J. Hyg., Camb. (1962), 60, 341
Printed in Great Britain

The epidemiology of the common cold

III. The effect of ventilation, air disinfection and room size

BY D. KINGSTON, O. M. LIDWELL AND R. E. O. WILLIAMS*
Air Hygiene Laboratory, Central Public Health Laboratory, Colindale, London, N.W. 9

(*Received* 26 *February* 1962)

INTRODUCTION

In two previous papers (Lidwell & Williams, 1961*a*, *b*) we have described the methods employed in a 6-year study of the common cold carried out in some clerical offices in Newcastle and London. The principal factors associated with a reduced experience of colds were age and, to a less extent, male sex. Attempts to unravel the paths of infection within the offices were largely unsuccessful since we were only able to account for a small fraction of the colds reported in terms of recognized contacts. In this paper we shall discuss the effects on the number of colds reported by the staff of the naturally occurring differences in room size and of the introduction of special ventilating plant or of air disinfectants. Since we were not able to distinguish between colds caught in the offices and those acquired elsewhere, we could only study the effect of changes in the office environment on the total number of colds experienced. While this does not impair the practical value of our results it prevents us from assessing the efficacy of any environmental treatment in preventing the transmission of the common cold within the environment to which it is applied. Substantial control of spread within the office environment might be almost entirely nullified by a compensating increase in the number of infections acquired outside the office if immunity were the main factor determining the result of exposure to infection.

ENVIRONMENTAL TREATMENTS AND CONDITIONS

Ventilation

Three rooms, 72 ft. long × 36 ft. wide × 10 ft. high (i.e. approx. 26,000 cu.ft.) in the central executive offices of the Ministry of Pensions and National Insurance at Newcastle upon Tyne were each fitted with four input fans. These delivered a total of about 3000 cu.ft. of air per minute, warmed to room temperature (about 68° F.), to each room, corresponding to an air replacement rate of 7 changes/hr. Three similar rooms were each given a small extract ventilation fan. The capacity of these fans was only about 200 cu.ft./min. corresponding to a ventilation rate of less than one air change/hr. In fact, owing to leakage through cracks the average ventilation rate of these 'dummy control' rooms over the period studied was 1·4 air

* Now at The Wright-Fleming Institute of Microbiology, St Mary's Hospital Medical School, London, W. 2.

changes/hr. In addition two or three other rooms, naturally ventilated by opening windows in favourable weather, were observed as untreated controls. Over the period studied these rooms had an average ventilation rate of 2·4 air changes/hr.

Ventilation measurements were made using acetone vapour as a tracer substance with the automatic ventilation recording apparatus described by Lidwell (1960). The results for the control and dummy rooms are given in more detail in Fig. 1.

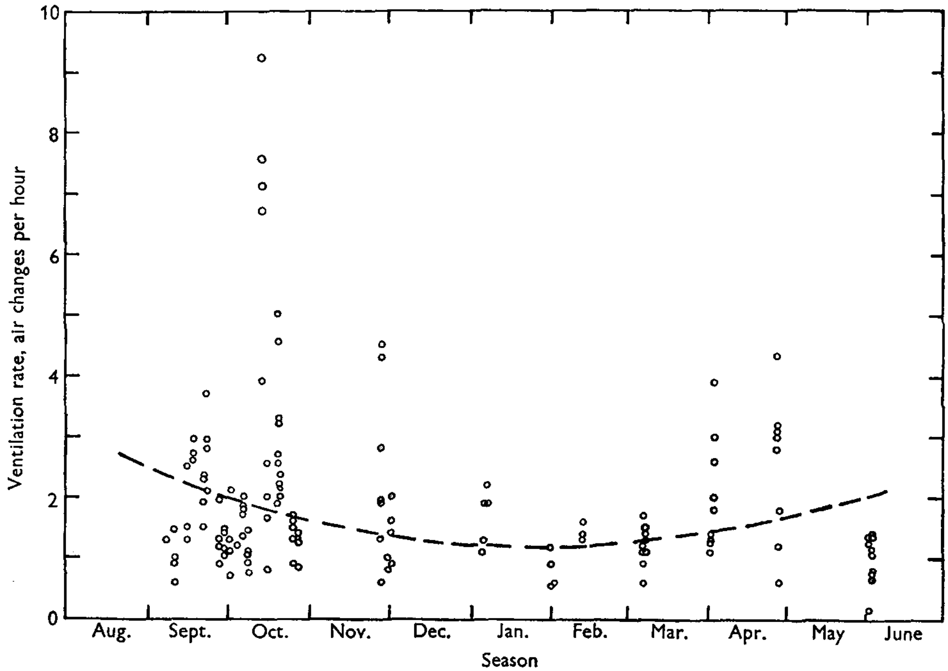

Fig. 1. The variation of ventilation with season. The small circles represent the individual observations, the interrupted line has been drawn freehand through the monthly means.

Records obtained in a similar way from the mechanically ventilated rooms showed that, in these rooms, the decay of tracer concentration was not exponential, i.e. the turbulent air movements were not sufficient to maintain adequate mixing throughout the room space. No simple evaluation of a ventilation rate was therefore possible for these rooms. As will be shown, however, the effect of the ventilation on the bacterial content of the air of these rooms agreed closely with that which would be expected from the rate of air replacement.

Room size

Evidence has been presented that both for tuberculosis (Hewitt & Stewart, 1951) and for influenza (Acheson & Hewitt, 1952) the risk of infection increases with the number of persons working together in one room but is not significantly correlated with the extent of crowding within the rooms, at least within a considerable range. Observations were therefore made during 1 year in ten rooms in the Newcastle offices. Two of these were approximately 150 ft. long × 36 ft. wide and 10 ft. high. The average working population in these two rooms was 80 and 81 respectively. Four were approximately 36 ft. square × 10 ft. high with average working populations of 19, 18, 20 and 18. The remaining four rooms were similar to those observed during the other years of the experiment, 72 ft. long × 36 ft. wide × 10 ft. high with average working populations of 40, 40, 40 and 39.

Chemical air disinfectants

Hexyl Resorcinol. During one season air disinfection by this substance, using commercially available vaporizers (Shepherds Aerosols Ltd.), was attempted in three rooms. Three other rooms were fitted with similar vaporizers containing inert material and two further rooms were observed as untreated controls. Half-way through the season, at the end of January, the hexyl resorcinol and the inert material were interchanged. This part of the study has already been reported (Lidwell & Williams 1954).

α-hydroxy-α-methyl butyric acid ('C' acid). This substance appeared from laboratory studies and limited field trials (Medical Research Council, *Report* 1948, chaps. 19 and 26) to be one of the more promising air disinfectants and trials were carried out with it both in one of the London offices and in the Newcastle offices. The method of application differed in the two places.

The London offices were very large, the main part of each floor, which was effectively a single room, having a cubic capacity approaching 500,000 cu.ft. Each of the floors was fitted with input ventilation at a rate of approximately 1·5 air changes/hr. The air disinfectant was introduced into the air of one floor by suspending in the supply duct pans containing the molten material at a controlled temperature. Owing to losses on the walls the concentration in the air of the room was much lower than that in the duct. The average air concentration maintained during the first period of treatment was about 60 μg./cu. ft. This increased to 75 μg. during the second period. The concentration in the ducts was rather more than twice these values. In order to reach these concentrations it was necessary to evaporate 81 g. of 'C' acid/hr. (4·0 kg./week) during the first period and 146 g./hr. (7·3 kg./week) during the second.

The air concentrations were determined by the colour reaction with ferric salts described by Lovelock (Medical Research Council, *Report* 1948, chap. 14). A 3 % solution of ferric nitrate in 0·3 N nitric acid was found to be a more suitable reagent than that recommended; 0·04 c.c. of this was added to each 10 c.c. of sample.

Owing to technical difficulties it was not possible to interchange the treated and control floors during the experiment. Measurements of temperature and relative humidity were taken daily with a sling hygrometer during the course of the morning throughout the working week in each of the rooms under observation. In addition a recording thermohygrograph was placed in one of the rooms. The temperature in the treated room averaged 71° F. with only slight variations. The relative humidity averaged 49 % with a range of 40–59 %.

In the Newcastle offices the disinfectant was evaporated from heated pans placed towards one end of the room about 7 ft. 6 in. above floor level over which air was blown by a small table fan. During the first season three rooms treated in this way were compared with three rooms fitted with similar apparatus containing inert material and with three untreated control rooms. Half-way through the season the inert material and the disinfectant were interchanged. The 'C' acid was evaporated at the rate of 18 g./hr. (0·9 kg./week) and the average air concentration in the treated rooms was 114 μg./cu.ft. at a temperature of 68° F. and a relative humidity of 49 %. The temperature was fairly constant and the recorded values of relative humidity fell within the range 33–76 %, with fewer than 2·5 % of the measurements falling below 40 %. Owing to accidental causes the bacteriological records obtained during this year were inadequate and treatment with the disinfectant was therefore continued in one room for a limited period during the following year. The average air concentration was rather higher during this second period, about 150 μg./cu.ft.

The concentration of 'C' acid found in the treated rooms varied widely from time to time and from place to place in both the London and the Newcastle offices. This was partly due to the limited accuracy of the method of estimation but also reflected variations in room ventilation and irregularities in the mixing of the vapour into the air of the rooms. The mean concentrations, however, agree reasonably well with those calculated from the size and shape of the rooms, the ventilation rates within them and the rates of vaporization of the acid. Following the methods of calculation previously suggested (Medical Research Council, *Report* 1948, chap. 21) these should be given by $Q/(RV+10A)$, where Q is the rate of vaporization, R the ventilation rate, V the volume of the room in cubic feet and A the exposed surface area of walls, floor and ceilings in square feet. If Q is given in grams per hour and R in air changes per hour then the concentration is given in grams per cubic foot of air. Applying the formula to the London and Newcastle offices the expected concentration of 'C' acid in the air would be 50 and 90 μg./cu.ft. for the 1st and 2nd period respectively in the London office and 118 μg./cu.ft. in the Newcastle offices, where a much more extensive series of measurements was made.

Ultraviolet irradiation

Since the effects of the chemical air disinfection on the airborne bacterial flora was less than expected, a limited experiment involving ultraviolet irradiation of the upper part of one room, above 8 ft., was carried out during the last year of the study. Previous experience in school classrooms (Medical Research Council, *Report* 1954, p. 19; Williams, Lidwell & Hirch, 1956) had shown that the airborne streptococci found in the infant classrooms were apparently more susceptible to the effects of the irradiation than those encountered in the junior classrooms. This difference was associated with a larger proportion of these organisms apparently deriving directly from the upper respiratory tract in the infant rooms, as indicated by the correlation with talking. It was thought possible that the trend might be continued into the adult age groups and that the airborne streptococci in these environments might be dispersed largely from secondary reservoirs such as clothing or dust and that such dispersed material might be less sensitive to chemical as well as to ultraviolet disinfection.

https://doi.org/10.1017/S0022172400020453 Published online by Cambridge University Press

Eight tubular 30 W. low-pressure mercury lamps were suspended in the room. The lamps and fittings were identical with the hanging fittings in the classroom study (Medical Research Council, *Report* 1954, p. 67). No measurements of irradiation intensity were made but calculations made by the method described by Lidwell (1946) gave a mean intensity in the irradiated zone, assuming clean lamps, of about $30\,\mu W./cm.^2$. Experience in the schools suggested that this would result in values of $15–20\,\mu W./cm.^2$ being attained during the experiment. The temperature and relative humidity conditions were similar to those during the 'C' acid treatment.

Bacteriological air sampling

In addition to the measurements described under the individual treatments, sampling for airborne bacteria was carried out at intervals throughout the study. The general flora was estimated by collection on to nutrient agar containing 5% of horse serum. The colonies developing on the plates were counted after 18–24 hr. incubation at 37° C. Streptococci were determined from samples collected on to a selective medium (Williams & Hirch, 1950). The colonies of levan-producing *Str. salivarius* (Williams, 1956) were recognized by their colonial appearance and counted after 40–48 hr. incubation at 37° C. Other presumptive mouth streptococci were estimated by picking a random sample of the colonies from the plates and examining them by methods previously described (Medical Research Council, *Report* 1954, routine C, pp. 52–54).

The air samples were collected in various models of the slit sampler (Bourdillon, Lidwell & Thomas 1941; Medical Research Council, *Report* 1948, chaps. 1 and 2) and in the size grading impaction sampler described by Lidwell (1959). For the purpose of estimating the expected effect of the mechanical ventilation on the airborne bacteria the following values were taken. Ventilation rate in the control and dummy-treated rooms, 2 air changes/hr. Ventilation rate in the mechanically ventilated rooms, 7 air changes/hr. The effective settling diameters of the particles collected in the four stages of the impaction sampler, 25, 15, 7·5 and 3 μ respectively. These correspond in the rooms, which were 10 ft. high, to die-away rates due to sedimentation of 22, 8, 2 and 0·3 changes/hr. The expected ratio of the numbers of airborne bacteria carrying particles collected in the high ventilation rooms to the numbers collected in the control rooms is therefore, for the smallest particles $(2+0{\cdot}3)/(7+0{\cdot}3) = 0{\cdot}32$ and similarly for the other size ranges.

RESULTS

In order to assess the effect of the various treatments on the incidence of infection with the common cold, the numbers of colds expected within each room over each period were computed. On the basis of our experience of the effects of age and sex on the liability to infection, the population at risk in each room was divided into the four categories, males under 30, females under 30, males over 30, females over 30. The average number of colds experienced during the period in question by individuals in each of the four age-sex categories was then evaluated, taking all the rooms, treatment and control, together. The expected number of colds for each room separately was then calculated by multiplying the number of individuals of each category in that room by the average number of colds experienced by individuals in that category and adding together the four figures obtained. Since the age-sex distribution was very similar in each room standardization for these factors did not, in fact, significantly alter the picture given by a simple comparison of the incidence rates in the room. No effects on the number of

Table 1. *The incidence of colds in the Newcastle offices*

Period no.	Date	Rooms and treatments	Mean population	No. of colds: Observed	No. of colds: Expected	$\Sigma\chi^2$	n	P
	1951–52:	6 Control rooms	285	494	—			
1	1. x.–26. v.	0 Treated rooms	—	—	—	4·37	5	0·5
	1952–53:	2 Control rooms	75	161	169·3			
2	1. ix.–18. i.	3 Dummy-treated rooms	128	290	291·6	12·56	14	0·6
3	19. i.–3. v.	3 Rooms treated with hexyl-resorcinol	130	304	294·2			
	1953–54:	2 Large rooms	163	319	335·5			
4	31. viii.–31. v.	4 Medium-sized rooms	159	332	329·7	18·78	9	0·03
		4 Small rooms	75	171	156·9			
	1954–55:	3 Control rooms	115	182	167·6			
5	6. ix.–28. xi.	3 Dummy-treated rooms	115	159	166·3			
6	29. xi.–28. ii.	3 Rooms treated with 'C' acid	118	159	166·0	13·25	18	0·75
		†1 Room with high ventilation	33	41	41·0			
	1955–56:	2 Control rooms	78	132	129·9			
7	3. x.–22. iv.	3 Dummy-treated rooms	112	184	191·3			
		3 Rooms with high ventilation	109	182	182·5	8·33	8	0·4
		‡1 Room treated with 'C' acid	35	67	61·3			
	1956–57:	2 Control rooms	81	141	136·0			
8	15. x.–5. v.	3 Dummy-treated rooms	118	194	194·8			
		3 Rooms with high ventilation	117	170	175·0	10·43	8	0·25
		1 Room with ultraviolet irradiation	36	62	61·0			
All periods		—	—	—	—	67·70	62	0·29

In 1952–53 and 1954–55 the dummy and treated rooms were interchanged approximately midw through the experimental portion of the winter, which did not always comprise the whole of the time observation. Each period, the dates of these are given in the table, was considered separately in formi the χ^2 sum so that the number of degrees of freedom in these years, n in the table, is twice the number rooms studied less two. Except in 1953–54 all the rooms studied were medium-sized rooms.

* The $\Sigma\chi^2$ within groups was 16·98, $n = 7$ hence $P \simeq 0{\cdot}02$, between groups $\Sigma\chi^2 = 1{\cdot}81$, $n = 2$, a $P = 0{\cdot}4$.

† Mechanical ventilation at the high rate was not in operation until 11 Oct. 1954 and the figures gi in the table refer to experience subsequent to that date.

‡ This period of treatment with 'C' acid was included in order to obtain bacteriological data. Vapori tion of the acid was not maintained throughout the whole of the period.

colds experienced by the workers in these offices could be convincingly ascribed to any of the environmental conditions or treatments employed (Tables 1 and 2).

The only occasion when appreciably fewer colds than expected were reported from a treated room was during period no. 6 in the London offices, Table 2. This was during treatment with α-hydroxy-α-methyl-butyric acid. The colds observed during this period were less than two-thirds of the number expected. A similar difference was, however, observed in the succeeding 4-week period, no. 7, when no disinfectant was being vaporized. During the treatment period, no. 6, there was

Table 2. *The incidence of colds in the London offices*

riod no.	Date	Floors and treatments	Mean population	No. of colds: Observed	No. of colds: Expected	$\Sigma\chi^2$	n	P
	1951–52:	2 Control rooms	626	1665	—	0·01	1	0·9
1	24. ix.–1. vi.	0 Treated rooms	—	—	—			
	1952–53:	3 Control rooms	802	780	—	1·58	2	0·4
2	25. viii.–21. xi.	0 Treated rooms	—	—	—			
3	22. xi.–6. ii.	2 Control rooms	566	595	576	2·07	2	0·3
		1 Room treated with 'C' acid	259	242	261			
4	7. ii.–31. v.	3 Control rooms	818	908	—	0·06	2	0·8
		0 Treated rooms	—	—	—			
	1953–54:	2 Control rooms	631	100	100	0·10	2	0·75
5	31. viii. 27. ix.	1 Control room (before treatment)	263	39	39			
6	27. ix.–24. x.	2 Control rooms	648	238	211	12·7*	2	0·01
		1 Room treated with 'C' acid	273	60	87			
7	25. x.–22. xii.	2 Control rooms	645	254	230	8·6*	2	0·01
		1 Control room (after treatment)	266	74	98			
	23. xii.–6. vi.	3 Control rooms	866	810	—	1·20	2	0·6
		0 Treated rooms	—	—	—			
All periods		—	—	—	—	26·2	13	0·02

* The high values of $\Sigma\chi^2$ in *both* these periods derive from fewer colds than expected, about two-thirds, the room which was the treated room during periods 3 and 6.

a substantial reduction in the numbers of airborne bacteria in the treated rooms (Table 4). This difference between the rooms disappeared when the vaporization of disinfectant was discontinued in period 7. It seems therefore most probable that the smaller number of colds reported in the treated room was due either to some unrelated circumstances or to psychologically determined causes. The cessation of treatment before period 7 was not known to the staff at the time but became apparent during the period.

Increased ventilation, chemical disinfection with α-hydroxy-α-methyl butyric acid and ultraviolet irradiation all produced some reduction in the numbers of airborne bacteria (Tables 3–5), including the streptococci, which are thought to

https://doi.org/10.1017/S0022172400020453 Published online by Cambridge University Press

derive from the upper respiratory tract and hence might serve as indicators of atmospheric pollution by organisms derived from this source. In particular, the streptococci found in the air of the offices are as sensitive to the action of the ultraviolet irradiation as those found in the air of the school classrooms so that the

Table 3. *Airborne bacteria in the Newcastle offices, per cu.ft. of air sampled*

Periods no.	Date	Rooms and treatment	Total count	Total mouth streptococci	*Str. salivari*
	1952–53:	2 Control rooms	46·9 (8)	—	—
2	1. ix.–18. i.	3 Dummy-treated rooms	38·8 (12)	—	—
3	19. i.–3. v.	3 Rooms treated with hexyl resorcinol	39·7 (12)	—	—
	1954–55:	3 Control rooms	—	—	—
5	8. xi.–22. xi.	3 Dummy-treated rooms	31·0 (29)	—	—
6	1. xii.–23. ii.	3 Rooms treated with 'C' acid	20·6 (30)	—	—
		1 Room with high ventilation	11·7 (15)	—	—
	1955–56:	2 Control rooms	39·0 (9)	0·19 (8)	0·049 (8)
7	30. xi.–27. iv.	3 Dummy-treated rooms	46·9 (40)	0·34 (28)	0·058 (37)
		3 Rooms with high ventilation	24·8 (43)	0·14 (36)	0·024 (44)
		1 Room treated with 'C' acid	24·5 (23)	0·14 (19)	0·038 (26)
	1956–57:	2 Control rooms	35·7 (22)	0·35 (20)	0·023 (20)
8	26. xi. 20. v.	3 Dummy-treated rooms	36·5 (50)	0·28 (50)	0·033 (50)
		3 Rooms with high ventilation	18·3 (54)	0·13 (54)	0·021 (54)
		1 Room with ultraviolet irradiation	22·1 (55)	0·10 (52)	0·010 (52)

The number of samples on which the mean values are based is given in each case in brackets. Since t distributions were more nearly log-normal, geometric mean values have been given. The standard devi tion of the logarithm, to the base 10, of a single sample estimate averaged about 0·18 for the total coun and 0·30 for the two streptococcal counts.

Table 4. *Airborne bacteria in the London offices, per cu.ft. of air sampled*

Period no.	Date	Floor and treatment	Total count	Total mouth streptococci	*Str. salivarius*
	1953–54:	2 Control floors	34·3	0·16	0·020
6	27. ix.–24. x.	1 Floor treated with 'C' acid	26·3	0·11	0·013
7	25. x.–22. xii.	2 Control floors	41·7	0·17	0·019
		1 Control floor (after treatment)	32·0	0·17	0·019

Thirty-two samples were taken in each period. The variation of the individual sample estimates was similar to that for the Newcastle offices, given in Table 3.

relatively small effect of the α-hydroxy-α-methyl butyric acid on the office flora compared with that found in laboratory trials is unlikely to be due to difference in the airborne streptococcal particles. A reason for the inefficiency of chemical air disinfectants in these and other trials is possibly to be found in the dynamics of

https://doi.org/10.1017/S0022172400020453 Published online by Cambridge University Press

the process of distillation from the source on to the airborne particles (Nash, 1951; see also Williams, 1960).

Table 6 gives the particle size distributions for three components of the airborne flora and the effect on the size distribution of the several environmental treatments. The percentage in each size range is given for the control and dummy rooms. For the treated rooms the proportions are given in such a way that their sum is equal to the percentage of the count in the control and dummy rooms found in the treated

Table 5. *Effect of treatments on the numbers of airborne bacteria, percentages of the control and dummy-treated rooms*

Place and period	Treatment	Total count	Total mouth streptococci	*Str. salivarius*
Newcastle				
2 and 3	Hexyl resorcinol	92	87	104
5 and 6	'C' acid	66	—	—
	High ventilation	38	—	—
7	'C' acid	60	47	68
	High ventilation	59	47	43
8	High ventilation	50	43	70
	Ultraviolet irradiation	61	33	33
London				
6	'C' acid	77	69	65
7	After 'C' acid	77	100	100

Table 6. *Effect of treatments on the size distribution of airborne bacteria in the Newcastle offices, relative to the control and dummy-treated rooms*

prox. size	Total count					Total mouth streptococci					*Str. salivarius*				
ange (μ)	> 18	10–18	4–10	< 4	All	> 18	10–18	4–10	< 4	All	> 18	10–18	4–10	< 4	All
reatment															
ntrol and ummy	12	38	30	20	[100]	23	39	23	15	[100]	27	36	31	6	[100]
' acid	11	17	18	13	59	15	19	9	6	49	14	21	15	4	54
gh entilation	11	26	16	7	60	15	18	11	3	47	19	12	16	1	48
gh entilation alc.)	10	25	14	6	55	19	26	11	5	61	22	24	14	2	62

The percentage in each size range is given for the control and dummy rooms. For the treated rooms the pro- rtions are scaled so that their sum is equal to the percentage of the count in the control and dummy rooms found the treated room concerned, see text.

room concerned. As an example, the percentage of mouth streptococci carried on particles of less than 4 μ in the control and dummy rooms was 15. The numbers of mouth streptococci found in the air of the high ventilation rooms were 47 % of those found in the control and dummy rooms, of these 3/47, or 6·4 %, were on particles of less than 4 μ. The ventilation appears then to reduce the numbers of these small particles to 3/15, or 20 %, of their numbers in the control and dummy rooms. The calculated reduction, see above, was to 32 %. It can be seen that the effects of

https://doi.org/10.1017/S0022172400020453 Published online by Cambridge University Press

ventilation agree reasonably well with those predicted from the settling velocities of the particles, on the assumption that mixing is reasonably complete at all times within the rooms. There is also some indication that α-hydroxy-α-methyl butyric acid acts selectively on the smaller particles.

Fig. 2 shows the numbers of airborne micro-organisms found in relation to season. Each of the points represents the mean of a number of samples taken over a period of a few days. There is no indication of any systematic variation with the

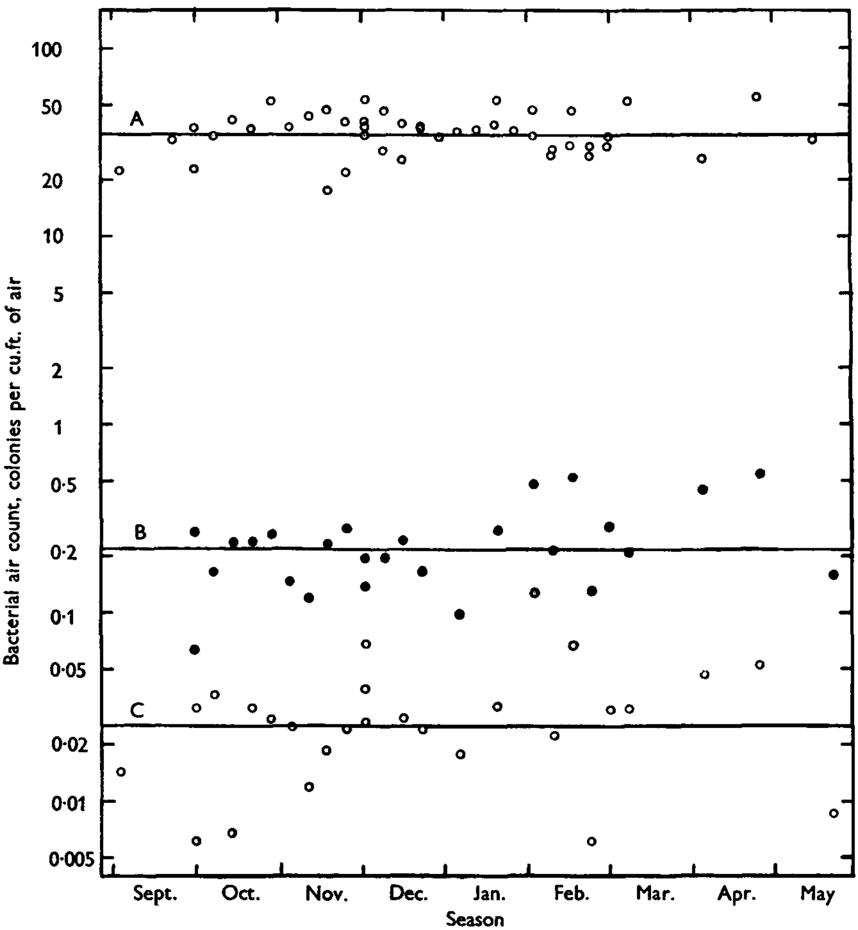

Fig. 2. Seasonal variation in the bacterial air counts. The small circles represent mean values of groups of observations made on different visits. The full lines are the mean values for each bacterial group: A, open circles, total count; B, filled circles, total mouth streptococci; C, open circles, *Str. salivarius*.

time of year nor of any change in bacterial count at times when the incidence of colds was high (e.g. Fig. 4, Lidwell & Williams, 1961*a*). These observations therefore do not confirm those of Torrey & Lake (1941) who found a marked seasonal variation in the numbers of streptococci in the air of a New York departmental store, which correlated with the incidence of colds but not with the numbers of persons using the store.

DISCUSSION

Our studies confirm previous observations that treatment of the working environment with air disinfectants does not affect the number of colds experienced by persons working within it. We find that the same is true of ventilation rates up to 7 air changes/hr. The reduction in the airborne bacterial flora in these and other field experiments has usually been much less than tenfold and it seems likely that the numbers of airborne virus particles will only have been reduced in numbers to a similarly limited extent. The most likely explanation of the failure to reduce the incidence of infection is that this reduction of dose is insufficient. Nevertheless, our inability to distinguish colds caught within the office from those acquired elsewhere means that we cannot certainly state that these treatments did not reduce the transfer of infection within the office. In the study of ultraviolet irradiation of school classrooms (Medical Research Council, *Report* 1954, pp. 29–40) there was evidence that the rate of transmission of measles was reduced within the irradiated classrooms although there was no overall effect on the total incidence of the disease. It is possible that a similar situation might have existed with respect to the common cold in these studies.

There would not now seem to be any valid reason for carrying out further field trials of measures designed to reduce the numbers of airborne microbes unless at least one of the three following conditions can be met: (i) the treatment can be applied to substantially the whole of the living environment of the persons under observations, or (ii) the treatment is an order of magnitude more effective than any of those so far studied, i.e. the airborne bacterial flora can be reduced to considerably less than one-tenth of their usual numbers, or (iii) it is possible to distinguish infections caught within the treated environment from those acquired elsewhere.

SUMMARY

Mechanical ventilation at 7 air changes/hr., air disinfection using vaporized hexyl resorcinol or α-hydroxy-α-methyl butyric acid, or irradiation of the air of the room above 8 ft. with ultraviolet radiation when applied to various clerical offices did not result in any observed alteration in the numbers of colds experienced by those working in them.

There were no differences in the numbers of colds experienced by those working in rooms of different sizes. The working population in these rooms varied from about 20 to more than 80.

We should like to express our thanks to the Ministry of Pensions and National Insurance and to the Shell Petroleum Company, to those members of their staffs and to the nurses and others who helped us in this investigation. We should also like to thank the Shell Petroleum Company for the supply of α-hydroxy-α-methyl butyric acid, and the British Thomson Houston Company of Rugby for the loan of the ultraviolet lamp fittings.

REFERENCES

Acheson, F. & Hewitt, D. (1952). *Brit. J. soc. Med.* **6**, 68.
Bourdillon, R. B., Lidwell, O. M. & Thomas, J. C. (1941). *J. Hyg., Camb.*, **41**, 197.
Hewitt, D. & Stewart, A. (1951). *Brit. J. soc. Med.* **5**, 209.
Lidwell, O. M. (1946). *J. Hyg., Camb.*, **44**, 333.
Lidwell, O. M. (1959). *J. sci. Instrum.* **36**, 3.
Lidwell, O. M. (1960). *J. Hyg., Camb.*, **58**, 297.
Lidwell, O. M. & Williams, R. E. O. (1954). *Brit. med. J.* ii, 959.
Lidwell, O. M. & Williams, R. E. O. (1961*a*). *J. Hyg., Camb.*, **59**, 309.
Lidwell, O. M. & Williams, R. E. O. (1961*b*). *J. Hyg., Camb.*, **59**, 321.
Medical Research Council (1948). *Special Report Series*, no. 262, H.M.S.O.
Medical Research Council (1954). *Special Report Series*, no. 283, H.M.S.O.
Nash, T. (1951). *J. Hyg., Camb.*, **49**, 382.
Torrey, J. C. & Lake, M. (1941). *J. Amer. med. Ass.*, **117**, 1425.
Williams, R. E. O. (1956). *J. Path. Bact.* **72**, 15.
Williams, R. E. O. (1960). *Ann. Rev. Microbiol.* **14**, 43.
Williams, R. E. O. & Hirch, A. (1950). *J. Hyg., Camb.*, **48**, 504.
Williams, R. E. O., Lidwell, O. M. & Hirch, A. (1956). *J. Hyg., Camb.*, **54**, 512.

https://doi.org/10.1017/S0022172400020453 Published online by Cambridge University Press