd-hay fever from 3.1 to 3.8%; dd-atopic dermatitis from 11.4 to 12.1%; dd-asthma from 1.1 to 1.4% [9]. In general, available data from the literature suggest that

in most parts of the world, the prevalence of asthma and atopic diseases is continuing to increase or remaining stable [10–12]. Data whether this is also true for children growing up on a farm are to the best of our knowledge lacking.

We admit that the study has weaknesses, i.e. the questions from the screening questionnaire did not go into detail and we do not provide any objective measures. However, this is a large epidemiological study, covers an entire federation state of Austria and provides prevalence data in the context of a particular living environment.

In conclusion, these data show that *regular exposure* to a farming environment protects against wheezing, asthma and hay fever. Regarding wheezing and hay fever, this effect was not restricted to children living on a farm but also notable in rural children with regular farm contact. Regular exposure for a longer time seems crucial to benefit from this environment. However, as the study is observational and questionnaire-based only the results have to be interpreted with caution and must be confirmed by controlled and in-depth studies.

**Acknowledgements**

This work was supported by the European Commission as part of GABRIEL (a multidisciplinary study to identify the genetic and environmental causes of asthma in the European Community), contract no. 018996 under the Integrated Program LSH-2004-1.2.5-1.

The authors thank all the field workers for their efforts and all teachers and parents in Tyrol/Austria for their study participation.

**Conflict of interest**

The authors declare that there is no conflict of interest.

**References**

1. Propp P, Becker A. Prevention of asthma: where are we in the 21st century? *Expert Rev Clin Immunol.* 2013;9(12):1267–78.
2. Wlasiuk G, Vercelli D. The farm effect, or: when, what and how a farming environment protects from asthma and allergic disease. *Curr Opin Allergy Clin Immunol.* 2012;12(5):461–6.
3. Genuneit J, Büchele G, Waser M, Kovacs K, Debinska A, Boznanski A, et al. The GABRIEL Advanced Surveys: study design, participation and evaluation of bias. *Paediatr Perinat Epidemiol.* 2011;25(5):436–47.
4. Asher MI, Keil U, Anderson HR, Beasley R, Crane J, Martinez F, et al. International Study of Asthma and Allergies in Childhood (ISAAC): rationale and methods. *Eur Respir J.* 1995;8(3):483–91.
5. Wong GW, Chow CM. Childhood asthma epidemiology: insights from comparative studies of rural and urban populations. *Pediatr Pulmonol.* 2008;43(2):107–16.
6. von Mutius E, Vercelli D. Farm living: effects on childhood asthma and allergy. *Nat Rev Immunol.* 2010;10(12):861–8.
7. Genuneit J. Exposure to farming environments in childhood and asthma and wheeze in rural populations: a systematic review with meta-analysis. *Pediatr Allergy Immunol.* 2012;23(6):509–18.
8. Riedler J, Eder W, Oberfeld G, Schreuer M. Austrian children living on a farm have less hay fever, asthma and allergic sensitization. *Clin Exp Allergy.* 2000;30(2):194–200.
9. Ege MJ, Frei R, Bieli C, Schram-Bijkerk D, Waser M, Benz MR, et al. Not all farming environments protect against the development of asthma and wheeze in children. *J Allergy Clin Immunol.* 2007;119(5):1140–7.
10. Deckers IA, McLean S, Linssen S, Mommers M, van Schayck CP, Sheikh A. Investigating international time trends in the incidence and prevalence of atopic eczema 1990–2010: a systematic review of epidemiological studies. *PLoS One.* 2012;7(7):e39803. doi:10.1371/journal.pone.0039803.
11. Anandan C, Nurmatov U, van Schayck OC, Sheikh A. Is the prevalence of asthma declining? Systematic review of epidemiological studies. *Allergy.* 2010;65(2):152–67.
12. Weber AS, Haidinger G. The prevalence of atopic dermatitis in children is influenced by their parents' education: results of two cross-sectional studies conducted in Upper Austria. *Pediatr Allergy Immunol.* 2010;21(7):1028–35.