

HYGIENE ASPECTS ANALYZED IN FINNISH HOSPITALS

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ABSTRACT

The present work is part of an extensive development project for Finnish health care property (VALSAI in Finnish), co-coordinated by the Finnish Institute of Occupational Health (FIOH). Related hygiene aspects and factors affecting them were studied in four hospitals in southern Finland in winter 2007. Viable bacteria and moulds were measured in indoor air and settled dust in surgery, emergency, intensive care, and internal disease units or departments. Inspections of other factors, e.g. the ventilation system, were carried out simultaneously. The concentrations of airborne viable fungi and bacteria in the hospitals were $<2-26$ cfu/m³ and 5-1000 cfu/m³, respectively. The dominant fungal types/genera were *Penicillium*, yeast and *Arthrographis*, and sterile. Actinobacteria were also detected in minor concentrations. Accumulations of micro-organisms on surfaces varied from minor to significant. The dominant fungus was *Penicillium*, but opportunistic fungi, such as *Aspergillus niger* and *Acremonium*, were also detected. The most dominant bacteria were *Micrococcus*, but pathogenic/opportunistic bacteria were also detected in air and on surfaces, entailing a possible infection risk. A severe functional problem was detected in one ventilation system, which resulted in elevated concentrations of airborne bacteria. In addition, the surfaces of some cooling systems were contaminated with moulds. Opportunistic fungi and/or actinobacteria were detected in three hospitals, indicating probable moisture and mould damage. In conclusion, ventilation systems and room surfaces should be maintained with greater care; moisture damage may affect the quality of air and need to be repaired immediately it occurs. Further, more research is needed on the hygiene of cooling systems.

INTRODUCTION

Hygiene aspects play a notable role in the every-day functioning of a hospital, especially in premises where medical processes critical to vital functions are carried out or where the patient is very vulnerable to infections. Clean indoor air can be achieved by technical as well as functional means. Related hygiene aspects and the factors affecting them were studied in four hospitals in southern Finland in winter 2007 and the results are discussed in this article.

METHODS

Viable bacteria and moulds were measured in four hospitals in southern Finland during February - March 2007. The premises included areas in surgery, emergency, intensive care (one for adults and the other for children) and internal disease units or departments. Microbial air samples (n=11) were collected using a six-stage cascade impactor, and settled dust samples (n=9) with a sterile moisture swab on horizontal surfaces (e.g. book shelves and the surfaces of cooling systems, sampling area about 100 cm²) at a height of 1.2–1.5 m. The surface samples were cultivated directly on the growth media, and the results were thus expressed on a semi-quantitative scale. All the samples were

collected on 2% malt extract agar (M2), tryptone-glucose-yeast agar (TGY) and tryptone-soya-agar (TSA) plates and then incubated at 25 °C for 7 to 14 days. The fungi were identified using a light microscope. Some of the bacteria were cultivated as pure cultures and analyzed by gas chromatography using the TSBA50 -aerobic database (version 5.00). The bacteria were identified at the University of Helsinki, Department of Applied Chemistry and Microbiology. No outdoor air samples were needed due to the subarctic climate prevailing in winter in southern Finland and the high quality filtration of supply air in hospitals.

Information on other factors, such as the functioning of a ventilation system and maintenance, operation, resources and work tasks, as well as indoor and hygiene problems, was obtained by means of a questionnaire and interviews as well as by conducting a walk-through investigation and studying the plans for the construction and technology of hospital buildings. Supply air was filtered by a laminar flow unit with a high-efficiency particulate air H12 filter (overall efficiency of test aerosol, 99.5%) located in the roof of surgery rooms and an F9 filter (average efficiency of 0.4 µm particles, ≥95%) in intensive care units for adults; in the other units; supply air was filtered with an F7 filter (average efficiency of 0.4 µm particles, 80-90%). In addition, particle measurements were carried out simultaneously in indoor and supply air, and pressure measurements were made between rooms and outdoor air (published elsewhere).

RESULTS AND DISCUSSION

The concentrations of airborne viable fungi in the hospitals were <2–26 cfu/m³. These concentrations were mainly lower than those in indoor air in Finnish office buildings [1] and in hospitals wards in other countries [2-4]. The dominant fungal types/genera were *Penicillium*, yeast, *Arthrographis*, and sterile airborne actinobacteria were also detected in minor concentrations in hospital C. In this hospital, moisture damage had occurred earlier in wall and window constructions. Accumulations of fungi and bacteria on surfaces varied from minor to significant in the hospitals studied. The dominant fungus was *Penicillium*, but opportunistic fungi, such as *Aspergillus niger* and *Acremonium*, were also detected in settled dust samples.

Concentrations of airborne bacteria were 5–1000 cfu/m³. The corresponding concentrations are usually < 300 cfu/m³ in office environments in Finland [1]. This limit was exceeded in three hospital premises. A severe functional problem in the ventilation system increased airborne bacteria concentrations: the ventilation system in an emergency department stopped for over 14 hours. The fault situation was noticed only due to the abnormal results of particle and bacteria measurements. The International Indoor Air Group has also stated that >500 cfu/m³ are abnormally high bacteria concentrations in offices [5], and concentrations in hospitals should easily be below these. The most dominant bacteria were *Micrococcus* (mostly *luteus* GC subgroup C or *lylae* subgroup a). Pathogenic or opportunistic bacteria were also detected in air and on surfaces: *Staphylococcus*, *Moraxella* and *Ochrobactrum (anthropi)*.

Indoor air was of very high quality in the orthopaedics surgery room in Hospital A. The concentrations were lower than guidelines given for these premises [6]. Good indoor air in orthopaedics surgery room resulted from good work habits, efficient filtration of supply air and adequate ventilation as well as protective clothing used by the hospital staff.

The measurements of fungi and bacteria in hospitals are shown in detail in Table 1 and 2.

Table 1. Airborne fungi and bacteria in hospitals.

HOSPITAL AND PREMISE	INDOOR AIR SAMPLE			DOMINANT FUNGI AND BACTERIA and pathogenic/opportunistic species
	Fungi, M2	Bacteria, TGY	Bacteria, TSA	
Hospital A. Orthopaedics surgery room • empty • during operation	<2 <2	4 5	2 19	
Hospital A. Orthopaedics surgery room • corridor • instrument/equipment maintenance	2 2	16 12	5 9	(sterile)
Hospital B. Intensive care unit for children, 4 patients	5	92	71	<i>Penicillium</i>
Hospital B. Intensive care unit for children, corridor (sampling with Biosampler-sampler)	<12	240	132	(bacteria were not identified)
Hospital C. Internal disease unit, power medical treatment, 6 patients	26	490	150	<i>Arthrographis</i> <i>Penicillium</i> <i>Micrococcus luteus</i> GC subgroup C, species of <i>Micrococcaceae</i> -class
Hospital C. Internal disease unit, corridor	26	340	160	<i>Penicillium</i> , <i>Arthrographis</i> (bacteria were not identified)
Hospital C. Intensive care unit, 4 patients	2	35	26	<i>Penicillium</i> <i>Micrococcus</i> , <i>Staphylococcus (aureus)</i> and <i>Moraxella</i>
Hospital D. Emergency unit, 6 patients	1	170	1 000	• yeasts • <i>Micrococcus</i> , <i>Mircococcus luteus</i> GC subgroup C and <i>Kytococcus sedentarius</i> .
Hospital D. Emergency unit, entrance hall	2	59	180	• <i>Penicillium</i> • <i>Micrococcus luteus</i> GC subgroup C, <i>Micrococcus lylae</i> subgroup a, <i>Staphylococcus hominis</i> ja <i>Sphingopyxis</i>

Table 2. Fungi and bacteria in settled dust in hospitals.

HOSPITAL AND PREMISE	SETTLED DUST Fungi: MEA Bacteria: TSA, THG)			DOMINANT FUNGI AND BACTERIA and pathogenic/opportunistic species
	Fungi, MEA	Bacteria, TSA	Bacteria, THG	
Hospital B. Intensive care unit for children, 4 patient in room, surface of cooling system (2 samples)	+	+	+	<i>Acremonium</i>
Hospital B. Intensive care unit for children, medical room, fan coil	+	++	++	<i>Penicillium</i> <i>Cladosporium</i> <i>Corynebacterium xerosis</i> , <i>Arthrobacter globiformis</i> GC subgroup B, <i>Micrococcus</i> - and <i>Paenibacillus</i> and species of <i>Micrococcaceae</i> - and <i>Nocardiaceae</i> -class
Hospital C. Internal disease unit, power medical treatment, 6 patients in room, fan coil	+++	+	+	<i>Penicillium</i>
Hospital C. Internal disease unit, power medical treatment, 6 patients, room surfaces dust	+++	+++	+++	<i>Penicillium</i> <i>Aspergillus niger</i> <i>Micrococcus luteus</i> GC subgroup C, <i>Bacillus subtilis</i> , <i>Staphylococcus (hominis hominis)</i> , <i>Ochrobacterum anthropi</i>
Hospital C. Intensive care unit, 4 patients in room	+	+	+++	<i>Penicillium</i> <i>Aspergillus niger</i>
Hospital D. Emergency unit, entrance hall, room surfaces dust	+++ -	+++ +++	+++ +++	<i>Penicillium</i> <i>Aspergillus niger</i> <i>Staphylococcus (hominis)</i> and <i>Arthrobacter aurescens</i>
Hospital D. Emergency unit, entrance hall, rest room, room surface dust	+	+++	+++	<i>Penicillium</i> <i>Mucor</i> <i>Micrococcus luteus</i> GC subgroup C <i>Staphylococcus (cohnii cohnii)</i> <i>Paracoccus</i>

CONCLUSIONS

Air hygiene in the hospitals was mostly at a good level. However, a severe functional problem was detected in one ventilation system, which resulted in elevated concentrations of airborne bacteria. In one intensive care unit, pathogenic bacteria were found in a room of four patients, entailing a possible infection risk via air. Some of the premises in the hospitals were very crowded, which may cause difficulties with hygiene. Opportunistic fungi and/or actinobacteria were detected in three hospitals, indicating probable moisture and mould damage. In addition, the surfaces of some cooling systems were contaminated with moulds. In conclusion, the ventilation systems should be maintained with greater care; moisture damage may affect the quality of air and needs to be repaired immediately it occurs. Further, more research is also needed on the hygiene of cooling systems.

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