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THE INFLUENCE OF VENTILATION BY OUTDOOR AIR ON SICK LEAVE ABSENCES FROM WORK IN OFFICE BUILDINGS

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Sick leave records of sample populations of workers in seven office buildings are examined for evidence of correlations between average rates of absence of less than one day (regarded as possible indicators of sick building syndrome) and rates of supply of outdoor air for ventilation. It is concluded that there is no such correlation for the samples studied. It is suggested that the incidence of minor illness depends on complex factors which may be related to the workplace and may include indoor air quality or to external circumstances or both.

INTRODUCTION

In the late seventies and early eighties rates of supply of outdoor air to air conditioning systems in some commercial buildings were being reduced as an energy conservation measure following the oil price crises of 1975 and 1982. Around the same time a number of authors, particularly in Europe and North America, reported higher than usual prevalence of minor illness among occupants of some buildings and some were suggesting that this increase in occupant malaise was related to the lower ventilation rates. Reported symptoms were headache, mucous membrane irritation, runny nose, sore eyes, skin irritation, lethargy and possibly nausea and dizziness with much similarity to minor respiratory and other minor ailments.

In 1984 Finnegan, Pickering and Burge[1] reported the results of their investigation of symptoms of minor illness and malaise experienced by occupants of nine office buildings in Britain. They wrote:

"comparison of prevalences of symptoms between naturally ventilated and other buildings showed a repeated pattern of nasal, eye and mucous membrane symptoms with lethargy, dry skin and headaches. There were highly significant excesses of these symptoms in the air conditioned buildings when compared with chi squared tests with naturally ventilated buildings."

In 1986 Finnegan and Pickering[2] reviewed a number of possible sources of the observed symptoms including volatile organic gases released from building and upholstery materials and various inorganic, organic and microbiological particulates. They were unable to positively identify any cause. Nevertheless they offered the concluding opinion that:

"The description of sick building syndrome illustrates the point that air conditioning does not, in practice, produce the comfort and satisfaction that it was originally designed to produce, even in offices without overtly expressed dissatisfaction. Unfortunately the cause of this dissatisfaction has not yet been identified, but there is some evidence to suggest that increasing the fresh air ventilation rate brings symptomatic relief."

Subsequent investigation by, among others, Skov and Valbjorn (1987)[3] in Denmark and Burge, Hedge, Wilson et al (1987)[4] in Britain suggested that other and more subtle causes might also be in operation.

With the aim of testing on a modest scale the hypothesis that prevalence of the symptoms was related to rate of supply of outdoor air for ventilation Rowe established, in 1987, a database containing details of sick leave absence from work for the year January to December 1986 for sample populations of workers in four office buildings in or near to Sydney, New South Wales. Time was not then available to complete an analysis of it but the topic has continued to receive considerable attention in the learned and the popular press. The opportunity arose in 1991 to analyse these records and a similar group for the year 1990/91.

In a previous report Rowe and Wilke (1992)[5] concluded that there was no correlation between rates of supply of outdoor air for ventilation and average rates of sick leave absence of undifferentiated sample populations of workers in these buildings.

The present study examines differences in absence rates between salaried professional architects (discipline 1) and engineers (discipline 2), a group consisting of land surveyors and their outdoor technical assistants (included in discipline 1), sub-professional technical staff (discipline 3) and administrative and clerical workers (discipline 4) in the same buildings.

STUDY POPULATION SELECTION

The four buildings included in the 1986 database were selected primarily because sick leave records were readily available for sample populations. The objective at that time was to test, on a small scale, whether there were significant excesses of minor respiratory and other minor ailments in air conditioned as compared with naturally ventilated buildings.

Building 1(a) is naturally ventilated and buildings 2 and 4 are air conditioned and located nearby in the Sydney Central Business District. Building 3 was chosen to add diversity by way of another air conditioned example located outside the Sydney conurbation in the provincial city of Newcastle. Sample populations were chosen to include, as nearly as possible, similar mixtures of salaried professional, sub-professional/technical and administrative/clerical workers.

In 1991 building 6 was added as an example similar to 3 by way of its location in a provincial city. Building 5 was included as an example in suburban Sydney with year round recirculation of return air and the minimum design rate of ventilation by outdoor air permitted under New South Wales building regulations. The sample of people from building 1(a) moved in 1987 to building 1(b) which was therefore included in the 1991 review.

Sick leave records for the period 1990/91 from buildings 2, 3 and 4 were for groups located in the same areas as in 1986. Very little staff turnover occurred in the sample groups from buildings 1(a) and 3 between the first and second periods although about 25% more staff were included in 1(b) than in 1(a). Turnover was higher in buildings 2 and 4 but the mix of occupations and type of work performed remained the same.

It has never been suggested that these buildings are sick but complaints have been registered by some members of the sample groups of thermal discomfort due to direct solar gain and radiant heat from sunlit windows in buildings 2, 3, 4 and 5. In addition occupants of building 2 have complained of periodic falls of black dust from air diffusers and have linked them to incidence of minor respiratory illness. The information was volunteered by the Personnel Officer in charge of sick leave records for building 1(a) when the records were gathered in 1987, that conditions in that building were overcrowded and uncomfortable.

All the sample populations worked under similar conditions concerning smoking at work and accountability for sick absence. Details are as follows:-

Environmental Tobacco Smoke: In 1986 smoking was permitted. A check of the sample group in building 4 in 1987 revealed 12 smokers in a population of 124. It is believed that the proportion of smokers in the other buildings was similar. All employers in the study group introduced policy of no smoking in the workplace between 1986 and 1990.

Accountability for Sick Leave was introduced by all the employers in 1989. Supervisors are required to review and report on instances where an employee has

five absences or more unsupported by a medical practitioner's certificate or seven or more supported by certification in a period of 12 months.

Some details of the buildings are shown in Table 1 below.

Table 1. Buildings details.

Bld.	Loc.	Age yrs	Vent. Method	Vent. Rate	Filt.	Remarks
1[a]	SCBD	100+	Nat.	n/a	n/a	Crowded. Heating by radiant gas fired wall mounted panels.
1(b)	SOS	5	A/C	7*	DBRDM	Comfortable, spacious, views.
2	SCBD	18	A/C	7*	OCMI	Radiant asymmetry discomfort near western windows in summer. Periodic black particulate discharge from diffusers.
3	N	8	A/C	7*	APMR	Some radiant asymmetry discomfort near western windows.
4	SCBD	25	A/C	11*	EP	Some radiant asymmetry discomfort near northern windows in winter.
5	SIS	3	A/C	3.5	WDMP	Radiant asymmetry discomfort near glass curtain walls.
6	W	4	A/C	3.5*	EA	

Loc. (location) - SCBD = Sydney central business district
- SOS = Sydney outer western suburb
- N = Newcastle - provincial city 160 km. north of Sydney
- SIS = Sydney inner western suburb
- W = Wollongong - provincial city 100 km south of Sydney

Vent. (ventilation) method - Nat = natural
- A/C = air conditioned

Vent. rate = design ventilation rate litres/second per person.

Filt. = Filtration - DBRDM = deep bed renewable dry media
- OCMI oil coated metal impingement (1986)
  deep bed renewable dry media (1990)
- APMR = automatic paper media roll
- EP = electrostatic precipitators
- WDMP = washable dry media panel
- EA = electrostatic agglomerating

* Buildings 1[b], 2, 3, 4 and 6 have outdoor air economiser cycles.

STUDY METHODS

Records of date, length of absence in quarter day increments and nature of approved sick leave in the subject buildings were made available to the authors and were recorded in seven broad categories. This paper focuses on periods of absence of less than one day for all reasons and a sub-classification including only minor respiratory type complaints. Certification by a medical practitioner is not required for these periods to qualify as sick leave. "Allergy", given as a reason for absence only rarely, has been included in the minor respiratory category.

Absences of less than one day are considered to be particularly interesting in relation to sick building syndrome. They have similar non specific symptoms and could, in

many cases, indicate onset after arrival at work and recovery after leaving the premises. This is widely regarded as a characteristic of sick building syndrome.

A full list of the illnesses and the classifications in which they were placed is provided in Appendix A.

The rates of outdoor air for ventilation are calculated from the design drawings. Access was not available to the authors to measure actual flow rates. Buildings 1(b), 3, 4, 5 and 6 are known to have been operated under carefully supervised maintenance regimes during the sampling periods and occasional inspection supported the view that outdoor air paths in them were not impeded by malfunction. Access for inspection was not available for building 2.

It is confidently believed that the value of 3.5 l/s per person (0.35 l/s per m^2) for building 5 was available but not exceeded. It has a fully sealed glass curtain wall facade on all sides and a supplementary exhaust system was installed to provide an adequate relief air path. It is believed that outdoor air rates for the remainder of the buildings are likely to be somewhat higher than specified. Very high rates of infiltration of outdoor air are experienced in building 4 where wide but concealed air gap paths occur due to poor closure of junctions between window heads and beams above.

Measurement of environmental conditions within the buildings and survey of occupant perceptions were outside the scope of the limited funding available for this project which was designed simply to test the relationship between ventilation and sick absence rates.

RESULTS

Findings of the investigation are summarised in Figures 1, 2, 3 and 4. Table B1 in Appendix B is included essentially to show the numbers on which the graphs in figures 2, 3 and 4 are based. Table B2 is reproduced for background information from the paper by Rowe and Wilkel[5] (1992) referred to above.

Figure 1 shows that when all the people are considered as a single sample average days lost in both years in the four occupational groups varied in ascending order from salaried professionals through technical staff to administrative and clerical workers. The salaried professionals and technical staff sample populations in this study are required to carry out part of their work outside their headquarters on building sites in and client offices. In contrast the administrative and clerical workers spend most of their time in their own office. **Figure 1** might be interpreted as an indication that the difference is related to the proportion of time spent in the office environment. However the random nature of variations between occupational groups within each building as illustrated in figures 3 and 4 suggests otherwise at least in respect of short periods of absence.

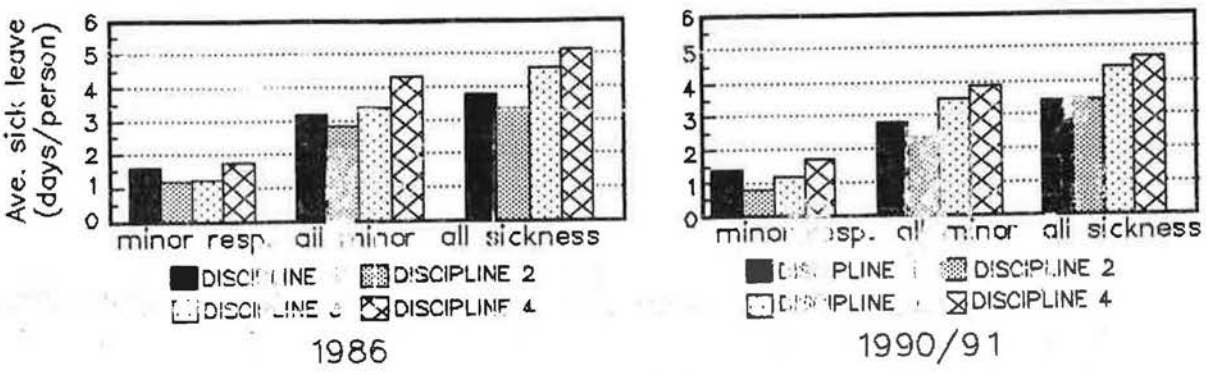

Figure 1. Absence rates for the whole sample populations differentiated by occupation. Minor absences in this graph are of three days or less duration.

Absence rates in the year 1990/91 were slightly lower than in 1986. The authors can only speculate that these may have been influenced by changed policy concerning accountability and possibly smoking in the workplace; by the differences in population samples due to turnover and organisational change; or by natural incidence of variations from year to year.

Observations from **figure 2** below (rates of absence of less than one day for the undifferentiated samples) include:-

- That there is no apparent correlation between outdoor air ventilation and sick leave absence rates.
- that absence rates for the occupant sample from naturally ventilated building 1(a) in the Sydney CBD are significantly high compared to those in other buildings.
- that these high rates persisted after this group moved to new air conditioned premises in building 1(b) in an outer western suburb of Sydney suggesting that the high levels are not building related.
- the proportions of absence rates for the undifferentiated groups from buildings 1(a&b), 2, 3 and 4 to each other were the same in 1990/91 as in 1986.

The significant similarity between the absence rates for undifferentiated population samples over the two sampling periods from buildings 1(a & b), 2, 3 and 4 can only be a matter for speculation. It is possible that the observed stability may be due to characteristics inherent in the groups and retained over time despite staff turnover. It may be that the level of malaise at which a decision to be absent is made varies from community to community but remains relatively constant over time. In other words there may be a sort of tacit agreement in each community as to what constitutes a reasonable level of ailment at which to remain at home or to leave work.

Reference to **figure 2** reveals that comparatively high rates of absence of less than one day duration were found for both years in building 4. As mentioned above, this building has the highest design ventilation rate of those sampled at 11 l/s per person and in addition is known to be subject to high rates of dilution of return air by infiltration. It was suggested by the Director of Personnel Services for this building that a reason might lie in its Head Office function and the extra stresses involved in working in that environment.

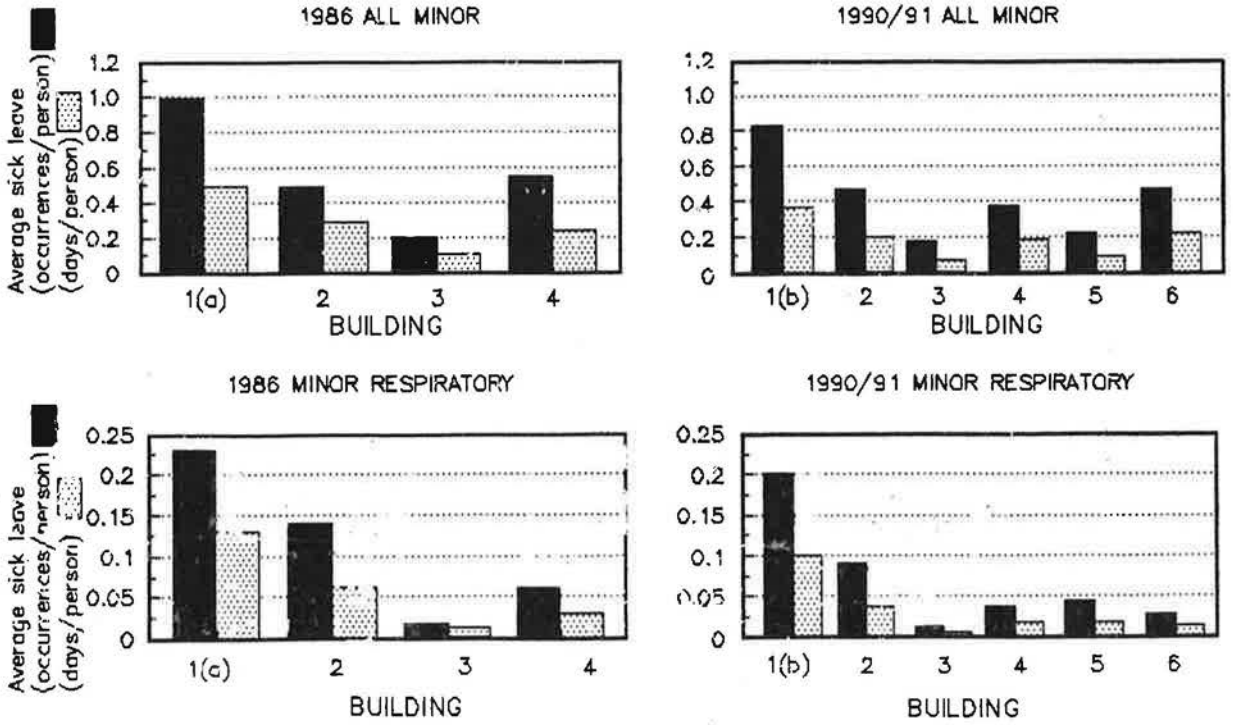

Figure 2. Average rates of occurrence and time lost due to sick leave absences of less than one day for undifferentiated samples of the building populations.

Consideration of **figures 3 and 4** suggests a high degree of variability of absence rates between occupational groups in the same building from year to year and between buildings in the same year and adds support to the view that correlation with ventilation rates is absent.

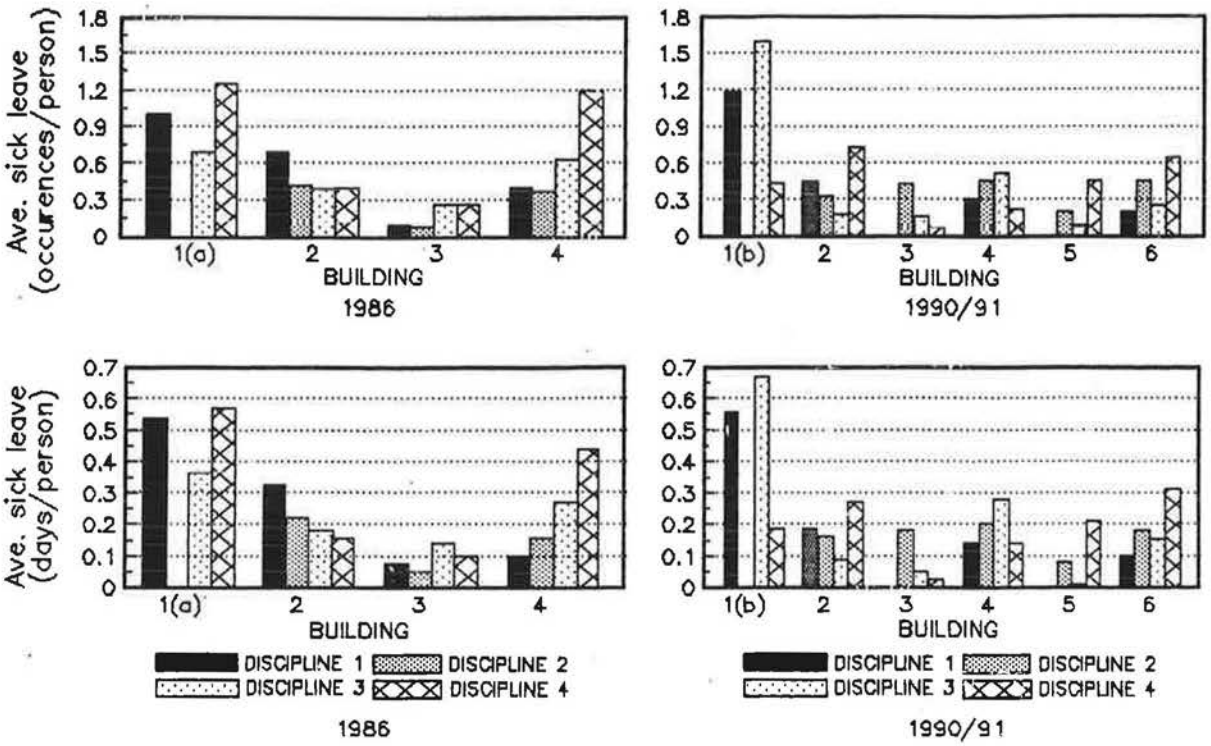

Figure 3. Sick leave absences of less than one day by occupation for all reasons.

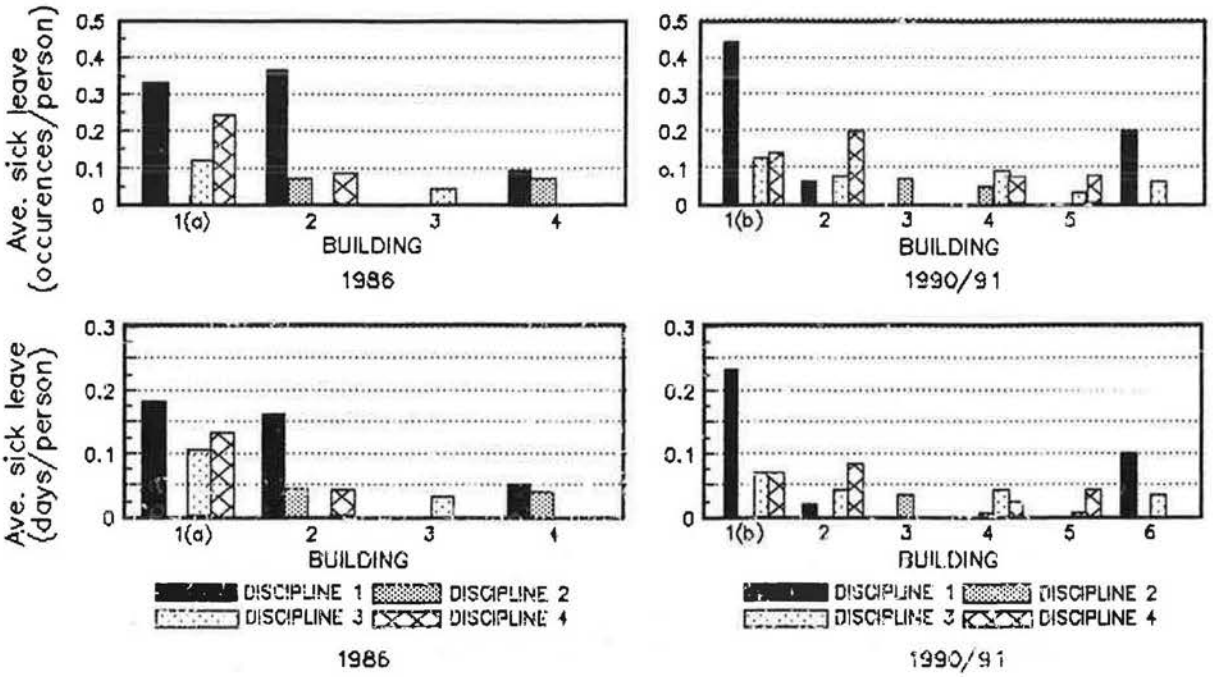

Figure 4. Minor respiratory sick leave absences of less than one day by occupation.

Taking all into account the view emerges that:-

- Absences are due to a variety of illnesses which occur with random frequency. The absence of pattern in variations between the occupational groups suggests that no specific building-related factor is operating.

- In the sample of workers as a whole there is a somewhat higher absence rate among people in administrative and clerical occupations in comparison with technical or salaried professional staff. Figures 3 & 4 however suggest that no such order can be stated for the occupational groups in individual buildings at least for short periods of absence. For example in reaching a decision to take time off a professional is more likely to be under pressure to meet a job deadline and therefore may decide against absence. The more creative nature of the work and the sensory stimulation of a variety of workplaces may also have an influence.

CONCLUSION

No correlation was found between rates of supply of outdoor air for ventilation and rates of sick leave absence due to minor respiratory and other illnesses of some 500 workers in this sample of seven office buildings. The highest absence rates were reported from the one naturally ventilated building in the study but similar high rates were reported from the same group of people after a move to near new air conditioned premises.

Random variations of sick leave absence rates between similar occupational groups in different buildings and the same buildings in different years as illustrated by Figures 3 and 4 suggest that the illnesses may have their source mainly outside the buildings. It must be remembered that most of the occupants spend less than 25% of their time in the workplace and are subject to contact with minor respiratory and other infections in the home, in public transport and in other locations where crowds congregate.

This sample is too small to permit firm conclusions to be drawn and the random variations may be present because none of the factors responsible for sick building syndrome were present in the subject buildings. The results suggests however that factors other than low ventilation rates alone should be considered when investigating complaints of excessive incidence of minor ailments and malaise in office buildings.

ACKNOWLEDGEMENT

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APPENDIX A: CATEGORIES OF ILLNESS

Minor respiratory: earache, throat infection, sore throat, tonsillitis, bronchitis, sinus attack, pharyngitis, asthma, influenza, cold, fever, URTI.
Minor stomach ailments: nausea, stomach upset, stomach virus, stomach cramps, food poisoning.
Other minor illness: eye ulcers, medical appointment, viral infection, migraine, gastric, diarrhoea, strained back, injured leg, dental appointment, haemorrhoids,

lumbago, nervous tension, sprains, glandular fever, chest pain, toothache, allergic reaction, hay fever, vertigo, dermatitis, gout, chicken pox, skin ulcers, insomnia, abdominal pain, dizziness.
Major respiratory: (more than 3 days): influenza, URTI, bronchitis, asthma, pneumonia.
Other major illness: (more than 3 days): wisdom tooth extraction, sprained limbs, intestinal infection, sprained back, gall stones, surgery, chicken pox, knee injury, shingles, glandular fever.

APPENDIX B: BACKGROUND INFORMATION

Table B1. Sample sizes and occurrences and rates of occurrence of minor sick leave absence of less than one day duration

Building	Discipline	No. in Sample		Sick Absence All illness less than 1 day No. Occurances per person PA 1986		Sick Absence All illness less than 1 day No. Occurances per person PA 1990/91		Sick Absence Minor Respiratory less than 1 day No. Occurances per person PA 1986		Sick Absence Minor Respiratory less than 1 day No. Occurances per person PA 1990/91	
		1986	1990/1991	No.	Rate	No.	Rate	No.	Rate	No.	Rate
1a	1	15		16	1.07			5	0.33		
	2	--		--	---			--	---		
	3	16		11	0.69			2	0.12		
	4	21		26	1.24			5	0.24		
	Total	52		53				12			
1b	1		16			19	1.19			7	0.44
	2		--			--	---			--	---
	3		15			24	1.6			2	0.13
	4		49			21	0.43			7	0.14
	Total		80			64				16	
2	1	25	33	17	0.68	15	0.45	9	0.36	2	0.06
	2	28	6	13	0.46	2	0.33	2	0.07	0	0
	3	18	12	7	0.39	2	0.17	0	0	1	0.08
	4	24	15	10	0.42	11	0.73	2	0.08	3	0.20
	Total	95	66	47		30		13		6	
3	1	9	5	1	0.11	0	0	0	0	0	0
	2	15	15	2	0.13	6	0.40	0	0	1	0.07
	3	24	20	6	0.25	3	0.15	1	0.04	0	0
	4	12	31	3	0.25	3	0.10	0	0	0	0
	Total	60	71	12		12		1		1	
4	1	43	59	18	0.42	18	0.31	4	0.09	0	0
	2	28	20	10	0.36	9	0.45	2	0.07	1	0.05
	3	13	23	8	0.62	12	0.52	0	0	2	0.09
	4	16	25	19	1.19	7	0.28	0	0	2	0.08
	Total	100	127	55		46		6		5	
5	1		5			0	0			0	0
	2		9			2	0.22			0	0
	3		41			1	0.02			1	0.02
	4		36			17	0.47			3	0.08
	Total		91			20				4	
6	1		5			1	0.20			1	0.20
	2		22			10	0.45			0	0
	3		17			4	0.24			1	0.06
	4		28			18	0.64			0	0
	Total		72			33				2	
Total		307	507								

Table B2. Summary of additional background data.

Building	1(a)	1(b)	2	2	3	3	4	4	5	6
	1986	1990/91	1986	1990/91	1986	1990/91	1986	1990/91	1990/91	1990/91
No. in sample	52	49	94	66	60	71	100	127	91	72
* Total work days available	11960	11270	21620	15180	13800	16330	23000	29210	20930	16560
Total sick days all reasons	336.5	385	427.75	245	104.5	225.75	403.25	558.25	407	250
Sick days per person per year	6.47	7.86	4.55	3.7	1.74	3.18	4.03	4.40	4.47	3.47
Occurrences per year	242	256	285	164	59	132	268	340	216	187
Percent of work days	2.8	3.4	2.0	1.6	0.8	1.4	1.8	1.9	1.9	1.5
Minor sick days 3 days or less	305.25	279.75	339.25	193	64	214.75	333.25	415.25	297	205
Minor sick days per person PA	5.87	5.71	3.61	2.93	1.07	3.02	3.33	3.27	3.26	2.85
Minor sick occurrences PA	236	244	271	156	54	130	254	317	202	179
Percent of work days	2.6	2.5	1.6	1.2	0.5	1.3	1.4	1.4	1.4	1.2
Minor resp. sick days PA	103.5	112.75	165	72	21.75	64	150.75	196.25	115	77.5
Minor resp. per person PA	1.99	2.3	1.76	1.09	0.36	0.9	1.51	1.54	1.26	1.08
Minor resp. occurrences PA	77	85	120	54	16	38	97	128	83	56
Percent of work days	0.9	1.0	0.8	0.5	0.2	0.4	0.7	0.7	0.5	0.5