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DUST CONTROL IN MEASLES WARDS

WITH A NOTE ON SULPHADIAZINE PROPHYLAXIS

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Allison and Brown (1936) showed that haemolytic streptococci may spread in measles wards as a secondary transmissible infection superimposed on the primary virus-caused disease. Their findings were confirmed by Wright, Cruickshank, and Gunn (1944), who showed in addition that dust particles are possibly an important means of streptococcal carriage in measles wards. They found that the oiling of blankets, bed linen, garments, and floors in a measles ward resulted in a 98% reduction in the numbers of haemolytic streptococci in the air during bed-making, when compared with the numbers in the air of an unoiled control ward; and that the streptococcal cross-infection rate among the patients fell from 58.1% during a preliminary period with oiled floor alone to 18.6% when, in addition, oiled bed-clothes, garments, and ward linen were in use. The comparable cross-infection rates for the same periods in the unoiled ward were 53.3% and 73.3% respectively. The method of laundry oiling was described by Harwood, Powney, and Edwards (1944).

Research on the control of air-borne infection was stimulated during the recent war by the occurrence of respiratory infection among men in barracks and other establishments. British workers demonstrated a great increase in numbers of dust-borne streptococci and other bacteria in the air of Army quarters and hospital wards during bed-making and sweeping, and successfully controlled dust-spread bacteria by the application of dust-laying oils to textiles and floors (van den Ende *et al.*, 1940, 1941; van den Ende and Thomas, 1941; Thomas, 1941). American workers confirmed these observations and introduced new methods of oil application (Robertson *et al.*, 1944; Commissions on Acute Respiratory Diseases and on Air-borne Infections, 1946; Loosli *et al.*, 1946; Puck *et al.*, 1946). In field trials they secured evidence that oiling floors and blankets reduced the incidence of haemolytic streptococcal infection among troops (Commission on Air-borne Infections, to be published).

Scope of the Investigation

Although the good results of dust control in a measles ward recorded by Wright, Cruickshank, and Gunn (1944) appeared clear-cut, it is notoriously difficult to make strict comparisons between one hospital ward and another. It seemed important, therefore, to repeat the experiment during another measles epidemic and in another hospital. At the same time nursing techniques and other matters, the importance of which had emerged during the first experiment, were standardized so far as possible. The investigation was undertaken during 19 consecutive weeks in 1945 in two first-floor measles wards of identical size, design, and aspect. Each ward had a side-room for two cots. In the oiled ward (opened on Jan. 28 and closed on June 7) the following dust-suppressive measures were taken: The floor of the main ward, which was of wood, was treated with spindle oil immediately before the start of the investigation and monthly thereafter (the floor of the side-room, sanitary annexes, and passages could not be oiled, as they were of composition); all blankets, counterpanes, sheets, pillow-slips, patients' garments, towels, and staff gowns were treated with technical white oil immediately before the start of the investigation and thereafter at each laundering. The blankets of each patient were disinfected after his discharge or transfer from the ward and were washed and re-oiled every four weeks. During the first three weeks the oiling was undertaken at the laundry of the British Launderers' Research Association, and during the rest of the investigation in the hospital laundry. The method used was that described by Harwood, Powney, and Edwards (1944). In the unoiled ward (opened on Jan. 25 and closed on May 31) no measures were taken against dust-borne infection. The floors of this ward and its side-room and annexes were of composition. In each ward the total bacterial and haemolytic streptococcal content of the air, and the cross-infection and complication rate due to haemolytic streptococci, were studied throughout the investigation. A third ward for the study of sulphadiazine prophylaxis was opened on Feb. 14 and closed on May 19, 1945. Particulars and results of this part of the investigation are the subject of a separate section of this report.

Ward Arrangements

1. The bed complement of each ward, which was normally 18, was raised to 20 (8 cots and 12 beds) during the investigation. The bed-spacing was 12 ft. (366 cm.) between bed centres. The length of each ward was 100 ft. (30 m.), the width 27 ft. (823 cm.), and the height 15 ft. (457 cm.). The ventilation turnover (between 4.30 and 6 a.m.), estimated once only, was five to seven changes in an hour. Each ward had a side-room with two cots reserved for patients with middle-ear suppuration.

2. Measles patients were allocated in rotation to the main wards; measles patients admitted with middle-ear suppuration were allocated in rotation to the side-rooms.

3. Toys and books were forbidden in the wards.

4. Mattresses, pillows, and blankets of each bed were disinfected (5 lb. (2.27 kg.) pressure for 30 minutes) at the start of the investigation, and thereafter on the discharge or transfer of each patient.

5. Barrier nursing was adopted for all patients with the following complications: pneumonia, severe bronchitis, tonsillitis, skin infection, and middle-ear suppuration.

6. Patients with uncomplicated measles were discharged on their tenth day in hospital.

7. Swabs for nasal toilets were sterilized in dressing drums; nurses were instructed to use a "no-touch" technique and to wash their hands in a solution of "O-syl" between each nasal toilet.

8. Convalescent patients were restricted to their own bed area.

Routine Procedures

Air Sampling.—The bacterial content of the air was investigated by means of a slit sampler (Bourdillon, Lidwell, and Thomas, 1941). Air samples were taken once weekly in each ward during bed-making (5 to 6.30 a.m.) and during sweeping (8.30 to 9.30 a.m.). The slit sampler, on a trolley, was moved from one bed to the next as each in turn was made. During sweeping the machine remained at a fixed central point in the ward. The height of the slit, through which air was drawn at the rate of 1 cu. ft. (28.317 c.cm.) per minute, was 34.5 in. (87.6 cm.) from the floor. For measuring the total bacterial content of the air, blood agar plates were exposed in the slit sampler for one to three minutes and were incubated aerobically for 24 hours at 37° C. The number of bacterial colonies on each plate was counted, though on crowded plates only an approximate count could be made. For measuring the haemolytic streptococcal content of the air, gentian-violet blood agar plates were exposed in the slit sampler for 5 to 15 minutes. The number of colonies of haemolytic streptococci on each plate was counted after 24 hours' incubation aerobically at 37° C.

Cross-infection Criteria.—Swabs were taken from the nose and throat (and from the ear discharge, if any) of every patient immediately before admission to the wards, then once weekly and on the day of discharge or transfer. Nose and throat swabs were taken once weekly from the ward and laboratory staffs and from the medical officers. Swabs were plated on gentian-violet blood agar plates and incubated aerobically for 18 hours at 37° C. Cross-infection was judged to have occurred if a patient, between his third hospital day and the day of his discharge or transfer from the ward, was found to have in his upper respiratory tract haemolytic streptococci of Groups A, C, or G which were not present on the day of, or the day after, admission. It was intended to take swabs in the receiving-room from the skin lesions of all new patients, but this was not always practicable as some patients had multiple or crusted lesions.

Complication Rate.—A daily round of all patients in the three wards was made and any complication or rise of temperature noted. Appropriate swabs were taken, plated on gentian-violet blood agar, and investigated for the presence of haemolytic streptococci after 18 hours' incubation aerobically at 37° C.

Serological Investigation of Haemolytic Streptococci.—Representative colonial forms of haemolytic streptococci were picked from gentian-violet blood agar plates to blood broths, which, after 18 hours' incubation aerobically at 37° C., were stored in the refrigerator for subsequent serological examination. All haemolytic streptococci thus stored were tested for Lancefield group by the formamide method (Fuller, 1938). Group A streptococci were tested for serological type by the Griffith agglutination method. Strains which had been derived from patients and which failed to type by agglutination were tested by the precipitin typing method (Swift, Wilson, and Lancefield, 1943); so also were representative strains from a large number of Group A streptococci which gave agglutination reactions with type 13 and B3264 sera. Strains which failed to give satisfactory reactions were recorded as "type not found."

Results of Investigation

Air Sampling

Air samples were taken once weekly during bed-making and sweeping in each main ward and also in the side-room, if occupied. The results in the unoiled and the oiled wards are shown in Table I.

TABLE I.—*Counts of Total Bacteria and of Haemolytic Streptococci in the Air of the Unoiled and of the Oiled Ward during Bed-making*

Unoiled Ward			Oiled Ward		
Date (1945)	Total Bacterial Colonies (approx.) per 10 cu. ft. of Air	Total Haemolytic Streptococcal Colonies per 100 cu. ft. of Air	Date (1945)	Total Bacterial Colonies (approx.) per 10 cu. ft. of Air	Total Haemolytic Streptococcal Colonies per 100 cu. ft. of Air
1/2 ..	4,638	2	2/2 ..	137	0
8/2 ..	4,060	180	9/2 ..	175	0
15/2 ..	3,230	27	16/2 ..	312	6
22/2 ..	1,750	7	23/2 ..	158	8
1/3 ..	1,260	4	2/3 ..	220	4
8/3 ..	2,710	8	9/3 ..	301	2
15/3 ..	1,460	12	16/3 ..	144	0
22/3 ..	4,250	142	23/3 ..	376	0
29/3 ..	1,560	0	30/3 ..	83	0
5/4 ..	1,630	7	6/4 ..	233	0
12/4 ..	2,870	80	13/4 ..	120	0
19/4 ..	2,810	2	20/4 ..	137	3
26/4 ..	3,180	17	27/4 ..	41	0
3/5 ..	3,010	3	4/5 ..	193	0
10/5 ..	1,890	0	11/5 ..	389	0
17/5 ..	790	0	18/5 ..	145	3
24/5 ..	1,210	0	25/5 ..	94	0
Total	42,308	491	Total	3,258	26

1 cu. ft. = 28,317 c.cm.

The table shows that the reduction in the mean total bacterial count of the air of the oiled ward during bed-making was 92.3% when compared with the figure for the unoiled ward. This reduction indicates that the oiling of the bed-clothes, etc., was effective in controlling bacteria-carrying dust particles. A striking feature of the investigation was the comparatively low counts of haemolytic streptococci in the unoiled ward. Only on three occasions did the counts in the unoiled ward rise above a figure of 50 haemolytic streptococci per 100 cu. ft. (2.832 m.^{3}) of air, and in eleven of the seventeen morning samplings the counts were below 10 per 100 cu. ft. The two highest counts—180 and 142 haemolytic streptococci respectively—were largely accounted for by two plates; on one of these 91 streptococcal colonies were collected from 10 cu. ft. (0.28 m.^{3}) of air, and on the other 82 from 12 cu. ft. (0.34 m.^{3}). Both samplings had been taken from the surroundings of patients with numerous streptococci in the nose and throat. The reduction in the mean haemolytic streptococcal count during bed-making in the oiled ward was 94.7% when compared with the figure for the unoiled ward.

Table II shows the counts of total bacteria and haemolytic streptococci in the air of the unoiled and of the oiled ward during sweeping.

The table shows that the reduction in the mean total bacterial count of the air of the oiled ward during sweeping was 79.1%, when compared with the figure for the unoiled ward. The counts of aerial haemolytic streptococci obtained during sweeping showed the same irregularity as those obtained during bed-making. On the whole the sweeping counts were low; from ten of the seventeen morning samplings no haemolytic streptococci were isolated. One high count—150 per 100 cu. ft. of air—was obtained; this occurred on the morning on which a high count was obtained during bed-making and may have been explained

TABLE II.—*Counts of Total Bacteria and of Haemolytic Streptococci in the Air of the Unoiled and of the Oiled Ward during Sweeping*

Unoiled Ward			Oiled Ward		
Date (1945)	Total Bacterial Colonies (approx.) per 10 cu. ft. of Air	Total Haemolytic Streptococcal Colonies per 100 cu. ft. of Air	Date (1945)	Total Bacterial Colonies (approx.) per 10 cu. ft. of Air	Total Haemolytic Streptococcal Colonies per 100 cu. ft. of Air
1/2 ..	1,315	0	2/2 ..	125	0
8/2 ..	2,640	150	9/2 ..	180	0
15/2 ..	4,035	47	16/2 ..	480	0
22/2 ..	1,515	5	23/2 ..	200	0
1/3 ..	1,410	0	2/3 ..	455	0
8/3 ..	1,505	0	9/3 ..	390	0
15/3 ..	1,150	0	16/3 ..	155	5
22/3 ..	1,695	5	23/3 ..	505	0
29/3 ..	805	0	30/3 ..	175	0
5/4 ..	1,075	5	6/4 ..	213	0
12/4 ..	1,445	25	13/4 ..	545	0
19/4 ..	475	5	20/4 ..	500	5
26/4 ..	1,380	0	27/4 ..	480	0
3/5 ..	1,520	0	4/5 ..	230	0
10/5 ..	795	0	11/5 ..	230	0
17/5 ..	890	0	18/5 ..	210	0
24/5 ..	1,065	0	25/5 ..	95	0
Total	24,715	242	Total	5,168	10

by the disturbance for nursing purposes of the bed of a heavy carrier during the sweeping. The reduction in the mean haemolytic streptococcal count during sweeping in the oiled ward, when compared with the figure for the unoiled ward, was 95.9%.

Table III shows the counts of total bacteria and haemolytic streptococci in the air of the side-rooms of the unoiled and oiled wards during bed-making and sweeping. In this connexion it should be recalled that the floors of both side-rooms were of composition and that therefore the side-room attached to the main oiled ward could not be treated with spindle oil. Air samples were taken from the side-rooms only when they were occupied; this accounts for the absence of readings in some weeks.

TABLE III.—*Counts of Total Bacteria and of Haemolytic Streptococci in the Air during Bed-making and Sweeping in the Side-rooms of the Unoiled and Oiled Wards*

Date (1945)	Total Bacterial Colonies (approx.) per 10 cu. ft. of Air		Total Haemolytic Streptococcal Colonies per 100 cu. ft. of Air	
	Bed-making	Sweeping	Bed-making	Sweeping
		Unoiled Ward		
8/2	—	4,490	—	0
15/2	10,000	3,060	0	40
22/2	10,000	920	13	0
1/3	10,000	2,430	20	0
8/3	10,000	—	0	0
15/3	2,100	620	0	0
22/3	2,340	1,400	0	20
29/3	3,200	2,270	75	0
5/4	2,180	1,170	10	20
12/4	1,630	2,100	38	60
19/4	270	670	20	40
10/5	2,930	540	0	0
17/5	4,000	680	0	0
Total ..	58,650	20,350	176	180
Average per sample	4,888	1,696	14·7	13·8
		Oiled Ward		
9/2	—	210	0	0
23/2	595	1,210	0	30
2/3	230	550	40	0
9/3	300	640	0	0
16/3	300	350	0	0
23/3	180	610	0	0
30/3	280	420	20	0
13/4	210	115	0	0
20/4	150	360	0	0
27/4	60	1,170	0	0
4/5	220	100	0	0
11/5	130	140	0	0
18/5	210	490	0	0
25/5	100	80	0	0
1/6	130	440	30	0
Total ..	3,095	6,885	90	30
Average per sample	221	459	6	2

The reduction in the mean total bacterial count in the air of the side-room of the oiled ward was during bed-making 95.5% and during sweeping 72.9%. Corresponding reductions in the mean haemolytic streptococcal counts were 59.2% and 85.5%. Patients with heavy streptococcal infections of the upper respiratory tract were being nursed in the side-room of the oiled ward on the three occasions when haemolytic streptococci were recovered from the air during bed-making. It is possible that some of these streptococci resulted from droplets, as the children were apt to cough in the early morning; alternatively, some may have arisen from the dressings applied to their ears.

Eighty-one colonies of haemolytic streptococci isolated from the air of the unoiled ward were tested serologically. Of these, 79 belonged to Group A, one to Group C, and one to Group G. Of the Group A strains, 1 was type 1; 3, type 11; 3, type 11/28; 1, type 12; 8, type 25; 3, type "impetigo 19"; and 60, "type not found." Twenty-seven colonies of haemolytic streptococci from the oiled ward were tested; of these, 23 belonged to Group A and 4 to Group G. Of the Group A strains, 1 was type 4/24; 1, type 6; 14, type 12; 1, type 25; and 6, "type not found."

Cross-infection Incidence

During the course of the investigation 186 measles patients were nursed in the unoiled ward. Of these, 23 became cross-infected in the upper respiratory tract with Group A, C, or G streptococci, giving a cross-infection incidence of 12.4%. Serological examination of the cross-infecting strains yielded the following results: 15, Group A (1, type 2; 1, type 4/24/29; 4, type 12; 2, type 25; 1, type 27; 1, type 29; and 5, "type not found"); 3, Group C; and 5, Group G. In 20 of the cross-infected patients the streptococcus was first isolated from the throat, in 1 from the nose and throat, in 1 from the nose, and in 1 from the ear. Ten of the cross-infections were first discovered in the swabs taken on the day of the patient's discharge from hospital.

In the oiled ward 190 measles patients were nursed. Of these, 39 became cross-infected in the upper respiratory tract with Group A, C, or G streptococci, giving an incidence of 20.5%. Serological examination of the cross-infecting streptococci yielded the following results: 33, Group A (1, type 2; 4, type 4/24/29; 1, type 6; 1, type 11; 1, type 11/27/28; 12, type 12; 1, type 14/R491; 1, type 22; 3, type 25; 1, type 29; 2, type "impetigo 19"; 5, "type not found"); 4, Group C; and 4, Group G. Double cross-infections with different serological types occurred in two patients. In 26 of the patients the cross-infecting streptococcus was first isolated from the throat, in 7 from the nose and throat, in 5 from the nose, and in 1 from the ear. Eleven of the cross-infections were first discovered in the swabs taken on the day of the patient's discharge from hospital. One small outbreak of type 12 streptococcal infection occurred in the oiled ward. The first cross-infection was discovered on Feb. 6. Possible sources of infection were a child admitted to the adjacent cot with type 12 streptococci in his upper respiratory tract, and a nurse who developed type 12 streptococcal tonsillitis on the day on which the ward was opened. By the following week three other children had become cross-infected with type 12 streptococci, and by the following week three more children and one nurse.

Complication Rate

None of the 186 patients in the unoiled ward developed middle-ear suppuration definitely attributable to streptococcal cross-infection. One child, admitted with non-streptococcal otorrhoea, acquired a Group G streptococcus in the ear discharge. Another child, admitted with Group

A streptococci in the nose and throat, developed left otorrhoea due to Group A streptococci; since all the streptococci isolated from this patient failed to type, it was not possible to decide whether the otorrhoea was or was not due to cross-infection. Two patients in the unoiled ward developed "late" middle-ear suppuration due to pneumococci.

Of the 190 patients admitted to the oiled ward, only one case of "late" middle-ear suppuration (that is, occurring on or after the sixth hospital day) could be attributed to streptococcal cross-infection (Group A, type 12). One other child in this ward developed "late" otorrhoea, also due to type 12 streptococci, but she was a throat carrier of this type on admission.

Other complications among patients after admission were also few. Those which might possibly have been due to cross-infection were as follows: In the unoiled ward: mild conjunctivitis, Group A, "type not found"; follicular tonsillitis, Group G, type 25. In the oiled ward—fissure in angle of mouth, Group A, "type not found"; tonsillar plugs, Group C; fissure of lip, Group A, type 12; fissure of lips and cervical adenitis, Group A, type 12.

Sources and Spread of Infection among Patients

1. Unoiled Ward

(*a*) *Carrier Rate on Admission.*—Over the whole period of the investigation the carrier rate of haemolytic streptococci in the nose and/or throat of patients on admission was 19.7%. Of the 37 streptococcal strains, 26 were Group A (1, type 1; 2, type 2; 6, type 4/24/29; 1, type 8; 1, type 11; 3, type 12; 2, type 25; 1, type 27; and 9, "type not found"); 7, Group C; and 4, Group G.

(*b*) *Heavy Nasal Carriers.*—Hamburger, Green and Hamburger (1945) stated that patients with heavy streptococcal infection of the nose are more liable than others to contaminate their surroundings and should therefore be regarded as "dangerous" carriers. In this investigation it was found that, among the 186 patients nursed in the unoiled ward, only 9 were heavy nasal carriers of haemolytic streptococci; this may possibly account for the comparatively small numbers of haemolytic streptococci found in the air.

(*c*) *Middle-ear Suppuration.*—Seven patients with middle-ear suppuration were admitted direct to the side-room of the unoiled ward. Only one of these infections was due to streptococci (Group C). One patient was removed from the main ward to the side-room on the development of otorrhoea due to streptococci (Group A, "type not found"), and two on the development of pneumococcal otorrhoea.

2. Oiled Ward

(*a*) *Carrier Rate on Admission.*—The carrier rate of haemolytic streptococci in the nose and/or throat of patients on admission was 20.5%. Of the 40 streptococcal strains, 30 were Group A (1, type 2; 1, type 4/24/29; 1, type 6; 3, type 11; 6, type 12; 1, type 14; 1, type 24; 2, type 25; 1, type 27; 1, type 29; 2, type "impetigo 19"; 10, "type not found"); 9, Group C; and 1, Group G.

(*b*) *Heavy Nasal Carriers.*—Of the 190 patients who were nursed in the ward, only 11 were heavy nasal carriers of haemolytic streptococci.

(*c*) *Middle-ear Suppuration.*—Eleven patients with middle-ear suppuration were admitted direct to the side-room of the oiled ward. Five of these children were infected with haemolytic streptococci (Group A: 1, type 6; 1, type 24; 1, type 29; 1, "type not found"; and 1, Group C). One of these patients was found not to be suffering from measles and was removed from the ward after 24 hours. Two patients who developed streptococcal otorrhoea (Group A, type 12) were removed to the side-room from the main ward.

Sources and Spread of Infection among Staff

1. *Unoiled Ward.*—Haemolytic streptococci were isolated from the upper respiratory tract of 6 of the 32 nurses or domestic helpers (18.8%) who worked in the ward during the course of the investigation. The distribution of the streptococci was as follows: Group A: 1, type 4/24/29; 1, type 11; 1, type 25; 3, "type not found." In addition, one nurse suffered from a septic finger due to Group A, type 25, streptococci and was taken off duty.

2. *Oiled Ward.*—Haemolytic streptococci were isolated from the upper respiratory tract of 8 of the 31 nurses or domestic helpers (25.8%) during the course of the investigation. The distribution of the streptococci was as follows: Group A: 2, type 2; 2, type 12; 1, type 12 and "impetigo 19"; 1, type 27; and 2, "type not found." One of these nurses developed a type 12 streptococcal tonsillitis and was taken off duty.

3. *Medical and Laboratory Staff.*—Of the ten members of the medical and laboratory staff who visited the wards, two were intermittent carriers of streptococci (1 Group A, "type not found," and 1 Group A, type 25), and 1 had streptococci (Group A, type 1) in the throat on two occasions.

Skin Conditions

If we include in the category of skin sepsis not only obvious sepsis such as impetigo, boils, etc., but also skin lesions which are commonly secondarily infected, such as burns, infantile eczema, seborrhoeic dermatitis, and so on, we find that the distribution of cases was not equal between the two wards. In the oiled ward 26 children had skin sepsis on admission and 15 developed lesions subsequent to admission. In the unoiled ward the corresponding figures were 14 and 16. This may have some importance in the subsequent interpretation of results, since the bacteriological cross-infection rate for all children with skin sepsis on admission was 27.5%, which is higher than the mean of 16.5% for all cases in both wards. Individual examples presented themselves during the study which showed that respiratory infection was probably due to auto-inoculation from a skin lesion. (*Example*: J. B., aged 2 years; when admitted on April 6, 1945, the nose and throat swabs contained no haemolytic streptococci, but an impetiginous lesion had numerous type 25 streptococci. On April 12 the nose and throat swabs had a fair number of type 25 streptococci.)

The view has been expressed that the oiling of bed-clothes is not free from drawbacks, as some of the oils are dermatitic (Mitman, 1945). Our experience was that among 190 patients nursed in oiled bed-clothes and garments, only 5 (2.6%) showed any evidence of skin irritation. This was mild and ceased immediately on discontinuing to wear an oiled vest. Attempts to incriminate the dermatitic element in the emulsion failed because, apart from these few cases early in the experiment, skin irritation neither appeared naturally nor could be produced artificially by the prolonged wearing of garments impregnated with various types of emulsion. It must be remembered that during the war high degrees of purity, particularly of the emulsifying agents, could not always be attained by the manufacturers. Given reasonable standards in this respect, our experience of this particular oiling method indicates that the risk of skin irritation is negligible. If any anxiety is felt on this account it may be dismissed by omitting the oiling of the inner garments such as vests which by themselves cannot contribute much to the risk of dust-borne infection.

Clinical Severity

The investigation started in late January, during a spell of cold weather which was followed by a mild late winter and spring. Some of the patients admitted early in the period were acutely ill and presented the usual diagnostic difficulty between severe uncomplicated measles and early bronchopneumonia. This phase lasted for only two to three weeks. Six patients in the oiled ward and five in the unoiled ward suffered from bronchopneumonia. In the oiled ward 65 of the 190 patients received sulphonamide therapy, and in the unoiled ward 58 of the 186 patients; with few exceptions the drug used was sulphadiazine. Taken over the whole period of the investigation the patients were only mildly ill, and, latterly, very few seriously ill patients were seen. It should be noted, too, that throughout the investigation there were close restrictions on measles admissions in London, the aim being to admit to hospital only on account of severity of attack or of poor home conditions.

During the period of the investigation 151 measles patients were nursed in wards other than those used for the dust-control work. Of these, 130 were allocated to a chemoprophylaxis study ward which is the subject of a separate report; the remaining 21 were housed elsewhere in the hospital for the following reasons: 14 were male patients over the age of 7 years, 3 were convalescent on admission, 3 had both pertussis and measles, and in 1 the diagnosis was in doubt. None of these patients had middle-ear suppuration either on or after admission; two had bronchopneumonia.

Discussion

Detailed bacteriological investigation was made in two measles wards at the North-Western Hospital during the 1943 epidemic. In both wards secondary type 6 streptococcal outbreaks occurred and resulted in high cross-infection and middle-ear suppuration rates. In the air of the unoiled ward an average count of 253 haemolytic streptococci per 100 cu. ft. (2.832 m.^{3}) was obtained during bed-making. In the oiled ward aerial streptococci during bed-making were 98% less and during sweeping 99% less than in the unoiled ward. The use of dust-control measures was coincident with a fall in the rate of type 6 streptococcal cross-infection from 58.1% to 18.6% and of middle-ear suppuration (due to this cross-infection) from 18.4 to 2.8% (Wright, Cruickshank, and Gunn, 1944; Wright, 1945). At the Eastern Hospital in 1943 a high incidence of "late" middle-ear suppuration—21%—was also found. Bacteriological investigations were not made, but it may be reasonably supposed that the high otorrhoea rate was due to secondary streptococcal infection and that the ward epidemiology was in fact similar to that of the North-Western Hospital.

The most striking feature of the 1945 investigation at the Eastern Hospital lay in the unoiled ward, which had a comparatively low cross-infection rate (12.4%), no cases of middle-ear suppuration due to streptococcal cross-infection, and a low streptococcal content of the ward air. Aerial streptococci in this ward, even including two plates with high counts, yielded an average content during bed-making of only 29 haemolytic streptococci per 100 cu. ft. of air; on four occasions no haemolytic streptococci were isolated from the ward air during the bed-making period; and on seven other occasions counts of less than 10 per 100 cu. ft. were obtained. The unoiled ward therefore failed to fulfil its function of supplying a yardstick against which possible benefits of dust control in the oiled ward could be measured.

Several other differences were noted between the results of the investigation in 1943 at the North-Western Hospital and in 1945 at the Eastern Hospital. With few exceptions the cross-infections in 1943 were due to type 6 streptococci. Mass invasion with this type occurred, as shown both in the number of patients infected and in the abundance of the streptococci yielded from the swabs. In 1945, 11 serological types of Group A and also Groups C and G streptococci were responsible for the cross-infections. Heavy streptococcal growth was obtained in 1943 from 72% of the cross-infected patients, whereas in 1945 only 25% of the cross-infections were heavy invasions and 42% were scanty. The degree of nasal cross-infection also differed. In 1943, 60% of the cross-infections resulted in a heavy streptococcal infection of the nose, while in 1945 only 8% were of the heavy nasal type.

The streptococcal cross-infection rates among patients in the unoiled and the oiled ward in 1945 were 12.4% and 20.5% respectively. Both wards had therefore a comparatively low cross-infection rate of the same order as the 18.6% rate which was regarded as satisfactory for the oiled ward in the 1943 investigation. The low degree of aerial contamination by streptococci in both wards suggests that the cross-infections were caused by a type of spread which was not air-borne. Possibly they were due to contact infection, for which there is ample opportunity in the catarrhal stage of measles. The fact that cross-infections of this type were more numerous in the oiled than in the unoiled ward could not be explained. Undetected differences in nursing technique in the two wards were a possible cause, since in field trials of this type an unavoidable variable between the experimental and the control ward lies in their different nursing staffs. In spite of careful alternate allocation of patients to the wards, two factors acting unfavourably to the oiled ward were observed: (*a*) it had a higher admission rate of type 12 streptococci—the only streptococcal type which showed signs of "communicability" and "virulence"; and (*b*) it had a higher admission rate of skin sepsis and streptococcal otorrhoea cases.

Complications due to streptococcal cross-infection were exceedingly few in 1945. Only one patient out of a total of 376 nursed in the two wards developed "late" middle-ear suppuration definitely attributable to streptococcal cross-infection—an incidence of 0.27%. The safety of the measles wards of 1945 contrasted strongly with the risks in 1943, when one in every five patients contracted middle-ear suppuration. It is evident that conditions favourable to the spread of streptococci in measles wards vary considerably from one epidemic year to another. The results of the 1945 investigation need in no way discourage further trials of dust suppression by oiling. It is possible that the unfavourable conditions of 1943 may recur in subsequent measles epidemics; in such an event the introduction of dust control may again assume importance as a measure in preventing cross-infection.

Summary

An investigation into the control of dust-borne haemolytic streptococci was carried out in two identical measles wards at the Eastern Hospital for a period of 19 weeks in the spring of 1945. In one, the oiled ward, all bed-clothes, patients' garments, and ward linen were treated in the hospital laundry with technical white oil, and the floor of the main ward was oiled. In the unoiled ward no anti-dust measures were taken. In both wards the air was sampled for total bacteria and for haemolytic streptococci during bed-making and sweeping, and the streptococcal cross-infection and complication rates were recorded.

The oiling methods were successful in suppressing dust-borne bacteria. This was shown by the fact that the mean total bacterial count was reduced, when compared with the count for the unoiled ward, by 92.3% during bed-making and by 79.1% during sweeping. Counts of aerial haemolytic strepto-

cocci in the unoiled ward varied considerably from week to week and in general were of a low order. On three occasions comparatively high counts were obtained: 180, 142, and 80 streptococci per 100 cu. ft. (2.832 m.³). On four occasions, however, no haemolytic streptococci were collected during a complete bed-making round, and on seven other occasions the count was below 10 per 100 cu. ft. The same irregularity of aerial contamination by haemolytic streptococci was found during sweeping.

The cross-infection rate among 186 measles patients nursed in the unoiled ward was 12.4%, and among 190 patients in the oiled ward, 20.5%. These cross-infections, the rates of which were comparatively low for such a highly susceptible group as measles patients, appeared to be due to contact rather than to air-borne infection. The fact that this type of cross-infection was higher in the oiled than in the unoiled ward was unexplained. The complication rate due to streptococcal cross-infection was exceedingly low; only one case of streptococcal otorrhoea due to cross-infection occurred among the total of 376 patients nursed in the two wards, making an incidence of 0.27%.

Striking differences were found from the results recorded in an earlier and similar investigation at the North-Western Hospital in 1943. In the unoiled ward there a high haemolytic streptococcal count was found in the ward air, and secondary type 6 streptococcal spread caused a cross-infection rate of 72% and a "late" middle-ear suppuration rate of 18.5%. In the unoiled ward of the 1945 investigation at the Eastern Hospital the streptococcal content of the air was in general low, the cross-infection rate was 12.4%, and no case of "late" middle-ear suppuration due to streptococcal cross-infection occurred. The unoiled ward in 1945 therefore failed in its function of acting as an adequate control ward against which possible benefits of dust control by oiling could be measured.

It is evident that conditions favourable to secondary streptococcal epidemics in measles wards vary considerably from year to year. The results of the investigation at the Eastern Hospital in 1945 should in no way discourage further trials of dust control by oiling. Should the unfavourable conditions of 1943 recur in consequent measles epidemics, dust-suppressive measures may again assume importance in the control of cross-infection.

SULPHADIAZINE PROPHYLAXIS IN MEASLES

Large-scale studies of sulphadiazine prophylaxis of respiratory infections in the United States Navy during the war years (Coburn, 1944) encouraged an attempt to evaluate chemoprophylaxis of streptococcal cross-infection in measles. For this purpose a third study ward was set up, as has been mentioned in the main report on the dust-control investigation. The hope of thereby comparing cross-infection rates among patients having sulphadiazine prophylaxis with those in the control ward was prevented by differences, some unforeseen and some unavoidable, between the two wards. The sulphadiazine patients had to be nursed in a ground-floor ward with blast-protected windows, whereas the control ward was on the first floor and had unprotected windows. The sulphadiazine ward could not be opened until three weeks after the control ward and was closed two weeks earlier. Also, owing to an oversight due to changes of staff, discharge swabs from 17 of the 130 sulphadiazine patients were omitted. A further difficulty in comparison arose because nearly one-third of the patients in the control ward received sulphonamides therapeutically. For these reasons the results must be regarded as quite inconclusive, but they are briefly described here, since they include evidence on sulphonamide levels attainable with small doses of the drug.

The ward regimen was as follows: Sulphadiazine was given to all patients, the daily dose being: 0–2 years of age, 0.25 g.; 3–9 years, 0.50 g.; 10–16 years, 0.75 g.; over 17 years, 1 g. The first dose was given soon after admission, and subsequent doses between 9 and 10 a.m. daily, up to and including the day of discharge. From 18 patients blood samples were taken 24 hours after the daily dose and were estimated for sulphadiazine content. The three samples from the 0–2 years group contained 2, 1.9, and 1 mg. per 100 ml. of blood; the eleven from the 3–9 years group contained a mean of 1.95, with a range from 4.3 to 0.6 mg. per ml. of blood; the two from the 10–16 years group, 3 and 1.2 mg.; and the two from the over 17 years group 2.5 and 2.7 mg.

The following results were recorded for the ward:

Air Sampling.—During bed-making the mean total bacterial count was 3,880 and during sweeping 1,570 per 10 cu. ft. (0.28 m.³) of air (2,360 and 1,230 respectively per 10 cu. ft. in the control ward). During bed-making the mean haemolytic streptococcal count was 3.7 and during sweeping 1.6 per 100 cu. ft. (2.832 m.³) of air (28.9 and 14.2 respectively per 100 cu. ft. in the control ward).

Cross-infection Rate.—Of the 130 patients admitted to the ward, 13 (10%) became cross-infected with Group A streptococci (1, type 1; 2, type 4/24/29; 1, type 11/28; 1, type 12; 1, type 22; 1, type 25; and 6, "type not found"). None was cross-infected with Group C or G streptococci.

Complication Rate. — None of the patients developed otorrhoea or other complications attributable to streptococcal cross-infection.

Sources and Spread of Streptococcal Infection

Among Patients.—(a) Carrier Rate on Admission: The carrier rate of haemolytic streptococci (Groups A, C, or G) among patients on admission was 10.8%. Of the 14 strains isolated, 12 were Group A (3, type 4/24/29; one, type 11; 1, type 12; 3, type 22; 2, type 25; 2, "type not found"); 1, Group C; and 1, Group G.

(*b*) *Heavy Nasal Carriers*: Only three of the 130 patients were heavy nasal carriers of haemolytic streptococci.

(c) Middle-ear Suppuration: Five patients were admitted to the side room with middle-ear suppuration, one only of which was due to streptococci (Group A, type 11).

Among Staff.—Haemolytic streptococci (Group A, types 11 and 12) were isolated from only two of the 27 nurses and domestic helpers who worked in the ward during the investigation. The type 12 streptococcus was isolated from a domestic worker with tonsillitis.

Skin Infections

Eleven children in this ward had skin sepsis on admission, in contrast to 14 in the control ward. It is interesting to note, however, that in the three study wards—the sulphadiazine ward, the oiled ward, and the control ward—the numbers of children admitted with frank impetiginous lesions were 8, 9, and 6 respectively, and that these gave rise to 4 secondary cases of impetigo in the sulphadiazine ward, 1 in the oiled ward, and 1 in the control ward. The four secondary cases in the sulphadiazine ward were of the bullous type and occurred as an explosive little outbreak, which suggested that sulphadiazine in these doses has very doubtful prophylactic value against the spread of this form of skin sepsis.

Toxic Effects

No toxic effects were noted. In this connexion it must be emphasized that, owing to the general mildness of the measles attacks in the whole period of the study and the particular absence of complications in the ward, the period of in-patient treatment and hence the sulphadiazine administration was short. Most patients were discharged on their tenth day in hospital, and the longest stay of any patient was 31 days.

Summary

The complete absence of complications attributable to streptococcal cross-infection in the sulphadiazine ward and the low bacteriological cross-infection rate justify a further attempt to evaluate the difficult question of sulphonamide prophylaxis in measles. No other significance should be attached to the results of this study.

The daily ingestion of 1 g. of sulphadiazine with downward adjustments for age to 0.25 g. attained minimum and maximum blood concentrations of 0.6 and 4.3 mg. per 100 ml. respectively, in samples taken 24 hours after administration.

In these doses, given normally over a period of 10 days and in no case in excess of 31 days, no toxic effects from sulphadiazine were encountered in the 130 patients studied.

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ADRENALECTOMY IN MENTAL DISORDER

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Although the endocrines have been largely employed in the practice of psychiatry, on the whole little progress has yet been made towards either improving the patients by their use or elucidating a relationship between glandular disturbances and mental disorders. Moreover, few of the diseases of the endocrine glands or the operative procedures connected with their relief have thrown any definite light on the relationship between psychiatry and endocrinology. At least seven cases of amelioration of mental symptoms following unilateral adrenalectomy have been reported (Allen *et al.*, 1939; Allen and Broster, 1945; Greene, Paterson, and Pile, 1945). It would seem equally important to describe two cases with well-marked mental abnormalities associated with characteristic glandular changes which were unimproved by this operation, whilst other findings of some interest have emerged from the investigations.

Case 1

A 44-year-old single woman was admitted to hospital in December, 1945. She was in an extremely neglected bodily state, and prior to her admission she was treated by the authorities as a person wandering at large. No history was available, and she was unable to give any details of her previous life until after the operation. She was completely apathetic, dull, retarded, and disinterested. Although she answered questions, her replies were monosyllabic and hardly relevant. During the time she was in hospital before the operation she remained apathetic, and she either did not properly appreciate her position or was completely indifferent to it. It appeared that she had some intellectual impairment and at times a mild clouding of consciousness. Her physical state approximated closely to that described by Broster as "adrenal virilism," because it seems to have arisen in adult life many years after the development of menstruation and the female secondary sexual characteristics. She was a well-built woman, muscular rather than obese. The outstanding abnormality in the secondary sex characters was that the hair growth was male in distribution. The whole of the beard area—lip, chin, lower cheeks, and pre-auricular region—was covered with long coarse hair, the pubic hair extended up to the umbilicus, the thighs were hairy to a very marked degree. The hirsuties had been noticed for three or four years. The blood pressure was not raised: 135–125/95–75. Menstruation had ceased for about two years. The history suggests that the abnormality of suprarenal cortical function did not occur until about the age of 40, so that it was not surprising to find well-developed breasts and a female relationship between the respective widths of the pelvic and pectoral girdles. Preoperatively her urinary steroids measured as androsterone were 60 mg. in 24 hours (normal 9–12 mg.). Her blood sugar (Fig. 1, curve A) showed a flat curve of the pituitary

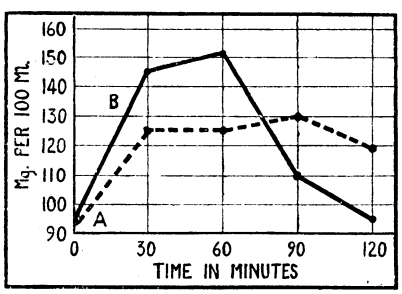

FIG. 1.—Case 1. Blood-sugar curve before operation, A, and after operation, B.

type as found in Broster and Vines's polyglandular type 3. The blood sedimentation rate fell 8 mm. in the first hour (200 mm. Westergren column). The differential blood count, blood cholesterol, urea, and serum chlorides were within normal limits. Intravenous pyelography did not give any indication of unilateral suprarenal enlargement, and therefore laparotomy was performed in April, 1946. The right suprarenal was much larger than the left. Examination revealed a normal development of the female pelvic organs. When, two days before the adrenalectomy, she was told that she was to have an operation in order to lose all her hair growth, the only remark she made was: "Rather far-fetched to operate on the tummy to lose hair on my face." Then she sank back into her apathetic condition again.

In May, 1946, right adrenalectomy was performed by Bernard Fey's costo-abdominal approach, which gave an excellent exposure of the suprarenal. Briefly, in the Bernard Fey approach an incision is made along the upper border of the eleventh rib to the tip and continued thence towards the anterior iliac spine in the line of the fibres of the external oblique. The eleventh rib is freed subperiosteally and displaced downwards. The posterior periosteum is incised, the common origin of the diaphragm and transversalis abdominis muscle divided near the tip of the rib, and the transversalis split in the direction of its fibres. This exposes the upper pole of the kidney and leads direct to the suprarenal. Mouat (1939) wrote: "I can find no record of Fey's costo-abdominal route having been used for operations other than those on the kidney and ureter, but inspection of the surrounding structures during operation, and my experience of it in the dissecting-room, lead me to suggest that this route might with advantage be used for operations on the adrenals or for repair from below of the hiatus in diaphragmatic hernia." Since 1939 Mr. John Everidge has strongly recommended to one of us (E. J. R. S.) the use of this route for operations on the suprarenal, and whatever its role may be in renal surgery it does appear to