

Original article

The protective effect of rural living against atopy in Mongolia

Background: Farm environment in childhood protects against atopy.

We investigated in a population-based study in Mongolia the effects of rural living and migration from rural to urban areas on the risk of atopy.

Methods: The screening study data of 9453 subjects, aged 10–60 years, were used for taking the sample for the clinical study in which 869 subjects were examined. Asthma, allergic rhinoconjunctivitis and sensitization were clinically defined and their risk factors analysed by logistic regression.

Results: The risks of allergic rhinoconjunctivitis [adjusted odds ratio (OR) 0.43, 95% confidence interval (CI) 0.19–0.98] and allergic sensitization (OR 0.26, 95% CI 0.13–0.55) were the lowest in subjects living in a village from birth and intermediate in subjects who had relocated from a village to a town (OR for rhinoconjunctivitis 0.68, 95% CI 0.36–1.27, OR for sensitization 0.62, 95% CI 0.35–1.12) compared with subjects living in a town from birth. Simultaneous exposure to herd animals and dung heating decreased the risk of atopy. Keeping animals was a risk-factor for asthma only in Ulaanbaatar city.

Conclusions: Continuing farm exposure after childhood may be important in reducing the risk of atopy.

**A. Viinanen¹, S. Munhbayarlah²,
T. Zevgee², L. Narantsetseg²,
Ts. Naidansuren³, M. Koskenvuo⁴,
H. Helenius⁵, E. O. Terho¹**

¹Department of Pulmonary Diseases and Clinical Allergology, University of Turku, Turku, Finland;

²Department of Pathophysiology, Health Sciences University of Mongolia, Ulaanbaatar, Mongolia;

³Department of Pulmonary Diseases, Health Sciences University of Mongolia, Ulaanbaatar, Mongolia; ⁴Department of Public Health, University of Helsinki, Helsinki, Finland; ⁵Department of Biostatistics, University of Turku, Turku, Finland

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Arja Viinanen
Department of Pulmonary Diseases
Turku University Hospital
PO Box 52
20521 Turku
Finland

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Growing up on a farm has been convincingly shown to reduce the risk of atopic diseases in childhood with about a similar magnitude in different countries with large variations in the population prevalence of atopic diseases (1–6). The reduction in the risk of atopy has been related especially to contact with farm animals (2, 3, 5–8) and it has been dose-dependent (7, 8). The effect is probably mediated by exposure to endotoxin and other microbial products (9).

Until recently, the focus has been on early life, since the period of the maturation of the immune system has been considered the most important time for either developing allergy or tolerance to allergens (8, 10). The risk of atopy has been the lowest when exposure to the farm environment has been the earliest (8). The protective effect of childhood farm environment has lasted until adulthood (10–13). Continuing exposure to the farm environment may, however, have importance until adulthood (14, 15). The differences in the prevalence of asthma and allergic rhinitis between farm and non-farm environments seem to have increased during the past decades when a number of unknown factors have resulted in a faster increase in

non-farm environments and a slower increase in farm environments (16).

We have reported that the risk of atopy increased with increasing urbanization level in Mongolia, which is a country in transition between traditional nomadic and western lifestyles (17). We also investigated from the same data, whether migration from rural to urban areas after childhood increases the risk of atopic diseases and whether any environmental exposure would explain the lower prevalence of atopy in rural areas.

Methods

The data were collected between April 1999 and August 2000 in Ulaanbaatar city (population at the time of the study 760 000), three rural towns (population 15 000–20 000) and seven villages (population 1000–2000) in Mongolia. The methods have been described in detail previously (17). In the screening study, mother, father, daughter and son of random family samples were interviewed by family doctors using a questionnaire on respiratory diseases based on the Tuohilampi questionnaire (18). Screening data were complete from 9453 subjects aged 10–60 years (Fig. 1).

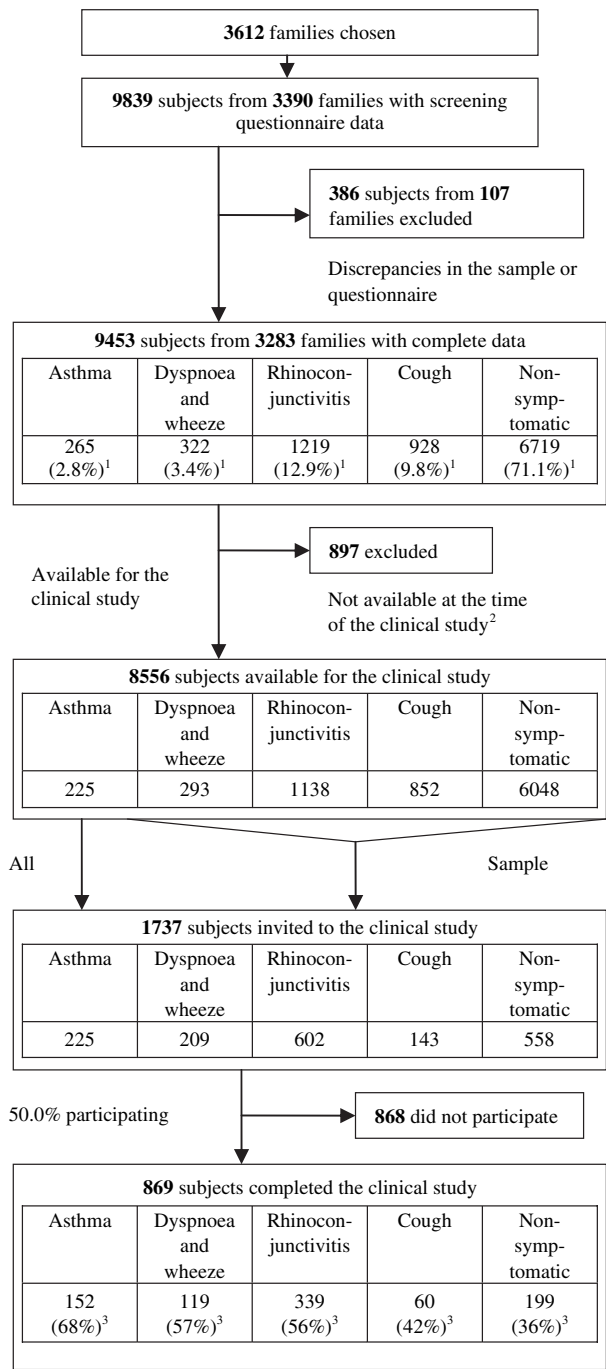


Figure 1. Course of the study. The subjects were divided into five hierarchical symptom groups on the basis of answers to the screening questionnaire. ¹The percentage of the symptom group out of the whole sample; ²A total of 876 subjects could not be invited because the family doctor who had collected the screening data was absent at the time of the clinical study, one subject had died and 20 subjects were absent; ³the participation rate to the clinical study in the symptom group. In the clinical study 81 subjects were defined to have asthma and 254 subjects allergic rhinoconjunctivitis.

All the subjects who reported having asthma [1] and a random sample of subjects reporting dyspnoea with wheezing [2], rhinoconjunctivitis [3] and cough [4] were invited in the clinical study. In addition, a sample of age- and sex-matched non-symptomatic subjects [5] was taken (Fig. 1). The sample was enriched with symptomatic subjects to have enough cases in the clinical study and to confirm the diagnoses of asthma and allergic rhinoconjunctivitis. The possibility for diagnostic examinations in public health care was variable in the different areas, and in general the availability of spirometric examination and skin testing for allergy was low in Mongolia. We therefore chose to use the clinical study data in the definitions of the outcomes. The clinical sample was weighted in the risk factor analyses using sampling fractions between the two phases of the study as weights. The weights were calculated by dividing the number of the subjects in each above mentioned symptom group in the screening study by the number of the subjects participating from that group in the clinical study. Each subject thus represented by his/her weight the subjects with similar symptoms in the initial screening sample. Participation rate in the clinical study was 50.0%. Altogether 869 subjects were examined.

Clinical study

The clinical study included a detailed interview with a questionnaire on respiratory diseases based on the Tuohilampi questionnaire (18). Questions were included also on other diseases, medication, vaccinations, family history of atopic diseases, family size, lifestyle factors and the living environment. The subjects were clinically examined. The examination included auscultation of the lungs and heart, inspection of nose, throat, eyes and skin and the measurement of the blood pressure.

Spirometry was carried out successfully in 785 subjects using the computerized Medikro D9 spirometer, calibrated daily according to the manufacturer's instructions. The reference values used were European Coal and Steel Community (ECSC) reference values for adults and Zapletal reference values for children under 18 years of age. In subjects with the relation of FEV1 to FVC <88% of the reference value or FEV1 <70% of the reference value, bronchodilation test was carried out using 0.4 mg inhaled salbutamol (77 subjects). A >12% improvement in FEV1 was considered significant (19). The methacholine challenge test was carried out in subjects with symptoms suggestive of asthma and FEV1 ≥70% of the reference value and in a subset of subjects without asthmatic symptoms (173 subjects). Cardiac symptoms were a contraindication for methacholine challenge. Controlled tidal breathing technique was used (20) with the Spira Elektro 2 dosimeter (Respiratory Care Center, Hämeenlinna, Finland). The subjects inhaled first 0.9% saline and then increasing doses of methacholine solution (18, 72, 270, 810 and 2610 µg). The provocative dose causing a 15% fall in FEV1 (PD₁₅) was calculated. Subjects were defined as having bronchial hyperreactivity if methacholine PD₁₅ was ≤ 2610 µg or if FEV1 decreased ≥15% after initial saline inhalation.

Skin prick tests were carried out on the volar surface of the forearm in 864 subjects. The allergens used were birch, white poplar, meadow grass and mugwort pollens, *Dermatophagoides pteronyssinus*, *D. farinae*, *Acarus siro*, German cockroach, cat, dog, horse, cow, sheep, goat, *Cladosporium herbarum* and *Aspergillus fumigatus* (Soluprick®; ALK-Abelló, Copenhagen, Denmark). Histamine chloride 10 mg/ml was used as a positive control and the diluent as a negative control. Each drop was pricked using a separate sterile lancet and the reaction read after 15 min. Positive reaction was defined as a wheal with a diameter ≥3 mm after subtraction of the diameter of the negative control.

The criteria for *asthma* were symptoms suggestive of asthma (self-reported asthma, dyspnoea with wheezing or cough with wheezing) and at least one clinical finding (bronchial hyperreactivity, positive bronchodilation test, or in a subject with <5 pack-year smoking history obstructive spirometry defined as FEV1/FVC <88% of the reference value). The criteria for *allergic rhinoconjunctivitis* were self-reported chronic, recurrent or allergic nose or eye symptoms at times without a cold or flu and at least one skin prick test wheal ≥ 3 mm in diameter. *Allergic sensitization* was defined as at least one skin prick test wheal ≥ 3 mm in diameter. *Sensitization to farm allergens* was defined as at least one skin prick test wheal ≥ 3 mm in diameter to any of the allergens of the farm environment (*A. siro*, horse, cow, sheep or goat) and *sensitization to other allergens* as a skin prick test wheal ≥ 3 mm in diameter only to other allergens. *Non-allergic rhinoconjunctivitis* was defined as chronic or recurrent nose or eye symptoms at times without a cold or flu without any positive skin prick test result.

Sufficient tests for asthma could not be completed in 34 subjects, for allergic rhinoconjunctivitis in three subjects and for assessment of sensitization in five subjects. These subjects were not included in the analyses of the respective disorders.

Statistical analysis

Logistic regression analysis was used in the analyses of risk factors. SUDAAN statistical software release 8.0.0. (SUDAAN Software for the Statistical Analysis of Correlated Data, Research Triangle Institute, NC, USA, 2001) and SAS version 8e (SAS Institute Inc. Cary, NC, USA, 1999) were used. Interclass correlation in family clusters was taken into account in the analyses.

The explanatory factors used in the models of the risk of asthma, allergic rhinoconjunctivitis and allergic sensitization were chosen to describe the change in the environment (the area of residence at birth and currently) and exposures in the farm environment (exposure to herd animals: cows, horses, sheep or goats, to other than herd animals and dung heating). In addition, the family history of asthma and allergic rhinitis and active and passive smoking were examined as explanatory factors. All models were also adjusted for age and sex. Only 12 subjects had relocated from a town to a village and one subject had missing data on the area of birth. Therefore, the analysis of relocation was carried out in the subset of the 856 subjects of 869 who had lived in a village or in a town from birth or who had relocated from a village to a town. Ulaanbaatar city and rural towns were united in this analysis as the effect of relocation on atopy was similar in subjects relocating from villages to rural towns or to Ulaanbaatar. Odds ratios (OR) and 95% confidence intervals (CI) were calculated. *P*-values below 0.05 were considered significant.

Response rate to the screening study was high but to the clinical study it was low (Fig. 1). Therefore, an analysis of non-response was carried out and has been reported previously (17). Males, smokers, and in Ulaanbaatar city subjects who kept animals and subjects who were born in urban areas participated less frequently, but the interaction analysis showed no interaction between the symptom-group from which the subject was chosen to the clinical study and these factors on participation. Therefore, the symptoms did not modify the participation of the subjects with certain risk factors.

The ethics committee of the University of Turku and Turku University Hospital approved the study. In Mongolia, the study was approved by the National Medical University of Mongolia (at present, Health Sciences University of Mongolia). All subjects gave their informed consent.

Results

Table 1 shows the characteristics of the subjects participating in the clinical study. The subjects living in villages from birth had less often a family history of asthma, were less often active or passive smokers, worked more often in agriculture, had more often herd animals, lived more often in a ger (a typical Mongolian dwelling made of felt), had never central heating and used more often dung as a heating fuel in comparison with subjects living in towns. The subjects who had relocated from a village to a town were older and had less often a family history of asthma and allergic rhinitis than subjects who had lived in a town from birth.

Asthma was more common in females and allergic rhinoconjunctivitis and allergic sensitization in males, but the associations were not statistically significant (Table 2). Asthma was significantly less prevalent in the middle age group from 21 to 39 years, whereas the prevalences of allergic rhinoconjunctivitis and allergic sensitization increased with increasing age. Family history of asthma was a risk factor for asthma and family history of allergic rhinitis was a risk factor for allergic rhinoconjunctivitis. Active smoking was associated with a lower prevalence of allergic rhinoconjunctivitis and sensitization. Passive smoking had a similar, although statistically non-significant association. The number of siblings, self-reported infections (measles, mumps, rubella, pertussis, hepatitis or tuberculosis) or vaccinations did not have any association with the outcomes (data not shown).

The odds ratio (95% CI) for allergic rhinoconjunctivitis for those living in a village from birth was 0.43 (0.19–0.98) and for those who had relocated from a village to a town 0.68 (0.36–1.27) in comparison with subjects living in a town from birth when analysed using a logistic regression model adjusted for age, sex, parental asthma, parental allergic rhinitis and active or passive smoking (*p* for trend = 0.046; Table 2). The respective figures for allergic sensitization were OR 0.26 (95% CI 0.13–0.55) for those who had lived in a village from birth and OR 0.62 (95% CI 0.35–1.12) for those who had relocated from a village to a town (*p* for trend = 0.001; Table 2). The results were similar in logistic regression models which were adjusted only for age and sex (data not shown).

When the analyses were carried out separately among subjects living currently in villages or in Ulaanbaatar city (analysing the effect of relocation to a city) and among subjects living currently in villages or rural towns (analysing the effect of relocation to a rural town) the effect of relocation was similar but larger in subjects relocating to a city. The odds ratio for sensitization for subjects living in a village from birth was 0.23 (95% CI 0.10–0.51) and for subjects who had relocated to a city 0.68 (95% CI 0.33–1.38) in comparison with subjects living in a city from birth (*p* for difference = 0.001, *p* for

Table 1. Characteristics of the subjects in relation to relocation*

	All (<i>n</i> = 869)	Village–village (<i>n</i> = 178)	Village–town (<i>n</i> = 309)	Town–town (<i>n</i> = 369)
Sex, <i>n</i> (%)				
Female	557 (64.1)	115 (64.6)	213 (68.9)	219 (59.4)
Male	312 (35.9)	63 (35.4)	96 (31.1)	150 (40.7)
Age (years), <i>n</i> (%)				
10–20	137 (15.8)	31 (17.4)	11 (3.6)	94 (25.5)
21–39	368 (42.4)	79 (44.4)	111 (35.9)	172 (46.6)
40–60	364 (41.9)	68 (38.2)	187 (60.5)	103 (27.9)
Mean age (years) (±SD)	35.4 ± 12.4	34.3 ± 12.8	40.9 ± 10.1	31.2 ± 12.2
Parent's allergic rhinitis, <i>n</i> (%)	88 (10.3)	12 (6.9)	21 (6.9)	53 (14.6)
Parent's asthma, <i>n</i> (%)	70 (8.2)	4 (2.3)	22 (7.2)	43 (11.8)
Active ± passive smoking, <i>n</i> (%)	188 (21.8)	31 (17.4)	79 (25.8)	77 (21.1)
Passive smoking, <i>n</i> (%)	254 (29.5)	35 (19.7)	98 (32.0)	117 (32.1)
Occupation, <i>n</i> (%)				
Agriculture	31 (3.7)	23 (13.6)	3 (1.0)	5 (1.4)
Industry/manual	108 (13.0)	11 (6.5)	43 (14.5)	53 (14.9)
Office	284 (34.1)	51 (30.2)	115 (38.9)	111 (31.2)
Student	122 (14.6)	23 (13.6)	11 (3.7)	88 (24.7)
Homework/unemployed	289 (34.7)	61 (36.1)	124 (41.9)	99 (27.8)
Keeping herd animals	183 (21.1)	102 (57.3)	28 (9.1)	46 (12.5)
Keeping only other animals	344 (39.6)	52 (29.2)	137 (44.5)	149 (40.4)
Type of residence, <i>n</i> (%)				
Ger†	262 (30.2)	92 (52.0)	85 (27.6)	81 (22.0)
Own house	294 (33.9)	62 (35.0)	101 (32.8)	126 (34.2)
Flat	311 (35.9)	23 (13.0)	122 (39.6)	162 (43.9)
Central heating (water radiators)	255 (29.5)	0 (0)	108 (35.1)	147 (39.8)
Oven heating	610 (70.5)	175 (100)	200 (64.9)	222 (60.2)
– Of them dung heating‡	163 (19.4)	82 (49.1)	34 (17.6)	43 (20.2)
Asthma§	81 (2.0)	8 (1.2)	34 (2.6)	39 (2.1)
Allergic rhinoconjunctivitis§	254 (15.8)	28 (9.3)	88 (13.9)	133 (20.4)
Allergic sensitization§	325 (26.9)	39 (14.0)	113 (25.9)	168 (34.1)
Sensitization to pollens¶	176 (11.4)	19 (6.1)	51 (9.0)	104 (18.7)
Sensitization to, <i>n</i> (%)				
Farm allergens§,**	172 (15.2)	19 (6.0)	68 (19.0)	82 (14.2)
Only other allergens§,††	153 (11.7)	20 (8.0)	45 (6.9)	86 (19.8)

*The analysis of relocation was carried out between the subjects who were born in a village and lived currently in a village (village–village), born in a village and lived currently in a town (village–town), born in a town and lived currently in a town (town–town). Twelve subjects who were born in a town and lived currently in a village and one subject without information of the area of birth were not included in the analysis of relocation; †typical Mongolian dwelling made of felt; ‡using information from 573 of 597 subjects with information of the fuel used; §age-adjusted and sex-adjusted prevalences calculated using sampling weights; ¶birch, white poplar, mugwort or meadow grass; ***Acarus siro*, horse, cow, sheep or goat ± other allergens; ††only other allergens than *A. siro*, horse, cow, sheep and goat.

trend = 0.001). The odds ratio for sensitization for subjects living in a village from birth was 0.30 (95% CI 0.12–0.73) and for subjects who had relocated from a village to a rural town 0.45 (95% CI 0.16–1.29) in comparison with subjects who had lived in a rural town from birth (*p* for difference = 0.03, *p* for trend = 0.009). Table 3 shows that sensitization to pollens increased most clearly with increasing lifelong exposure to urban environment.

In the group of subjects who had relocated from a village to town, the onset of the symptoms occurred after moving in 27 (87%) of 31 asthmatic subjects (three subjects did not give information on the onset time of symptoms) and in 75 (94%) of 80 subjects (eight subjects did not give information) with rhinoconjunctivitis, respectively. The onset of asthma and rhinoconjunctivitis

symptoms occurred at a significantly later age in subjects who had relocated from a village to a town than in subjects who had lived in a town from birth (data not shown).

In Ulaanbaatar city, 160 subjects (42%) kept some animals, but only four subjects (0.01%) kept herd animals. Most of the subjects (138) kept dogs. In rural towns, 201 subjects (68%) kept some animals and 70 subjects (24%) kept herd animals. In villages 166 subjects (87%) kept some animals and 109 subjects (57%) kept herd animals. Keeping animals was not significantly associated with sensitization and did not influence the association of increasing risk of sensitization with living in urban areas (Table 4). In Ulaanbaatar city, exposure to animals was an almost fourfold risk factor for asthma, whereas in rural areas keeping animals was not related to

Table 2. Association of asthma, allergic rhinoconjunctivitis and sensitization with explanatory factors in logistic regression analysis

	Asthma (<i>n</i> = 81)				Allergic rhinoconjunctivitis (<i>n</i> = 254)			Allergic sensitization (<i>n</i> = 325)		
	<i>n</i> †	<i>n</i> †	OR‡	95% CI	<i>n</i> †	OR‡	95% CI	<i>n</i> †	OR‡	95% CI
Area of residence§										
Village–village	178	8	0.66	0.25–1.75	28	0.43	0.19–0.98	39	0.26	0.13–0.55
Village–town	309	34	1.05	0.57–1.97	88	0.68	0.36–1.27	113	0.62	0.35–1.12
Town–town	369	39	1.00	–	133	1.00	**	168	1.00	*,**
Sex										
Female	557	55	1.99	0.88–4.48	153	0.54	0.28–1.04	189	0.59	0.33–1.06
Male	312	26	1.00		101	1.00		136	1.00	
Age (years)										
10–20	137	11	0.78	0.32–1.92	27	0.24	0.10–0.62	42	0.34	0.15–0.77
21–39	368	22	0.36	0.19–0.70	115	0.70	0.38–1.27	144	0.77	0.44–1.35
40–60	364	48	1.00	*	112	1.00	*,**	139	1.00	*,**
Parent's allergic rhinitis										
Yes	88	8	1.02	0.38–2.72	37	4.20	1.69–10.4	42	1.82	0.76–4.35
No	765	70	1.00		212	1.00	*	276	1.00	
Parent's asthma										
Yes	70	15	2.54	1.00–6.45	22	0.77	0.24–2.46	27	0.74	0.27–2.07
No	789	64	1.00	*	227	1.00		292	1.00	
Tobacco smoke exposure										
Active smoking	188	19	1.33	0.51–3.45	53	0.43	0.20–0.94	69	0.43	0.22–0.84
Passive smoking	254	28	1.17	0.59–2.33	64	0.52	0.27–1.01	84	0.56	0.30–1.04
No exposure to tobacco smoke	420	33	1.00		133	1.00	*	167	1.00	*

OR, odds ratio; CI, confidence interval.

†The number of subjects using all available information, ‡mutually adjusted for all variables in the table using all available information (801 subjects included in the analysis of asthma, 831 in the analysis of allergic rhinoconjunctivitis and 829 in the analysis of sensitization), §village–village, born in a village and lives currently in a village; village–town, born in a village and lives currently in a town; town–town, born in a town and lives currently in a town.

*Significant association for the entire explanatory variable ($P < 0.05$); **significant trend ($P < 0.05$).

the risk of asthma. Combined exposure to herd animals and dung heating protected most strongly from allergic rhinoconjunctivitis and sensitization (Table 5). On the contrary, the risk of non-allergic rhinoconjunctivitis was increased in subjects exposed to both herd animals and dung heating.

Discussion

Living in a village from birth was most protective against allergic sensitization, allergic rhinoconjunctivitis and non-significantly against asthma, but the risk increased after relocation. Contrary to the consistent findings of the highly protective effect of farm environment against the risk of allergic sensitization in childhood (1, 3–5, 7, 8), the relationship has not been as clear in adulthood. Some studies found no difference in the prevalence of sensitization in farmers compared with the general population (21, 22) or between livestock and other farmers (23) although asthma was reported to be less prevalent in farmers (22) and in atopic farmers with two or more types of livestock (23). Continuous exposure to the farm environment from childhood is probably important, as a reduction in the risk of allergic sensitization (14) and symptoms of allergic rhinitis (15) has been

reported in farmers with childhood exposure to farm environment in comparison with farmers not raised on a farm as a child.

In Mongolia, 49% of the work force was employed in agriculture in 1999 (24). Animal husbandry is the main branch of agriculture. In 1999, the number of livestock was 33.6 million, 15 million of which were sheep (24). Therefore, it is evident that the majority of rural inhabitants are exposed to animal husbandry from early childhood on which possibly explains the lowest risk of allergic rhinoconjunctivitis and sensitization in subjects living in a village in our study.

As discussed in a recent review, the results of several recent epidemiological studies have widened the initial hygiene hypothesis from a protective effect of early childhood infections against atopy to a hypothesis of a protective effect of several environmental microbial exposures as well as gastrointestinal microflora in addition to infections (25). It is probable that in Mongolia continuous environmental exposures are more important for the protection against atopy than infections because self-reported infections and the number of siblings had no association with asthma, allergic rhinoconjunctivitis or sensitization.

In rural Mongolia, the risks of allergic rhinoconjunctivitis and sensitization were the lowest in subjects

Table 3. Association of sensitization with the area of residence†

Sensitizing allergens	Skin prick test positive		
	n/N	OR	95% CI
Pollens			
Village–village‡	19/176	0.24	0.09–0.60
Village–town‡	51/307	0.36	0.16–0.81
Town–town‡	104/368	1.00	*,**
Animals			
Village–village‡	16/176	0.57	0.20–1.62
Village–town‡	33/307	0.59	0.26–1.32
Town–town‡	50/368	1.00	
Mites/cockroach			
Village–village‡	21/176	0.32	0.13–0.81
Village–town‡	72/307	0.98	0.51–1.88
Town–town‡	95/368	1.00	*
Farm allergens§			
Village–village‡	19/176	0.32	0.12–0.86
Village–town‡	68/307	1.02	0.50–2.05
Town–town‡	82/368	1.00	*,**
Other than farm allergens§			
Village–village‡	20/176	0.21	0.08–0.54
Village–town‡	45/307	0.31	0.13–0.72
Town–town‡	86/368	1.00	*,**

OR, odds ratio; CI, confidence interval.

†Results of logistic regression analyses adjusted for age, sex, parental asthma, parental allergic rhinitis and active or passive smoking; ‡village–village, born in a village, lives currently in a village; village–town, born in a village, lives currently in a town; town–town, born in a town, lives currently in a town; §results of a single logistic model including both sensitization to farm and other allergens.

*Significant association for the entire explanatory variable ($P < 0.05$); **significant trend ($P < 0.05$).

keeping herd animals and heating their flats with dung. These subjects are probably exposed abundantly to environmental microbes. Exposure to bacterial endotoxin is the highest in farm stables and has been shown to decrease the risk of sensitization, allergic rhinitis and atopic wheezing in rural children in a dose-dependent way (9). Current exposure to endotoxin was reported to reduce the risk of strong sensitization and sensitization to pollens also in adulthood (26), but the association was not confirmed in a study of farmers (23). On the contrary, current exposure to endotoxin and exposure to livestock increased the risk of non-atopic asthma in farmers (23).

On the contrary to the findings of exposure to animals having no association with asthma in rural areas, exposure to animals in a more hygienic urban environment was a risk factor for asthma in Mongolia. However, the animal exposures were different, as in Ulaanbaatar city the subjects were exposed to pets, whereas in rural areas also to herd animals. The hygiene hypothesis as a sufficient explanation to the increase of asthma has been recently questioned and other factors, such as reduced exercise, obesity and indoor exposures to allergens have been suggested to contribute importantly to the increased prevalence of asthma in Western societies (27).

There are several other life-style factors of interest in relation to the risk of atopy differing between urban and rural areas in Mongolia. These are for example using fermented milk products, having refrigerators, the frequency of washing hands and using river, well or pipe

Table 4. Effects of relocation from a village to a town and keeping animals on the risk of asthma, allergic rhinoconjunctivitis and allergic sensitization separately in rural areas (rural towns and villages) and in Ulaanbaatar city

		Asthma		Allergic rhinoconjunctivitis		Allergic sensitization	
	N†	n†	OR (95% CI)‡	n†	OR (95% CI)‡	n†	OR (95% CI)‡
Rural towns and villages							
Area of residence§							
Village–village	178	8	0.46 (0.17–1.26)	28	0.51 (0.17–1.48)	39	0.35 (0.13–0.89)
Village–town	123	10	0.43 (0.14–1.32)	34	0.59 (0.22–1.55)	39	0.49 (0.17–1.37)
Town–town	170	19	1.00	63	1.00	76	1.00**
Keeping animals							
Herd animals	179	12	1.36 (0.42–4.40)	39	0.76 (0.23–2.53)	48	0.38 (0.13–1.10)
Only other animals	188	17	1.70 (0.60–4.83)	56	0.68 (0.23–2.01)	67	0.63 (0.24–1.67)
No animals	117	8	1.00	35	1.00	44	1.00
Ulaanbaatar city							
Place of birth							
Village	186	24	1.42 (0.56–3.61)	54	0.69 (0.32–1.49)	74	0.66 (0.32–1.35)
Town	199	20	1.00	70	1.00	92	1.00
Keeping any animals¶	160	27	3.86 (1.57–9.52)	47	1.35 (0.67–2.72)	61	0.97 (0.50–1.89)
No animals	224	17	1.00*	77	1.00	105	1.00

OR, odds ratio; CI, confidence interval.

†Using all available data; ‡logistic regression models adjusted for age, sex, parental asthma, parental allergic rhinitis, exposure to tobacco smoke (active or passive smoking) and mutually for the variables in the table; §village–village, born in a village and lives currently in a village; village–town, born in a village and lives currently in a town; town–town, born in a town and lives currently in a town; ¶four subjects keeping herd animals, 156 subjects keeping only other than herd animals (138 of them keeping dogs).

*Significant association ($P = 0.003$); **significant trend ($P = 0.03$).

Table 5. Association of keeping herd animals (cows, horses, sheep, or goats) and dung heating with asthma, allergic rhinoconjunctivitis, allergic sensitization and non-allergic rhinoconjunctivitis. Analysed using data from rural areas (rural towns and villages)

Diagnosis (<i>n</i> = 484)	Herd animals +, dung heating + <i>n</i> = 56	Herd animals +, dung heating - <i>n</i> = 110	Herd animals -, dung heating + <i>n</i> = 107	Herd animals -, dung heating - <i>n</i> = 185	<i>P</i> -value*
Asthma/ <i>n</i>	2	10	9	16	
OR (95% CI)†	0.76 (0.14–4.09)	1.28 (0.47–3.46)	1.25 (0.41–3.76)	1.00	0.89
Allergic rhinoconjunctivitis/ <i>n</i>	6	31	25	64	
OR (95% CI)†	0.25 (0.09–0.70)	1.32 (0.48–3.59)	0.78 (0.28–2.17)	1.00	0.03
Allergic sensitization/ <i>n</i>	7	37	35	73	
OR (95% CI)†	0.10 (0.03–0.30)	0.66 (0.25–1.76)	0.75 (0.30–1.90)	1.00	<0.001
To pollens/ <i>n</i>	4	17	17	44	
OR (95% CI)†	0.29 (0.09–0.97)	1.71 (0.49–5.93)	0.84 (0.32–2.21)	1.00	0.12
To mites or cockroach/ <i>n</i>	3	22	25	38	
OR (95% CI)†	0.07 (0.02–0.28)	0.39 (0.16–0.93)	0.83 (0.28–2.45)	1.00	0.001
To animals/ <i>n</i>	1	15	7	28	
OR (95% CI)†	0.08 (0.01–0.68)	0.59 (0.21–1.63)	0.15 (0.04–0.53)	1.00	0.01
To farm allergens/ <i>n</i>	3	22	21	34	
OR (95% CI)†	0.08 (0.02–0.33)	0.38 (0.15–1.00)	0.85 (0.27–2.72)	1.00	
To other allergens/ <i>n</i>	4	15	14	39	
OR (95% CI)†	0.13 (0.03–0.56)	1.18 (0.32–4.34)	0.65 (0.18–2.29)	1.00	0.001‡
Non-allergic rhinoconjunctivitis/ <i>n</i> §	25	40	38	51	
OR (95% CI)†	3.67 (1.24–10.9)	2.01 (0.73–5.59)	1.32 (0.50–3.51)	1.00	0.007

OR, odds ratio; CI, confidence interval.

**P*-value for the entire explanatory variable; †results of a logistic regression model adjusted for age, sex, parental asthma or allergic rhinitis, and exposure to tobacco smoke (smoking or exposure to environmental tobacco smoke); ‡*P*-value for the three-categorical sensitization variable (sensitization to farm allergens, to other allergens and no sensitization); §analyzed in a model using a three-categorical rhinoconjunctivitis-variable (allergic, non-allergic and no rhinoconjunctivitis), OR given for comparison of subjects with non-allergic rhinoconjunctivitis to subjects without rhinoconjunctivitis.

water. These factors were not investigated in this study but they are of interest in future studies.

Other studies have also found the highest reduction in sensitization to pollens compared with other allergens in farm environment (8, 28). However, in Mongolia the prevalences of sensitization to both farm and other allergens were the lowest in the villages in contrast to some studies which did not find a reduced risk of sensitization to farm allergens in farm children (4, 8, 29). Our findings of the lowest prevalence of sensitization to mites/cockroach in the villages are in contrast also to the findings from rural Ethiopia, where the prevalences of asthma and wheezing were lower than in urban Ethiopia but the prevalence of sensitization to house dust mite was higher (30).

In our study, the protective factors of rural environment were most clearly associated with sensitization and allergic rhinoconjunctivitis, but the factors associated with asthma may be different. About half the subjects had non-allergic asthma and the proportion of it was similar in all study areas (17). Because of the small number of subjects with asthma we did not study separately the risk factors of allergic and non-allergic asthma. In our study, the risk for non-allergic rhinitis was increased in subjects exposed to dung heating and herd animals.

The findings of the increase in the risk of allergic rhinoconjunctivitis and sensitization after relocation suggest that either diminished exposure to protective factors or increased exposure to risk factors may increase the risk

of developing IgE-mediated allergies even at adult age. It is not probable that many of the subjects would have moved from rural to urban areas because of allergic symptoms, as most of the subjects had developed the first symptoms of asthma and allergic rhinoconjunctivitis after relocation, and were also older at the time of the first symptoms than subjects living in a town from birth. In Europe, where the lifestyle differences between rural and urban populations are not as wide as in Mongolia, the protective effect of childhood farm exposure has been shown to last until adulthood (10–13). However, these studies have not compared the subjects who had continued to live on a farm with those who had relocated to a town.

Our findings are consistent with the findings of a higher prevalence of asthma and respiratory allergies in migrants who have moved from countries with low prevalences of atopic diseases to countries with higher prevalences (31, 32). Interestingly, the risk has been shown to increase dose-dependently with the duration of the stay in the new environment (31, 32). This is the first time to show an increased risk of atopy in a migrant population within a country in transition between different lifestyles. We could not, however, assess the time-dependent association between relocation and the risk of atopy.

In conclusion, the prevalences of allergic sensitization and allergic rhinoconjunctivitis were the lowest in subjects who had lived in rural Mongolia from birth. The prevalences were especially low in those rural subjects who kept herd animals and heated their flat with dung.

The risks of allergic rhinoconjunctivitis and sensitization increased after relocation from a village to a town. Future studies of the risk of atopy in relation to age at relocation and the duration of living in a town would give still more information of the change in the risk of atopy in urbanizing Mongolia.

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