THE PERSISTENCE OF DUST IN OCCUPIED ROOMS

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(With 1 Figure in the Text)

Various factors are involved in determining the possible role of dust as a vehicle of infection. We know something about the rate at which bacteria from mouth and nose are contributed to dust (Bourdillon, Lidwell & Lovelock, 1942; Hamburger, Green & Hamburger, 1945; Duguid, 1946; Dumbell, Lovelock & Lowbury, 1948). We also have information on the death-rate of such bacteria in dust under various environmental conditions (Cornet, 1889; Garrod, 1944; Lidwell & Lowbury, 1950). It would be a further link in the chain of evidence to know how quickly dust is removed from occupied rooms. An attempt to obtain such information is described in this paper.

METHODS

Small amounts of insoluble fluorescein were dispersed from an insufflating bottle into the air of twelve bedrooms used by volunteers at the Common Cold Research Unit. On the following day the volunteers were asked to sweep and collect the dust from the floor of their bedrooms, and to continue doing so daily. The complete sweepings each day were weighed and extracted by shaking in bottles containing 10 ml. of decinormal sodium hydroxide and glass beads. After 10 min. centrifugation at 2000 r.p.m. the supernatant was removed, and the fluorescence of a suitable dilution was matched in daylight against a standard range of fluorescein solutions.

The optimum range in the fluorescein standard was between the 9th and 15th tubes in a series of doubling dilutions of 0·05 g. 'insoluble' fluorescein dissolved in 10 ml. decinormal sodium hydroxide. The dilutions were colourless when held up to the light but were clearly fluorescent. More concentrated solutions were coloured and showed little obvious difference in fluorescence in adjacent tubes. Matching of dust samples containing little fluorescein was difficult because of the green or brown colour of undiluted extracts. Quantitative assessment of these specimens was impossible, and where fluorescence was obvious they were recorded as containing a 'trace'.

The physical properties of fluorescein cannot be assumed to correspond with those of house dust. An attempt was made to overcome this difficulty by saturating a piece of blanket material in a concentrated solution of fluorescein in decinormal sodium hydroxide, washing the blanket in decinormal hydrochloric acid to precipitate fluorescein, and then in water to rinse. The blanket was dried in the incubator at 37° C., and then beaten vigorously in two of the volunteers' bedrooms. As the dust obtained from bedrooms contains a large proportion of recognizable

Table 1. *Approximate amounts of fluorescein in micrograms per sweeping*

	Fluorescein powder														Fluorescein blanket						Fluorescein powder Normal floor				
	Normal floor								Oiled floor						Normal floor		Oiled floor		Oiled floor Broom cleaned daily		Broom cleaned daily				Weekly sweeping
Days	Room 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	390	195	195	1560	195	97	390	390	195	390	1560	1560	12	12	6	24	6	24	12	24	97	195	390	195	390
2	24	195	97	780	48	97	195	195	97	97	195	97	12	97	1·5	—	12	48	3	12	195	97	97	195	—
3	780	24	24	195	48	97	195	195	48	390	390	780	24	—	1·5	—	tr.	tr.	3	3	97	48	97	97	—
4	195	24	24	390	24	97	390	195	12	48	195	97	1·5	24	tr.	12	tr.	12	tr.	tr.	97	tr.	97	97	—
5	195	12	12	97	24	97	195	97	97	48	195	195	48	tr.	1·5	48	3	24	tr.	0	48	48	97	48	—
6	97	1560	12	97	12	12	97	48	48	48	97	97	3	tr.	tr.	12	3	12	tr.	0	48	24	48	48	—
7	24	195	12	24	12	97	97	48	195	48	97	97	24	tr.	0	12	0	tr.	tr.	0	24	24	97	24	—
8	48	97	6	3	12	97	tr.	97	24	48	97	97	48	tr.	0	12	0	tr.	0	0	48	—	97	97	—
9	97	24	6	12	3	24	48	97	97	12	97	97	tr.	tr.	tr.	tr.	tr.	0	0	0	24	—	48	24	—
10	97	1560	24	97	195	195	48	24	48	48	24	6	tr.	24	0·7	tr.	tr.	tr.	24	tr.	195	97	24	48	—
20	1·5	6	tr.	1·5	1·5	12	6	12	12	12	6	0	0	tr.	—	6	—	—	0	0	—	—	—	—	—
23	tr.	12	6	3	3	tr.	tr.	tr.	24	24	0	0	6	6	—	tr.	—	—	0	0	—	—	—	—	—
26	6	24	6	12	12	—	—	—	—	—	—	0	0	0	—	0	—	—	—	—	—	—	—	—	—
30	—	6	tr.	—	—	—	—	—	tr.	24	0	0	0	0	—	—	—	—	—	—	—	—	—	—	48
35	—	12	tr.	—	—	tr.	—	tr.	0	tr.	0	0	—	—	—	—	—	—	—	—	—	—	—	—	—
40	—	tr.	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50	—	0	0	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60	—	0	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
90	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	97
210	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0

tr. = trace.

blanket fluff, it was considered that this procedure would provide a tracer which behaves in the same way as floor dust on being swept.

In a second series of experiments the floors of ten bedrooms were oiled with spindle oil (Van den Ende, Lush & Edward, 1940). In six of them fluorescein powder was dispersed, and in four a fluorescein blanket was beaten. Dust was examined daily by the usual technique.

The rooms in which these tests were carried out were 16 by 8 ft. in area, and 8 ft. in height. The floor was covered with linoleum and a small rug, and the furniture consisted of a bed, a chest of drawers, a cupboard and a folding chair. Volunteers occupied the rooms for a period of 10 days, but sampling of dust was continued in some flats by volunteers occupying them during subsequent trials.

RESULTS

Table 1 shows the approximate amounts of fluorescein in sweepings. No. 25 was a room in the laboratory swept out once a week after fluorescein powder was dispersed in it. The other rooms were swept daily for 10 days, and in some the sweeping was continued daily from the 15th to 23rd day and from the 28th to 37th day. The sweepings on the 10th and 26th days were thorough.

The rooms (1–8) in which fluorescein powder had been dispersed showed large residues of fluorescein after 10 days and appreciable or measurable traces on the 23rd day. Room 25, which was swept weeekly, showed a large residue of fluorescein after 90 days, but none was detected after 210 days.

Rooms in which fluorescein blankets were beaten showed much lower initial concentrations of the tracer, but the dieaway rates in the two rooms comparable in other respects with rooms 1–8 were similar, and a measurable residue was present in the dust from one room after ten sweepings. Cleaning the broom daily after use (rooms 19–24) had no apparent effect on the dieaway rate of fluorescein; large measurable residues were found after 10 days' sweeping in rooms treated with fluorescein powder and in one of the rooms prepared by shaking a fluorescein blanket. Six rooms treated with fluorescein powder after oiling the floors (nos. 9–14) showed dieaway rates similar to those in rooms 1–8.

In Fig. 1 the dieaway curves are expressed as the average log micrograms of fluorescein per sweeping plotted against time, and indicate a fall to about one-tenth of the initial level after 7 or 8 days in oiled and unoiled rooms. In the latter, thorough sweeping on the 10th day showed a return to a higher yield of fluorescein.

The daily sweepings were weighed, because the amount of dust removed from a room might be proportional to the rate of disappearance of fluorescein. In Table 2 the weights of 10 days' sweepings in twelve flats are tabulated beside the fractions of the original fluorescein levels found in dust on the 10th day. There is no consistent or significant relation between the two quantities in this very limited series, a finding which is not unexpected, as the factors that determine the size of a sweeping include the amount of dust deposited from bedmaking and from shoes, as well as the thoroughness with which the room was swept.

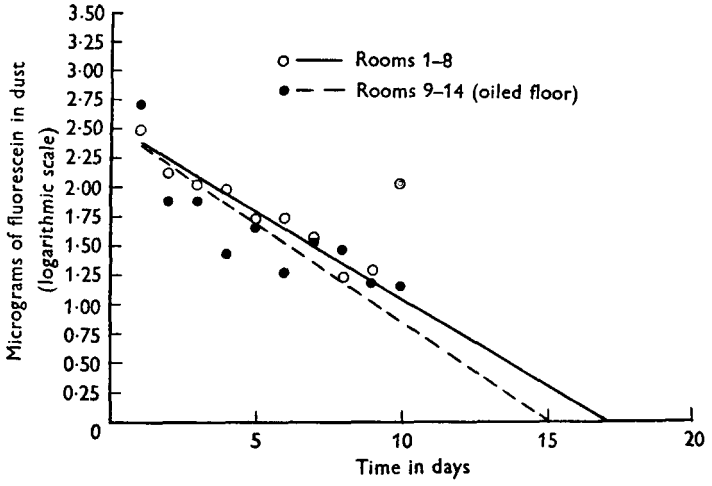

Fig. 1. Dieaway of fluorescein in dust. The points plotted are the averages of the logarithms of the weights of fluorescein found per sweeping on the respective days.

Table 2

Room	Weight of 10 days' sweepings	Fluorescein level on 10th day divided by fluorescein level on 1st day
1	4·00	0·24
2	4·40	8·00
3	3·05	0·12
4	2·00	0·06
5	2·65	1·00
6	2·05	2·00
7	2·45	0·12
8	3·35	0·06
9	2·55	0·24
10	2·70	0·12
11	5·55	0·06
12	5·50	0·012

DISCUSSION

No tracer can reproduce the physical properties of house dust, which are complex and variable. The advantages of fluorescein are: (1) it is detectable at very high dilutions; (2) like dust, it is not dissolved by water spilt or condensing on the floor; (3) it does not decay; (4) coloured substances normally present in dust do not prevent matching, or at least detection, of fluorescein. Fluorescence was not observed in samples of dust from unprepared rooms. The fact that dust shaken from dry fluorescein-saturated blankets did, in spite of low initial concentrations, behave similarly lends weight to the finding with fluorescein powder.

Particles of fluorescein appeared on microscopic examination to fall largely between 1 and 5 μ in diameter. Floor dust has a wide range of particle sizes, from macroscopic textile fibres to minute particles of the order of 1 μ. Bacteria-carrying particles shaken from dry used handkerchiefs have an average diameter of 20 μ

(Dumbell *et al.* 1948). A richer flora, including larger numbers of haemolytic streptococci, has been found in the finer components of floor dust (Lidwell & Lowbury, 1950). Persistence of pathogens in the environment cannot be estimated without taking into account both the viability of the organisms and the rate of turnover of their vehicle; the findings reported in this paper should be helpful in attempts to assess the second of these factors.

SUMMARY

Fluorescein dispersed as powder into the air of occupied rooms was extracted in measurable quantities from dust after as many as twenty previous sweepings.

The value of fluorescein in showing the rate of removal of dust from occupied environments is discussed in relation to the transfer of infection.

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