Pollen and spores in the air of a hospital out-patient ward

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SUMMARY

Background: Aerobiological studies of interest to the allergy specialist are routinely carried out using information from outdoor traps. However, most of our time is spent indoors and it is often the content of this air that is responsible for allergic phenomena.

Material and methods: The air of a hospital outpatient ward was analyzed using two portable volumetric aerobiological traps, one at floor level and the other at a height of 1 meter. Both spores and pollen grains were counted and their values were compared with those outside the building.

Results and conclusions: Twenty types of pollen grains were found. Their concentrations ranged from 2.7 and 25.1 grains/m^3, with the most frequent being (in order) grasses, evergreen oak (holm and cork oaks), water plantain, and olive. Twenty two different types of spores were found with concentrations of between 175.0 and 1395.8 spores/m^3 and the most frequent were *Cladosporium*, *Ustilago* and basidiospores. No significant differences were found between the floor level and the meter-high measurements. Comparison with outdoor levels showed that the three most abundant pollen types were correlated, with a ratio of 30:1 between indoor and outdoor levels. For the spores and fungi propagules, the indoor:outdoor ratio was highly variable, depending on the type. Thus, for *Aspergillus-Penicillium* spores, the concentration was even higher indoors than outdoors, although for most types, lower levels were found indoors, with a mean outdoor:indoor ratio of 4:1. We argue that this relationship reflects the presence of indoor spore sources. Rainfall was correlated with a decline in pollen levels and a rise in spore levels.

Key words: Air sampling. Allergens. Fungi. Hospital. Indoor. Outdoor. Pollen.

INTRODUCTION

Aerobiological studies of interest to the allergy specialist are routinely carried out using the information from outdoor traps. We spend most of our time, however, indoors, and it is often the content of this air that is responsible for allergic phenomena.

Although the presence of pollen grains and spores inside buildings could be an attenuated reflection of what is happening outside, there are often other additional factors that may alter the spectra of the particles or their concentrations. Such factors may include heating, ventilation, and air-conditioning systems, furniture, frequency of cleaning, number of people transiting the site, etc. All these factors lead to there being many variations from one place to another, and require specific studies to accurately evaluate the air quality from the aerobiological viewpoint in places of such importance as hospitals.

While the sampling method used indoors can vary greatly depending on the focus of the study, there always have to be portable traps. For example, Burkard trap (1), Lanzoni trap (2), Rotorod trap (3), or Partrap device (4). If the aim is to obtain fungi cultures, one has to provide a culture medium in Petri dishes onto which the stream of sampled air is directed. For instance, a Slit Sampler (5) or an Andersen trap (1). These isolated methods, however, neither allow one to determine the presence of other spores which do not grow on the culture media not to count the pollen. There also exist other sampling methods

using filters which may be used to evaluate simply the concentration of allergens. For example, Ormstad et al used polycarbonate filters analysed under an electron scanning microscope (6), and D'Amato et al measured allergenic activity with a RAST method (2).

The goal of the present work was to quantify the pollen grain and spore concentration inside a hospital out-patient ward, to analyse the daily variation, to check whether there was any dependence on height of the trap, and to gain a broad idea of the seasonal variation and evaluate it in terms of the outdoor concentration.

MATERIAL AND METHODS

During the year 2000 in the Hospital Infanta Cristina in Badajoz (SW Spain), the air in the waiting room of the allergy department was sampled on six days: 25 February, 14 April, 10 May, 2 June, and 12 July. The sampling devices were Burkard model portable aerobiological traps with a constant power supply. On the first two days, a single trap was used, placed at floor level (input orifice at 11 cm above the floor). On the other four days, two traps were used, one at floor level and the other at a height of 1 metre, both in the same place in the room and away from the doors and windows. In all cases, sampling was continuous from 09:30 h to 13:30 h. Samples were withdrawn every hour, changing the sampler which was impregnated with petrolatum white as adhesive. This gave a total of 40 preparations.

The waiting room is located on the third floor of the hospital. It is 5.90 5.24 m in size, with two windows to the exterior facing Southeast (120°) and 1.60 1.32 m in size. These windows remained closed throughout sampling. There are two doors, one to the access corridor and the other to an office. The furniture consisted of 20 chairs covered with a synthetic imitation leather ("polipiel"). The walls were tiled up to 1.60 m, above which they were painted with acrylic paint. There was no nearby source of humidity such as toilets or water conduits. There was no carpeting on the floor. The room has two ventilation grids for the air-conditioning which kept the temperature constant to within 22° to 25 °C during the sampling period. It was visited by an average of 60 patients per day, between 08:30 and 14:30 h, with the number kept between only 15 and 20 at any given time.

Simultaneously with the indoor sampling, we sampled the outdoor air using a Burkard model fixed volumetric aerobiological trap of the Hirst type (7), located in the grounds of the School of Agricultural Engineering 2580 m away from the hospital. This trap was at a height of 6 m above the ground and was running continuously throughout the year.

The immediate surroundings of the hospital consist of a semi-urbanized zone with parking lots and small garden areas with pine *(Pinus pinaster)*, shade plane trees *(Platanus hispanica)*, black and white poplar *(Populus nigra, Populus alba)*, ornamental cherry (*Prunus cerasifera* var. *pisardii*), and lawns.

The preparations were mounted in glycerinated gelatine stained with fuchsin. All pollen grains present in each sample were counted under 400x magnification. Spores were counted using ten transversal scans across the line of particle deposition at 1000x magnification with an immersion lens. The results are expressed as pollen grains or spores/m^3 of air sampled at each hour. As spores, we included all types of fungal spores (sporangiospores, conidia, basidiospores, ascospores, etc.), complete sporangia *(Peronospora)*, and hyphae. While the term propagules would be more precise, we shall use the term spores in the following for the sake of simplicity.

Meteorological data were supplied by the Meteorological Center of Extremadura. They came from the automatic observatory of Talavera at 11 km from Badajoz. Total rainfall in 2000 was 535.9 mm. The wettest months were December (172.2 mm) followed by April (137.4 mm) in which month the figure was three times greater than normal (45.4 mm). May was also a month with high rainfall values, but in this case only twice the normal. The other months had rainfall below normal. During spring, rainfall was concentrated between the end of March and the beginning of May. There were only 16 dry days between 21 March and 10 May (51 days). With respect to temperatures, the minima were equal to or greater than normal values, except in January, and the maxima rose notably in February and March to fall sharply in April. In the rest of the year, the values were normal (fig. 1).

To compare the results between traps, between hours, and between days, we used the non-parametric Kruskal-Wallis test statistic. To compare the outdoor and indoor pollen concentrations, we used the Pearson correlation coefficient.

RESULTS

We identified 20 pollen types and 22 spore types. The mean pollen grain concentration varied between 2.7 and 25.1 grains/m^3, and that of spores between 175.0 and 1395.8 spores/m^3. The highest concentrations were those of pollen from grasses, with a mean concentration of 2.1 grains/m^3, followed by

Table I

Mean daily concentration of pollen grains or spores/m³ on the sampling days (at floor level and at 1 metre height)

	25/2	14/4	10/5		2/6		20/6		12/7		Average		Total
	0 m	0 m	1 m	0 m	1 m	0 m	1 m	0 m	1 m	0 m	1 m	0 m	
Alnus	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Anthemideae	0.8	0.8	0.0	0.2	0.0	0.8	0.0	0.4	0.0	0.0	0.0	0.5	0.3
Castanea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.1	0.0
Cupressaceae	1.7	0.0	0.4	0.0	0.0	0.0	0.4	0.0	0.4	0.4	0.3	0.3	0.3
Echium	0.0	0.0	0.0	0.0	0.0	0.8	0.4	0.0	0.0	0.0	0.1	0.1	0.1
Eucalyptus	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4	0.0	0.2	0.1	0.1
Fraxinus	0.4	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.0	0.0	0.1	0.1	0.1
Lactuceae	0.0	0.4	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.4	0.0	0.3	0.2
Morus	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Olea europaea	0.4	0.4	0.4	0.4	2.1	4.6	1.7	1.7	0.0	0.4	1.0	1.3	1.2
Pinaceae	0.4	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Plantago	0.8	2.1	0.8	0.2	5.4	3.3	0.8	0.8	0.8	0.0	2.0	1.2	1.5
Poaceae	2.5	0.4	0.4	0.4	3.3	7.9	2.5	1.7	1.3	0.4	1.9	2.2	2.1
Quercus	1.3	5.8	1.3	0.6	1.3	2.1	1.3	0.8	0.4	0.8	1.0	1.9	1.6
Rumex	0.0	0.8	0.2	0.0	0.8	1.7	0.0	0.4	0.0	0.0	0.3	0.5	0.4
Salix	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Senecio	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.4	0.1	0.1	0.1
Spergularia	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0.0	0.1	0.1
Typha	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.1	0.0	0.0
Urtica membr.	0.4	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Urticaceae p.p.	0.8	0.4	0.0	0.0	0.4	0.4	0.8	0.0	0.0	0.0	0.3	0.3	0.3
Unidentified	1.3	0.4	0.0	0.0	2.5	2.1	0.0	0.8	0.4	0.8	0.7	0.9	0.8
Total	11.7	11.7	4.0	2.7	17.1	25.1	8.8	7.1	3.8	4.6	8.4	10.5	9.6
Alternaria	12.5	12.5	6.3	4.2	4.2	20.8	0.0	4.2	8.3	8.3	4.7	10.4	8.1
Basidiospores	8.3	100.0	258.3	216.7	29.2	41.7	8.3	0.0	16.7	37.5	78.1	67.4	71.7
Beltramia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.7	0.4
Botrytis	4.2	0.0	10.4	8.3	4.2	8.3	0.0	0.0	4.2	0.0	4.7	3.5	4.0
Cladosp. Clad.	87.5	291.7	83.3	58.3	187.5	187.5	16.7	25.0	150.0	45.8	109.4	116.0	113.3
Cladosp. Herb.	20.8	204.2	110.4	108.3	54.2	70.8	20.8	12.5	20.8	12.5	51.6	71.5	63.5
Chaetomium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	1.0	0.0	0.4
Drechslera	0.0	0.0	0.0	0.0	4.2	8.3	0.0	4.2	0.0	8.3	1.0	3.5	2.5
Epicoccum	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	1.4	0.8
Leptopsphaeria	4.2	4.2	35.4	56.3	4.2	4.2	0.0	0.0	0.0	0.0	9.9	11.5	10.8
Myxomycetes	4.2	0.0	4.2	0.0	4.2	0.0	0.0	0.0	0.0	0.0	2.1	0.7	1.3
Nigrospora	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0	4.2	1.0	0.7	0.8
Penicillium	0.0	116.7	0.0	0.0	20.8	20.8	0.0	4.2	0.0	0.0	5.2	23.6	16.3
Pleospora	12.5	4.2	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	1.9
Polythrincium	0.0	4.2	4.2	6.3	16.7	33.3	8.3	0.0	0.0	0.0	7.3	7.3	7.3
Spegazinia	4.2	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	1.0	0.7	0.8
Stemphyllium	0.0	0.0	8.3	0.0	4.2	4.2	0.0	0.0	0.0	0.0	3.1	0.7	1.7
Tilletia	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.4
Torula	4.2	0.0	0.0	0.0	0.0	0.0	4.2	0.0	4.2	0.0	2.1	0.7	1.3
Uredospores	4.2	0.0	0.0	0.0	0.0	4.2	0.0	4.2	0.0	0.0	0.0	2.1	1.3
Ustilago	12.5	583.3	16.7	18.8	79.2	66.7	212.5	266.7	62.5	54.2	92.7	167.0	137.3
Venturia	8.3	12.5	8.3	8.3	0.0	4.2	0.0	0.0	0.0	0.0	2.1	5.6	4.2
Hiphae	58.3	62.5	0.0	4.2	41.7	16.7	37.5	12.5	29.2	50.0	27.1	34.0	31.3
Unidentified	25.0	170.8	87.5	83.3	83.3	104.2	25.0	37.5	20.8	29.2	54.2	75.0	66.7
Total	245.8	1,396	545.8	487.5	420.8	483.3	275.0	320.8	270.8	175.0	378.1	518.1	462.1

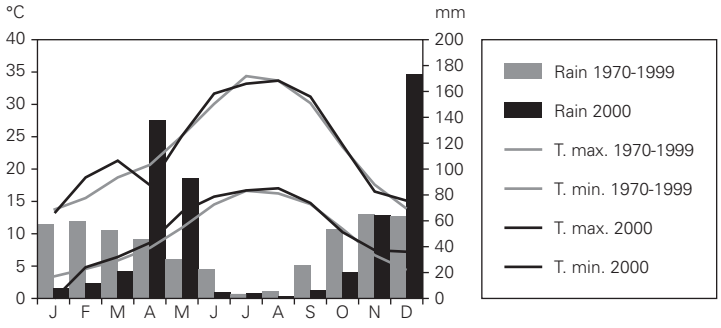

Figure 1.—Mean values of maximum and minimum temperatures (in degrees Celsius) and of rainfall (in mm) for the year 2000, and the normal values in Badajoz.

holm and cork oak (1.6 grains/m^3), water plantain (1.5 grains/m^3), and olive (1.2 grains/m^3). None of the other pollen types reached a mean concentration of 1 grain/m^3. Grass pollens also presented the greatest daily value of 7.9 grains/m^3 at floor level on 20 June. With respect to spores, the highest levels were attained by spores of *Cladosporium* (*C. cladosporioides* and *C. herbarum*), 176.8 spores/m^3, with the greatest daily value reached on 14 April at floor level (495.9 spores/m^3). Next in importance were spores of rusts and mildews *(Ustilago)* with mean values of 137.3 spores/m^3, basidiospores (71.7 spores/m^3), hyphae (81.3 propagules/m^3), *Penicillium* (16.3 spores/m^3), and *Leptosphaeria* (10.8 spores/m^3). The other fungi types had mean values below 10 spores/m^3 (table I).

The mean pollen concentrations at floor level and at 1 metre were 8.4 and 9.9 grains/m^3, respectively, but the difference was not statistically significant. The mean propagule concentrations at floor level and at 1 metre were 378.1 and 366.7 propagules/m^3. This difference too was not statistically significant (table II).

There were variations in pollen and spore concentrations during the course of the day, but these differences were not statistically significant for the complete set of days, taking into account the differences both at floor level and at 1 metre height for pollen and spores. The greatest differences occurred between pollen concentrations at floor level (table II).

The relationship between total pollen concentration indoors and outdoors is shown in figure 2. It's evident that the rainfall had a significant effect in reducing these levels. The spore concentrations, however, increased during periods of greatest rainfall (figure 3).

There were obvious differences between sampling days which corresponded with variations outside (table III). We calculated the Pearson correlation coefficients between the indoor and outdoor values for the pollen grains. There were significant correlations for total pollen ($r = 0.838$, $p = 0.037$), grasses ($r = 0.840$, $p = 0.036$), holm and cork oak ($r = 0.976$, $p = 0.001$), water plantain ($r = 0.928$, $p = 0.008$), and olive ($r = 0.954$, $p = 0.003$). The mean outdoor:indoor ratio was 30:1, although this was highly variable ac-

Table II

Pollen grain and spore concentrations/m^3 on the sampling days according to sampling hour and the height of the trap, on the days when the two traps were used

		10/5		2/6		20/6		12/6		Average	
		Pollen	Spores	Pollen	Spores	Pollen	Spores	Pollen	Spores	Pollen	Spores
9:30	1 m	3.3	600.0	20.0	316.7	8.4	150.0	6.7	150.0	9.6	304.2
	0 m	3.3	516.7	25.1	700.0	15.0	66.7	5.0	166.7	12.1	362.5
10:30	1 m	8.4	700.0	10.0	300.0	11.7	200.0	0.0	533.3	7.5	433.3
	0 m	1.7	350.0	23.4	316.7	1.7	150.0	3.3	233.3	7.5	262.5
11:30	1 m	2.5	366.7	23.4	566.7	6.7	616.7	1.7	100.0	8.6	412.5
	0 m	2.5	416.7	18.4	400.0	6.7	933.3	1.7	66.7	7.3	454.2
12:30	1 m	1.7	516.7	15.0	500.0	8.4	133.3	6.7	300.0	7.9	362.5
	0 m	3.3	666.7	33.4	516.7	5.0	133.3	8.4	233.3	12.5	387.5
Average	1 m	4.0	545.8	17.1	420.8	8.8	275.0	3.8	270.8	8.4	378.1
	0 m	2.7	487.5	25.1	483.3	7.1	320.8	4.6	175.0	9.9	366.7
Total		3.3	516.7	21.1	452.1	7.9	297.9	4.2	222.9	9.1	372.4

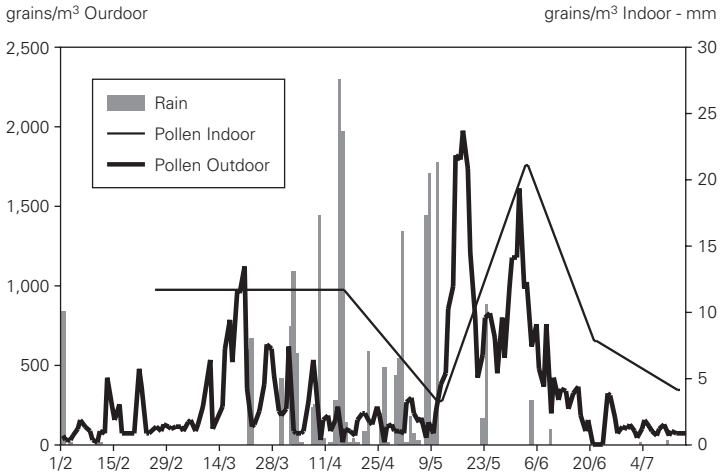

Figure 2.—Variation in pollen concentrations/m^3 from February to July 2000. The daily rainfall values in mm are also included.

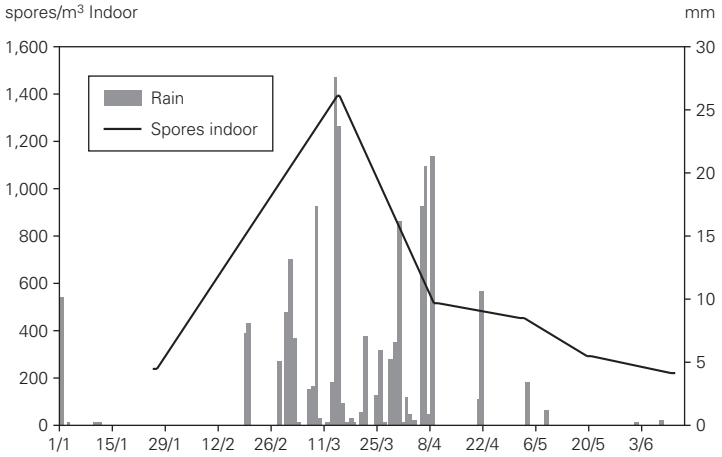

Figure 3.—Variation in spore concentrations/m^3 from February to July 2000. The daily rainfall values in mm are also included.

cording to the date and the pollen types. These relationships are shown graphically in figures 4a and 4b.

To compare the spore concentration with the corresponding outdoor value, we took as reference the work of Paredes performed between 1993 and 1995 for the atmosphere of Badajoz (8). Table IV lists the values of the mean concentration of spores and propagules during the months from February to July compared with the values obtained in the present work, as well as the relationship outdoor:indoor. Exceptionally, there were increases in spore concentration of *Aspergillus-Penicillium* and of *Polythrincium*. For the rest, the reductions were small in basidiospores, hyphae, *Leptosphaeria*, *Stenphillium*, and *Venturia*, but large in *Drechslera*, *Epicoccum*, and *Pleospora*.

Table III

Mean concentration of pollen grains/m^3 outdoors and indoors for the sampling days and for the most important pollen types

	Total Pollen		Poaceae		Quercus		Plantago		Olea	
	Out	In	Out	In	Out	In	Out	In	Out	In
25/2	102	11.7	2.0	2.5	4.0	1.3	1.0	0.8	0.0	0.4
14/4	242.0	11.7	2.0	0.4	184.0	5.8	11.0	2.1	0.0	0.4
10/5	210	3.2	156.0	0.4	28.0	0.9	12.0	0.5	2.0	0.4
2/6	984.0	21.1	844.0	5.6	29.0	1.7	74.0	4.4	68.0	3.4
20/6	194.0	7.9	74.0	2.1	7.0	1.3	12.0	0.8	12.0	1.7
12/7	64.0	4.2	15.0	0.8	9.0	0.6	2.0	0.4	2.0	0.2
Total	299.3	10.0	182.2	2.0	43.5	1.9	18.7	1.5	14.0	1.1

DISCUSSION AND CONCLUSIONS

It is well known that the indoor atmosphere of hospitals is not free of aerobiological particles. Nevertheless, we observed in the present work a marked reduction in levels from outdoors to indoors, which may vary greatly according to the conditions of

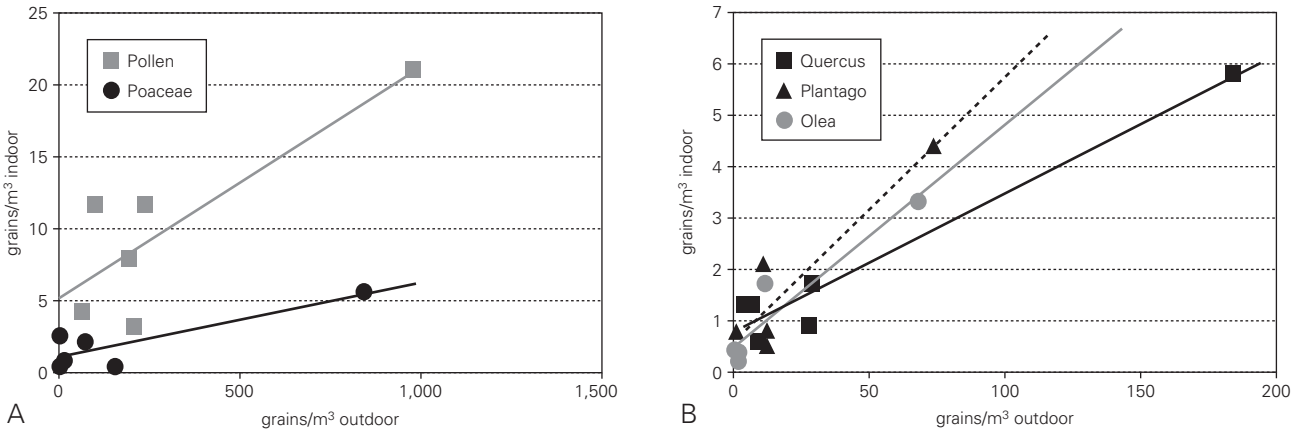

Figure 4.—The relationship between pollen grain concentrations outdoors and indoors on the sampling days for the total of total pollen and grass pollen grains (a) and for holm and cork oak, water plantain, and olive pollen grains (b).

ventilation or air-conditioning of the interior and the transit of people, as had been noted by other authors (2, 5, 9). The values found indicated reductions of the order of 30 times for the pollen grains. The reduction from outdoors to indoors was linear for the most representative types (grasses, holm and cork oak, water plantain and olive).

The reduction was less significant, however, for particles of fungal origin. Paredes obtained monthly mean values of 407 to 4,049 propagules/m^3, with a mean value for this period of 2,012 propagules/m^3 (8), so that the reduction from outdoors to indoors is somewhat more than fourfold. This means that either the particles of fungal origin penetrate more easily into buildings due, for instance, to their smaller size, or, as most authors indicate, to the existence of sources inside the buildings which provide most of the interior concentration. There are clues to the origin of spores and propagules in the spectra corresponding to indoors and outdoors. Thus, for example, the spores of the *Aspergillus-Penicillium* group (fungi which grow well inside buildings) presented greater levels indoors. Somewhat stranger is the case of the *Ustilago* spores. These species are parasites on plants, but they show similar concentrations indoors and outdoors which were maintained throughout the sampling period. It would be difficult to explain this on the basis of an internal source. The observed reduction in the difference between spores and pollen from outdoors to indoors has also been described by Sterling & Lewis, with the values of the ratio outdoor:indoor in the present work being very similar to the values reported by those workers (3).

Although the concentration of aerobiological particles inside buildings is to a good degree a reflection of the outdoor levels, the latter is influenced by meteorological parameters, especially by rainfall. Thus, as is generally observed by other researchers, we observed that rainfall reduced pollen concentrations but increased spore concentrations.

We found no differences between the floor level and the 1 metre height samples, whether for pollen grains or for spores. We therefore estimate that the circulation of air in the room was sufficient to homogenize the concentrations. With respect to this aspect, Fiorina et al found differences with height, alt-

Table IV

Comparison of the mean spore concentration outdoors between the months of February and July and the mean indoor spore concentrations found in the present work. The ratio Outdoor/Indoor (O/I) is also included

	Outdoor	Indoor	O:I		Outdoor	Indoor	O:I
Cladosporium	1,307.7	176.8	7.4	Epicoccocum	14.2	0.8	17.8
Leptosphaeria	37.5	10.8	3.5	Stemphyllium	7.7	1.7	4.4
Pleospora	32.2	1.9	16.9	Torula	19.2	1.3	14.8
Venturia	27.9	4.2	6.6	Hifas	79.6	31.	2.5
Basidiosporas	138.0	71.7	1.9	Polythrincium	1.9	7.3	0.3
Alternaria	66.1	8.1	8.2	Drechslera	58.0	2.5	23.2
Asperg.-Penicil.	5.9	16.3	0.4	Ustilago	157.8	137.3	1.1

hough in that work the heights sampled were 1.5, 5, and 15 metres (4). Neither did we find any significant variations over the course of the morning, whereas outdoors there is a variation in most of the pollen types. This phenomenon therefore appears strongly damped.

It has to emphasized that, despite the reduction in pollen grains and fungal spores from outdoors to indoors, there is not necessarily a proportional reduction in the allergic phenomena triggered by these aerobiological particles, since it has been shown that the air can transport allergens on even smaller particles. Only such procedures as electrostatic air cleansing (10) or suitable filters (6) are able to reduce the allergen concentrations significantly.

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RESUMEN

Antecedentes: De forma rutinaria se hacen estudios aerobiológicos con interés alergológico basados en la información obtenida por captadores situados en el exterior, pero la mayor parte del tiempo de nuestra actividad la desarrollamos en interiores y es con frecuencia el contenido de este aire el responsable de fenómenos alérgicos.

Material y métodos: El aire de una consulta hospitalaria ha sido analizado utilizando dos captadores aerobiológicos volumétricos portátiles, uno a nivel del suelo y otro a un metro de altura. Se contaron tanto los granos de polen como las esporas y su concentración se comparó con los valores en el exterior del edificio.

Resultados y conclusiones: Se encontraron 20 tipos de granos de polen con una concentración entre 2,7 y 25,1 granos/m^3, siendo los más frecuentes por orden: gramíneas, encinas y alcornoques, llantenes y olivo; respecto a esporas se encontraron 22 tipos diferentes con una concentración entre 175,0 y 1395,8 esporas/m^3, siendo las más frecuentes Cladosporium, Ustilago y basidiosporas. No se encontraron diferencias significativas entre la concentración a nivel del suelo y a un metro de altura. Comparando los valores del exterior y el interior los tres tipos polínicos más abundantes presentan una correlación entre ambas concentraciones, siendo la proporción exterior:interior de 30:1. Respecto a las esporas y propágulos fúngicos la relación exterior:interior es muy variable dependiendo de cada tipo, así, para las esporas Aspergillus-Penicillium la concentración ha sido incluso superior en el interior que en el exterior, aunque para la mayoría se presenta una disminución, siendo la relación media exterior:interior de 4:1; se argumenta esta relación en base a la presencia de fuentes internas de esporas. Se pone también de manifiesto la relación directa de las precipitaciones del exterior respecto a la concentración de polen, disminuyéndola, o de esporas, aumentándola.

Palabras clave: Exteriores. Alergenos. Hongos. Hospital. Interiores. Muestreo del aire. Polen.

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