Indoor air climate and microbiological contamination in dental clinics

Monica Popa*, Dana Manuela Sîrbu, Andreea Ruxandra Sîrbu

University of Medicine & Pharmacy Cluj-Napoca, Romania

ABSTRACT
The use of high-speed rotary and spray-producing instruments can pose a serious risk in dental clinics, by continuously creating a potential harmful contamination of the room. Indoor climate parameters (temperature, relative humidity) and microbiological airborne contamination (total bacterial count at 37°C, fungal particles) were evaluated in 12 private dental clinics, partially equipped with air conditioning systems. Carbon dioxide air concentrations were also measured to evaluate the efficacy of air exchange. Air microbial counts were highest in the consulting rooms and waiting rooms. The coagulase-positive staphylococci were present in the air of rooms with the highest flow of traffic. The microbial contamination was not correlated with the air conditioning systems. The most important measure to prevent the excessive airborne contamination is an efficient source control. The better management of the air conditioning systems would lead to a notable improvement in indoor air quality in these particular environments.

INDEX TERMS
Dental clinic; Bacteria; Fungi; Microclimate

INTRODUCTION

As people spend a fair proportion of their time indoors, specific attention is drawn to contaminants of indoor air. The indoor air climate and microbiological airborne contamination in high risk hospital areas have been dealt with a number of studies. The dental clinic is an environment especially subjected to microbial air pollution. The use of various high-speed rotary and spray-producing instruments creates aerosols of water, viruses, bacteria, secretions, exudates and particulate dental materials which may cause contamination of the room environment. Exposure to various infectious diseases such as tuberculosis, hepatitis, upper respiratory infections and other viral or bacterial diseases appears to be dangerous to the dental staff (Wood, 1992).

If the dental clinic is equipped with an air conditioning system, the health-related problems may take another form: inadequate management of the temperature-regulation system and in particular insufficient ventilation may cause disorders of the respiratory tract and the eyes. Humidification systems may also represent an ideal terrain for the multiplication of pathogenic and non-pathogenic microorganisms and contribute to the microbiological contamination of the air (Morey, 1989).

The aim of this study was to analyse the indoor air climate and microbiological airborne contamination characteristics in various dental clinic areas, i.e. consulting rooms, comparing them with those found in rooms used as offices, laboratories and waiting rooms. Moreover, since a few studied dental clinics were partially equipped with an air conditioning system, it was possible to estimate the effect of the conditioning system on the quality of the air.

* Corresponding author. E-mail: popa.monica@personal.ro

MATERIALS AND METHODS

Design of the Buildings

The study was carried out in 12 dental clinics located in three Romanian cities (Cluj-Napoca, Ploiesti, Campina), located in different geographical areas of the country. From an air conditioning point of view, the investigated buildings can be divided in two categories:

- Old buildings (nine locations), not equipped with an air conditioning system and heated in winter by radiators and stoves.
- Modern buildings (three locations), equipped with a centralized summer and winter air conditioning system which automatically controls local heating and cooling. The mean of the outdoor air intake is 35 m^3/h/person during periods of maximal occupancy by patients. These locations were equipped with convectors which permit recirculation of the air and regulation of the climatic conditions by means of a thermostat.

Measurement Methods

A total of 49 rooms were examined, being divided into four groups according to their use: offices, laboratories, waiting rooms and consulting rooms. Each of these rooms was studied twice: a first set of samples was collected in wintertime (January–February 2001) and a second set during summer (June–July 2001).

Indoor climate and air quality

For determination of the environmental parameters (air temperature, relative humidity) we have used an aspirative psychometer; the dry bulb temperature was considered the air temperature in the room. Carbon dioxide concentrations in the air were measured with a specifically designed battery operated sampler (precision range: ±10%).

Microbial count

The sampling device was a portable electrically sampler that collects air through 350 holes at a flow rate of 120 l/min; air is impacted on a Petri plate containing medium. The sampler was placed at 1 m from the floor in the middle of the rooms. The sampling period varied from 10 to 15 min (1200–1800 l of air). The total bacterial count at 37°C (Agar), the fungal particle count (Dextrose Agar), the *Staphylococcus aureus* count (Agar with Tellurite Enrichment) were evaluated. Following an incubation period of 48 h at 37°C (total bacteria, *S. aureus*) and of 5 days at 22°C (fungal particles), the colony forming units were counted and referred to the cubic meter. To prove the potential patogenity of the staphylococci, the ability to ferment manitol was tested. The mould colonies were identified to genus level by standard mycological techniques based on macroscopic and microscopic morphological examinations (Ionut,1998). The microbial and fungal measurements were carried out both indoors and outdoors, for control.

RESULTS

Indoor Climate

In the winter the relative humidity varies between 19.4 and 43.5% (acceptable range 30–70%); in 26.5% of the cases (13 rooms) values below 30% were detected and in 10.2% of the cases (five rooms) values fell below 25%. The air temperature varied between 16.8 and 21.5°C, remaining below the minimal value of the interval of comfort (18–22°C) in 53% of the cases (26 rooms), most of them being represented by waiting rooms and offices (23 rooms).

In summer, relative humidity was within the range of comfort in almost all rooms, with the sole exception of two consulting rooms (no air conditioned) where the values were slightly higher than the comfort interval. The air temperature was outside the comfort range in 69.4%

of the cases (Figure 1); in particular it was too hot in all rooms without air conditioning devices (34 rooms with air temperature higher than comfort limits, between 25.3 and 27.8°C).

As regards the percentage of carbon dioxide, the Romanian standard for hospital environments (max. 0.07% CO_2) was exceeded both in winter and in summer mainly in the waiting rooms; this fact was due to the excessive number of people present during the day and to the fact that the samples were generally taken at the end of the daily working programme. In winter, due to a reduced ventilation rate, the percentage of the samples out of norms was almost four times higher than in summer (55% compared with 14.3%) (Figure 1).

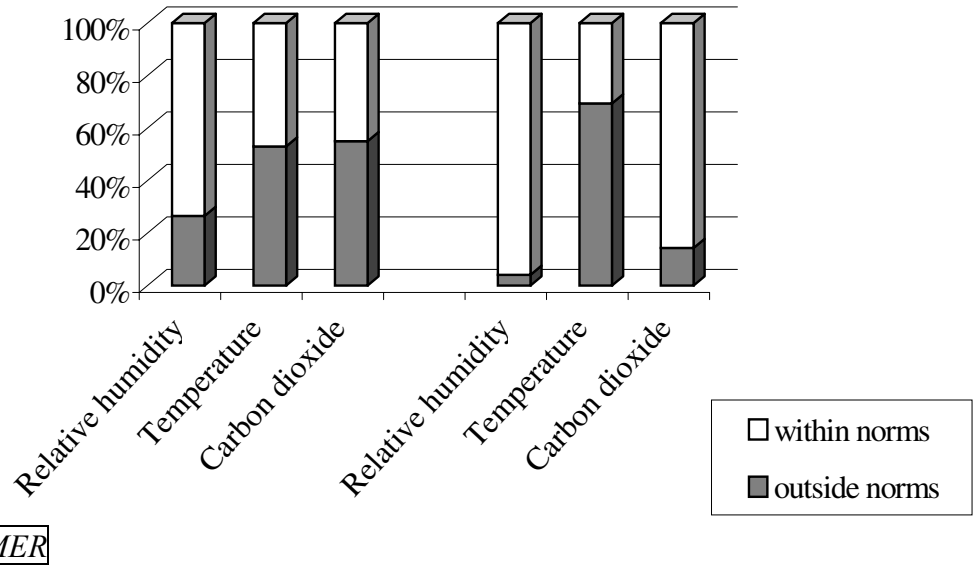

Figure 1 The rate of conformity to norms for indoor climate conditions in investigated rooms.

Microbial Count

In winter the total microbial counts at 37°C in all rooms examined were within an interval of 215–1200 cfu/m^3. Statistically significant differences (unpaired *t*-test with *p*-value <0.005) were observed between the counts in the consulting rooms and those of the rooms used for office work. The lowest bacterial count values were detected in the rooms used by a limited number of people, i.e. offices, whether they were equipped with air conditioning systems or not (values between 215 and 569 cfu/m^3—median value equal to 367 cfu/m^3), and in the laboratories (values between 232 and 460 cfu/m^3—median value equal to 310 cfu/m^3). These counts were five to eight times higher than those observed in the outdoor air close to the investigated buildings (values between 29 and 114 cfu/m^3—median value equal to 65 cfu/m^3). On the other hand, bacterial contamination was significant higher in waiting rooms (520–632 cfu/m^3) and above all in the consulting rooms (values between 470 and 1200 cfu/m^3, median value equal to 894 cfu/m^3) (Figure 2). In some situations, the bacterial count in consulting rooms were exceeding 1000 cfu/m^3—the Romanian standard for medical wards (Ministry of Health and Family,1997) and a limit traditionally considered as acceptable for the bioaerosols of the air in normal living and working conditions.

In the rooms with the highest flow of traffic (waiting rooms, consulting rooms) a significant great number (unpaired *t*-test with *p*-value <0.005) of coagulase-positive staphylococci was found. All were belonging to the *Staphylococcus aureus* species and were only occasionally present and to an insignificant extent in the air of the offices and laboratories. No significant differences were noticed by comparing the total bacterial counts

and those of *Staphylococcus aureus* of the rooms equipped with air conditioning systems and those of the rooms without it.

In the summertime, the bacterial counts at 37°C and of coagulase-positive staphylococci showed a similar trend to the winter results. The different distribution of counts between rooms with a greater flow or being destinated to specific medical procedures for dental patients and those without these characteristics was confirmed.

In winter the fungal particle count had a similar level for the majority of the rooms, whether they were equipped with air conditioning systems (values between 75 and 315 cfu/m^3, median value equal to 142 cfu/m^3) or not (values between 89 and 234 cfu/m^3, median value equal to 119 cfu/m^3). The fungal particle count was constantly higher in summertime (Figure 3), as a result of the seasonal differences in the outdoor air: in fact the mean value of the fungal particle count in the outdoor air in summer was 670 cfu/m^3, higher than the count in the investigated rooms. The greatest number of the identified fungi belonged to the genus *Cladosporium* (between 76 and 89%), followed by *Penicillium* spp. (between 7 and 21%); other genera were only occasionally present.

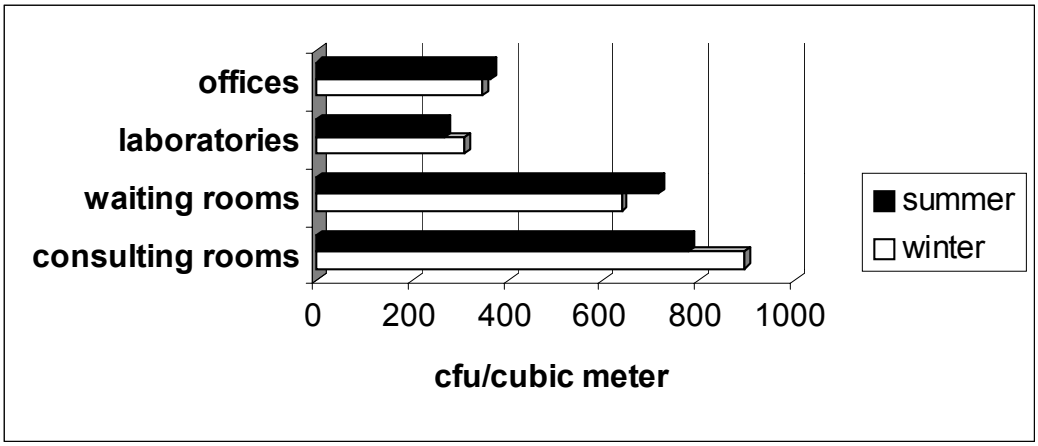

Figure 2 Average values of airborne bacteria in different categories of investigated rooms.

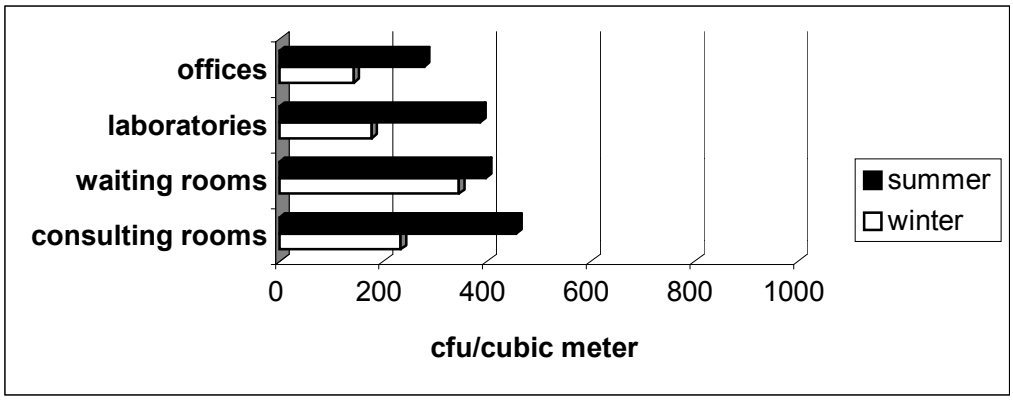

Figure 3 Average values of airborne fungi in different categories of investigated rooms.

DISCUSSION

The study design and execution was intentionally simple, using widely available microbiological methods that required basic equipment. Therefore, the results represent background levels and the extent of the researches would provide a broader database. The study site was represented by a particularly hospital environment—dental clinics—with specific sources and conditions of indoor air pollution. This study reported the levels of viable

bacteria and fungi that were recovered on general growth media, using aerobic incubation at moderate temperature, conditions that excluded certain groups of microorganisms. Fungi were characterized to the genus level, although some authors advised that one might fail to identify some indoor contaminants if isolates are not identified to the species level (Ledford, 1994; Flannigan, 1997), but this degree of identification is expensive.

The overall examination of the microclimatic data shows the deficiency of heating in winter and the excessive heating during summer. The situation from the heat point of view could be improved in many rooms by a rational use of the air conditioning systems and where these are missing, by an adequate use of the supplementary heating devices together with an improvement of the ventilation rate (Popa, 2000).

The greater bacterial contamination of the rooms open to the public can be attributed to the human presence. The total bacterial counts at 37°C and of coagulase-positive staphylococci were higher in the air of the rooms occupied by several people (waiting rooms), or subjected to microbial splatter discharged from the oral cavity of dental patients (consulting rooms), than in those with a reduced flow of traffic (offices, laboratories). Although the counts of coagulase-positive staphylococci were not high, the difference among rooms should be taken into consideration due to the importance of the species *Staphylococci aureus* in the aetiology of nosocomial infections (Popa, 2001). It is a confirmed human pathogen, present on surfaces, in the air, in dust, causing both infectious and toxigenic diseases. Therefore, bacterial contamination appears to be closely connected to the presence of people, to their movement within the rooms and to their number, while the presence of people has little effect on fungal contamination of the environment. However, the most important measure to prevent airborne contamination is an efficient source control and a good maintenance practice of the air conditioning system (Littner *et al.*, 1983; Gruendemann and Mangum, 2001). The air must more often be changed in the consulting rooms of a dental clinic than in other hospital environments because of the particularity of these rooms. The behaviour of the persons is another important factor; adequate steps must be taken for disinfection actions and to control the access to the rooms by avoiding overcrowding of some rooms (such as the waiting rooms).

As regards the significance of the microbial count values detected, there are unfortunately no national standards especially referred to dental clinics to which our results can be compared. The Romanian standard for microbial contamination in hospital environments (Ministry of Health and Family, 1997) makes no provision for dental clinics, only specifies a general maximal value of 1000 cfu/m^3 for medical wards. There is no sufficient epidemiological evidence to confirm the validity of this limit of acceptability for the air in dental clinics; some authors dispute also that the reference value of 1000 cfu/m^3 can be considered sufficient to establish the dangerousness or healthiness of the air breathed in any closed environment (Morey and Woods, 1987).

CONCLUSIONS

The microbial count values detected in our study can be considered acceptable if applied to a normal living environment, but are excessive when considering the particularity of the hospital environment. It is however necessary to point out a deficiency in this sector: the lack of particularly standardized reference indices for dental clinics, the comparison being made with the norms for medical wards. An improvement of the legislative framework in this sector is urgently needed.

Although the fungal particle count was constantly higher in the summertime, there was no remarkable difference in the concentration of airborne fungi among different types of rooms from dental clinics. In all instances, it was formed by fungi generated and transported through the air from vegetation or earth by natural ventilation.

Strategies for the control of biological contaminants in indoor air of the dental clinics should be based on the avoidance of the conditions that provide a substrate for the growth of viable particles (e.g. eliminate sources of condensed moisture), besides the observance of recommendations of working hygiene in this specific sector of the hospital environments. A better indoor air quality can be achieved too, by a careful control of the microclimate conditions (focussed on a higher indoor air temperature in winter) and the improvement of ventilation.

The analysis of collected data is not yet finished and more research is needed. The results of this study will be incorporated in a future epidemiological study to correlate the incidence of infections contracted in dental clinics with the microbial characteristics of the air.

ACKNOWLEDGEMENTS

The authors acknowledge support from medical staff in the investigated dental clinics, which allowed these measurements to be made.

REFERENCES

Flannigan, B. (1997). Air sampling for fungi in indoor environments. *Journal of Aerosol Science* **28**, 381–392.

Gruendemann, B.J. and Mangum, S.S. (2001). *Infection Prevention in Surgical Settings*. Philadelphia, PA: WB Sanders.

Ionut, C. (1998). *Guide of Practical Applications in Environmental Health*, pp. 75–105, 128–138. Cluj-Napoca, Romania: Univ. Med. Publ. House (in Romanian).

Ledford, D.K. (1994). Indoor allergens. *Journal of Allergy and Clinical Immunology* **94**, 327–335.

Littner, M.M., Kaffe, I. and Tamse, A. (1983). Occupational hazard in the dental office and their control. I. Measures for controlling infections. *Quintessence International* **1**, 67–70.

Ministry of Health and Family (1995). *The Law of the Environment Protection*. Nr.137/1995, Bucharest, Romania.

Ministry of Health and Family (1997). *Hygiene Norms and Recommendations for the Living Environment of the Population*. Nr.536/1997, Bucharest, Romania.

Morey, P.R. (1989). *Bioaerosols in the Indoor Environment: Current Practices and Approaches*. Wayne, PA: Clayton Environmental Consultants.

Morey, P.R. and Woods, J.E. (1987). Indoor air quality in health care facilities. *Occupational Medicin*e **2**, 547–563.

Popa, M. (2000). *Indoor Pollution and Human Health*. Cluj-Napoca, Romania: QuoVadis Publishing House (in Romanian).

Popa, M. (2001). *Concepts and Tendencies in the Environmental Pollution*. Cluj-Napoca, Romania: QuoVadis Publishing House (in Romanian).

Wood, P.R. (1992). *Cross Infection Control in Dentistry*, pp. 9–30. Wolfe Publishing Ltd.