Relationship between indoor air chemical, microbiological contamination and activities in hospitals

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1 Introduction
Indoor air quality in hospital is a very important issue and the chemical and microbiological contamination may be associated with a wide range of specific compounds emitted from various products and building materials but also influenced by the outdoor environment. Finally some activities related with the practices may also lead to human exposure. Based on large-scale sampling campaigns, a methodology has been defined with the aim of measuring concentrations of a wide range of chemical compounds, microbiological substances and particles. The study aimed to assess the indoor air contamination and spatial and temporal variability in two French hospitals.

2 Materials/Methods
The study was conducted in both French hospitals (Rennes and Nancy) in June 2014 for the “summer campaign” and in February 2015 for the “winter campaign”. These campaigns were conducted twice over a period of four consecutive days (from Monday morning to Friday midday) to take into account the activities’ difference according to the attendance period of health care facilities (Baurès et al., 2016). For each hospital, air samples were collected in seven sites in order to estimate the spatial and temporal variability. During both campaigns, 34 VOCs were measured, along with 7 aldehydes and 13 SVOCs. Ambient parameters were measured during all sampling periods. Fine particles were sampled and analysed. Finally, for the biological contamination assessment, 5 bacteria, 3 virus and 5 fungi were also analysed (Baurès et al., 2016).

As well as urban or rural setting and the building construction year, additional information, such as the type of ventilation and heating systems, the type of building materials, and the number of persons present during the sampling campaigns, was also collected with the hospital staff. These data were selected being able to have a more or less important impact on the indoor air quality. For statistical analysis, Principal Component Analysis (PCA) was used to extract and identify the factors/sources responsible for variations of indoor air quality at the different sampling sites. We used multiple logistic regression models to
evaluate the spatial variability (related with the healthcare activities and between 2 hospitals) and temporal variability (daily, weekly and seasonal) in chemicals, microbiological and particle compounds concentrations. Radar charts were used to display multivariate observations with an arbitrary number of variables. This graphical method allowed highlighting variabilities connecting the analysed parameters.

3 Results and Discussion
The results showed that the main chemical and microbiological contaminants found are in the same order of magnitude in both hospitals. The indoor air quality between Rennes and Nancy hospital was not significantly different (p = 0.08).

Nevertheless for specific chemical compounds, a spatial variability in concentrations related with some health care activities was observed. For example, ether concentrations were relatively low in both hospitals even if ether use is 50 times higher in Rennes than in Nancy (p = 0.007). In Rennes plaster cast room the median concentration was 2.5 µg/m³ where ether was used as an adhesive remover. However, aromatic hydrocarbon concentrations were higher in Nancy whatever the season (p < 0.05). Alcohol and mainly ethanol were the most-quantified compounds, due to the intensive use of alcohol-based hand rubs. The highest ethanol concentrations were recorded in Rennes (p = 0.04). This result was link with human activities and with the higher average number of present people (approximatively 30%).

The bacterial contamination did not vary between the sampling sites contrary to the fungal and particle contamination. Variability was observed for PM with highest concentrations in the plaster room according to the activity. The correlations between the ambient parameters (number of people, rate of CO2, relative humidity) and the bacterial or fungal enumeration were not significant. Nevertheless there was a strong relation between the sampling site temperature and the bacterial (r = 0.7; p = 0.008) or fungal (r = 0.56; p = 0.045) contamination on one hand, and between the fungal contamination and the PM10 (r = 0.52; p = 0.022) on the other hand. This interesting finding here was probably link more closely to activity than to geographical location. Furthermore, microorganism distribution varied by season, as observed by Sautour et al. (2009).

4 Conclusions
Results showed that indoor air in French hospitals contains a complex mixture of chemical, physical and microbiological compounds with both spatial (intra- and inter-hospital) and seasonal variability. Our study shows low contamination in comparison to the indoor environment (dwellings), probably linked to ventilation (air change rate is on average between 1 and 11 volume/hour) (Dallongeville et al., 2014; Blanchard et al., 2016). Exploitation of the temporal and spatial results will allow precise links to be made between the achieved values and health care activities and uses, building materials, ventilation and environment. This study will also enable specific indoor air quality recommendations to be made to health care facilities.

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6 References