The impact of Icelandic turf structures on occupant health

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F. van Dijken, J. van Hoof, J.H. Reijnierse. The impact of Icelandic turf structures on occupant health. Gerontechnology 2005;3(3):165-169. In Iceland, mineral based turf has been used as a building material for centuries. In this study the impact of Icelandic turf structures on occupant health is examined. Historical epidemiological and demographic figures have been studied, as well as building materials and geometry, biological contaminants, and the indoor environment of the Icelandic turf farm of Glaumbær. The occupants' health was not influenced by building properties that are characteristic to turf structures. Disease prevalence seems to have originated from the poor living conditions occupants were exposed to. Despite primitive living conditions, some of the Icelanders reached very high ages.

Keywords: turf architecture, Iceland, indoor environment, infectious diseases

In Iceland, mineral based turf was already in use as a building material before the year 1000, when Vikings settled on the island[1]. Traditional Icelandic buildings are characterised by turf walls and sod roofs (*Figure 1*), which serve as a thermally insulating envelope around a wooden structure[2,3]. The locally cut building material is largely composed of silt, held together by *Carex* roots[3,4]. Building geometry and application of materials have been derived from experience, enabling optimal functionality and satisfactory thermal comfort. Between 1910 and 1940 the number of turf dwellings declined from over 50% to 10% of the housing stock, since people moved to concrete and timber houses[5].

Aim of this study is to examine the impact of Icelandic turf structures on occupant health by analysing epidemiological and demographic figures, as well as building properties and the indoor environment of turf dwellings.

Figure 1. Glaumbær, an example of Icelandic turf architecture

MATERIALS AND METHODS

The study includes two research levels. First, historical demographic and epidemiological statistics were examined for the period 1910-1940. After these decades turf houses were no longer dwelled. Secondly, a case study was performed at one of the remaining turf structures.

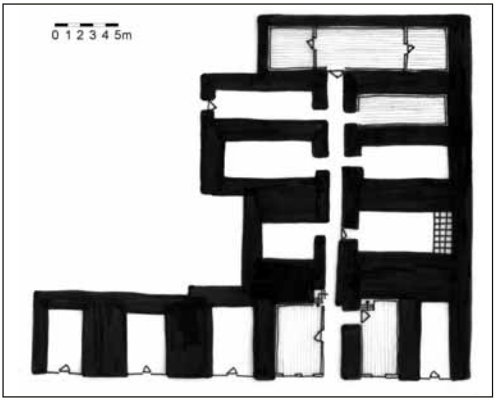


Figure 2. Ground plan of Glaumbær farm

Occupanth' health and demographic figures were examined using Icelandic historical statistics[5]. Epidemiological data included the 10 most common infectious and parasitic diseases prevalent during the time span considered (bronchitis acuta, influenza, angina tonsillaris, enteritis, pneumonia, morbilli, pertussis, parotitis, infectio gonococcia and scarlatina), plus tuberculosis, leprosis, and echinococcosis. Population age distribution in Iceland was studied for the years 1910, 1940, 1970, and 1990 on the basis of population pyramids, derived from historical statistics. Relations between health of the occupants and the use of turf as a building material were examined by statistical analysis. Relations between the percentage of turf buildings occupied and disease prevalence were determined by means of Pearson's correlation coefficients with a confidence level of 0.01 and 0.05.

Turf building properties were studied at Glaumbær farm (*Figures 1, 2*), a representative sample of Icelandic turf architecture. This building, constructed between 1750 and 1879, is one of the largest and oldest turf farms in existence. Nowadays, Glaumbær is in use as a folk museum. The site was visited by the authors in October 2003. The aspects investigated at Glaumbær were (i) materials and building

Table 1: Prevalence of infectious and parasitic diseases per 100 000 persons per quinquennium between 1911 and 1940, and Pearson correlation coefficient r with percentage of turf dwellings[5]

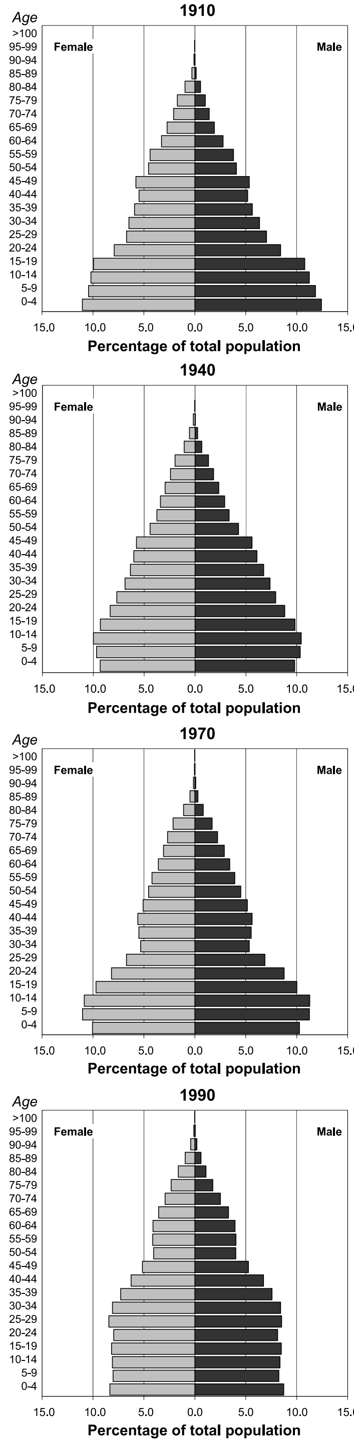
Disease	**Year**						**r**	**p**
	1911-15	**1916-20**	**1921-25**	**1926-30**	**1931-35**	**1936-40**		
Bronchitis acuta	1836	3844	4373	6678	9355	14937	-.856	.01
Influenza	805	2341	3121	3695	5424	5795	-.767	.05
Angina tonsillaris	1015	1044	1901	3376	4703	5602	-.852	.01
Enteritis sensu morbus diarrhoicus	1425	1586	1069	2077	2447	2718	-.870	.01
Pneumonia	914	1087	1599	1162	916	756	.250	
Morbilli	5	987	1089	1201	36	1685	-.348	
Pertussis	432	612	28	1401	1709	18	-.048	
Parotitis epidemica	319	10	20	571	67	43	-.441	
Infectio gonococcia	0	157	223	403	499	554	-.579	
Scarlatina / Angina streptococcia	62	389	146	49	479	130	.039	
Tuberculosis	550	552	910	1243	1373	1162	-.291	
Leprosis	193	129	101	80	59	40	.923	.01
Echinococcosis	121	101	83	52	43	34	.970	.01
% of Icelandic dwellings made of turf	52.4	49.9	44.5	36.3	27.0	18.6		

geometry, (ii) biological contaminants, and (iii) indoor environment, since these can influence human health. Materials used and geometry were studied by building inspection and desk research. Biological contaminants present in surface dust were examined by taking specimens, tape and dust samples. Dust samples, obtained by vacuuming 1 square meter for 1 minute, were analysed for invertebrate life by dust flotation[6]. These invertebrates were determined by visual inspection. Both specimens and tape samples were examined for organic matter by visual inspection only. Indoor environment was evaluated in terms of thermal comfort and indoor air quality. Thermal comfort (in compliance with the international standard ISO 7730[7]) was examined by building performance simulations. These simulations were based on material properties derived from literature, the measured infiltration rate of 0.4 h^{-1}, internal heat sources (occupant density for the year 1931) and local climate data (1931), as recently described by Van Dijken et al[3]. Indoor air quality evaluations are based on measured infiltration rates[3] and on historical information obtained from a historian associated to the Glaumbær Museum[8].

RESULTS

Epidemiological figures are shown in Table 1. Positive correlations (p=.01) were only present between the percentage of turf dwellings, and the prevalence of leprosis and echinococcosis. Negative correlations were found for bronchitis acuta (p=.01), influenza (p=.05), angina tonsillaris (p=.01) and enteritis (p=.01). Demographic pyramids of the Icelandic population for the years 1910 and 1940, shown in Figure 3, describe an expanding young population characterised by a large percentage of infants and a low percentage of elderly. From the late 1940s, when modern times were introduced to the island nation, the population changed towards more of an aging society.

Figure 3. Icelandic population at 31 December by sex and age groups for the years 1910, 1940, 1970 and 1990[5]



The 11 occupants (1931) of Glaumbær farm spent most of their time in a single room, the *baðstofa*, which had a surface area of 52 m². In contrary to the other rooms the walls and ceilings of the *baðstofa* and guestrooms were timbered and had raised wooden floors. In rooms like the kitchen and storage rooms, as well as the central corridor, turf was directly exposed to the indoor space. The turf walls were characterised by a rubiginous colouring originating from bog iron present in the Icelandic marshy soil. Moreover, white traces of salts (no moulds) leaching out from the turf were found on the building material. The high salt contents of turf blocks influenced the flora and fauna indoors. However, the turf blocks contained nutrient media, such as twigs to allow for fungal growth. Indeed, mushrooms, genus *Armillaria*, were found. Dust samples from both walls, floors and furniture, contained noticeably few invertebrates. Parts of *Acaroidia, Laelaptidae* and arachnids as well as 4 *Cryptostygmata* were found in approximately 0.5 g of dust.

The use of mineral based turf as a building material was essential to guarantee a comfortable indoor environment in the Icelandic climate. Based on building performance simulations, the thermal environment in Glaumbær was perceived as cool in winter, and between neutral and cool in summer, according to ISO 7730[7].
The indoor air quality was poor due to low air change rates (approximately 0.4 h^{-1}). Bioeffluents produced by the occupants and other air pollutants produced by human activity, such as kitchen combustion gasses, drying frish, the conservation of food in barrels with whey, and the production of ammonia used for cleaning out of urine, were not sufficiently removed.

DISCUSSION

The prevalence of infective and parasitic diseases cannot be explained by the use of turf as a building material. Indoor biological contaminants induced by turf as a building material had a marginal influence on human health. None of the specimens found are known as a perpetrator of infectious diseases. In agreement with these findings, no positive correlations were found between the percentage of turf buildings and the prevalence of infectious diseases. Positive correlations were only found between the percentage of turf buildings and the prevalence of leprosis as well as echinococcosis. However, no cause-effect relation seems to exist. Rather, leprosis seems connected to poor living conditions, more specific large occupant density, in early 20th century Iceland. A plausible cause of the prevalence of echinococcosis seems the consumption of crops infected by artic fox' (*Alopex lagopus*) faeces. In addition, some Icelanders already reached high ages when they still lived in turf buildings. Negative correlations that were found between the percentage of turf dwellings and the prevalence of some infectious diseases do not seem to originate from the use of turf as a building material either, but from the change to a modern society.

Thermal comfort is positively influenced by the up to 3.5 m thick turf walls[2] that provide a high thermal resistance. The high occupant density of the dwelling also influenced the thermal conditions positively. On the other hand, the high occupant density did not provide an optimal health situation. Due to low air change rates the various air pollutants produced by the occupants were not sufficiently removed.
In other turf dwellings, building characteristics and living conditions of the occupants did not differ from the situation at Glaumbær farm in the period considered, which allows us to generalise for all Icelandic turf structures in a similar climate zone. However, turf is a local building material, so regional differences in the material properties might exist.

The introduction of modern times also meant a radical change in living conditions and hygiene. People changed their turf dwellings for single-family concrete and timber houses, and occupant density decreased. And along went most sources of 'historical' indoor air pollution. Nowadays, turf is still a material used in modern architecture. Its thermal qualities are frequently exploited in green roofing.

CONCLUSIONS

Occupant health was not negatively influenced by building properties that are characteristic to turf structures. Disease prevalence seems to originate from the poor living conditions occupants were exposed to. Despite these primitive living conditions, some Icelanders reached very high ages.

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