

THE BACTERIAL CONTENT OF THE AIR IN ARMY SLEEPING HUTS, WITH ESPECIAL REFERENCE TO THE MENINGOCOCCUS.

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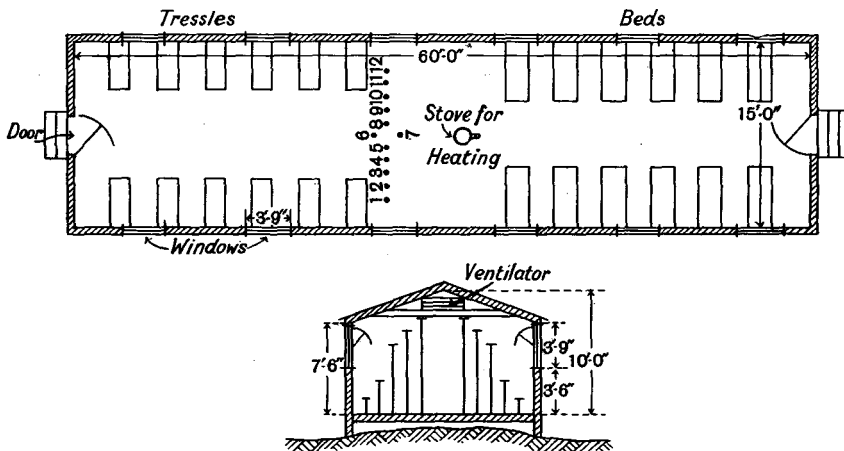
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(With 1 Diagram.)

THE following experiments were carried out in October and November, 1917. They have not been published hitherto as it was hoped that they might be extended and revised.

The onset of the influenza epidemic, the armistice and the resulting dispersal of troops prevented this, and in so far as some of the conclusions arrived at seem of no little importance, it has been thought advisable to publish the results of the work done, incomplete though it is.

The first series of experiments I-VIII deals with the number of organisms found on plates exposed during the night in men's sleeping huts, Barrack Design 230/14. The same hut was always used, and the number of men in the hut was always 22.



Men's Sleeping Hut: Barrack Design 230/14.

This diagram shows the ground plan and vertical section of the type of hut in which the experiments were conducted.

The "beds" used were either ward beds or plank trestles, but no appreciable difference in the bacterial content of the hut could be detected whichever type was employed. It will be noticed that there was a ventilator in the roof extending the entire length of the hut and that there were six windows on each side, the upper half of which could be opened. There was no ground ventilation but the huts were floored with planks and raised above the grass on wooden supports.

Experiment I.

Plates exposed 10.30 p.m., 25.10.17.

Plates removed to incubator 6.0 a.m., 26.10.17.

Temperature in hut: Maximum 58° F., Minimum 48° F.

Plates	Level	Colonies
1, 12	1 foot above ground	All plates showed innumerable colonies; no mould or other gross contamination.
2, 11	3 " "	
3, 10	5 " "	
4, 9	6 " "	
5, 8	7 " "	
6, 7	Ground level	

Experiment II.

Plates exposed 10.30 p.m., 28.10.17.

Plates removed 6.0 a.m., 29.10.17.

Temperature in hut: Maximum 56° F., Minimum 44° F.

Plates	Level	Colonies
1, 2	8 feet above floor	All plates showed innumerable colonies; Nos. 5 and 9 were overgrown with mould.
3, 4	7.5 " " (inverted)	
5	7 " "	
6	6 " "	
7	5 " "	
8	4 " "	
9	3 " "	
10	2 " "	
11	1 " "	
12	Floor level	

Experiment III.

A comparison of the effect of beds and trestles. The height of the men's heads above the floor was 2 feet 3 inches and 1 foot 3 inches in the two groups.

Plates	Level	Colonies
2, 6, 12, 14	Ground level	All plates in both sets showed innumerable colonies; none overgrown.
4	2 feet	
5	1½ "	
1	2½ "	
13	3 "	
9	3½ "	
11	4 "	
7	4½ "	
8	5 "	
15	6 "	

Two sets of plates used, one between beds and the other between trestles.

*Meningococcus**Experiment IV.*

An exact repetition of Exp. III with the same result.

Experiments V and VI.

Two identical experiments to show the number of bacteria in the air in spaces between beds and trestles at higher levels.

Plates exposed 19.10.17, midnight.

Plates removed 20.10.17, 6.0 a.m.

Temperature: Maximum 58° F., Minimum 40° F.

Plates	Level	Colonies
5	7 feet	In both sets innumerable colonies; none overgrown.
4	6½ „	
1	6 „	
6	5 „	
3	4 „	
2	3 „	

Two sets as in Experiments III and IV.

Experiment VII.

Plates placed as high as possible in intervals between beds.

Plates exposed 10.30 p.m., 20.10.17.

Plates removed 6.0 a.m., 21.10.17.

Temperature: Maximum 50° F. (?), Minimum 49° F.

Plates	Level	Colonies
1, 2, 3, 4	8½ feet	All plates showed innumerable colonies, except 5 and 7 (both inverted). 5, 250 colonies 7, 360 „
7, 8, inverted	7½ „	
9, 10	7 „	
6, 5, inverted	6½ „	

Experiment VIII.

Same as VII, only trestles instead of beds.

Plates exposed 21.10.17, midnight.

Plates removed 6.0 a.m., 22.10.17.

Temperature: Maximum 56° F., Minimum 48° F.

All plates showed innumerable colonies.

Experiments I–VIII show therefore that in the type of army hut investigated the bacterial content of the air during sleeping hours is very high and that the air throughout the hut is uniformly infected.

Experiment IX.

A larger type of hut used. Plates placed all on ground level.

Plates exposed 10.10.17, 10.0 p.m.

Plates removed 11.10.17, 6.0 a.m.

Temperature: Maximum 55° F., Minimum 45° F.

Plates	Position	Colonies
2, 3, 5, 6	Between trestles	Uncountable
1	In centre of room	48
4	" "	30

Experiment X.

Hospital ward. Space between beds 2 feet. Plates placed between beds.

Plates exposed 14.10.17, 9.30 p.m.

Plates removed 15.10.17, 4.30 a.m.

Temperature: Maximum 54° F., Minimum 43° F.

Plates	Level	Colonies
1	Ground	152
2	"	164
3	"	Overgrown
4	"	"
5	1 foot	176
6	1 "	Overgrown
7	1½ feet	184
8	1½ "	Overgrown
9	2 "	166
10	2 "	Overgrown
11	2½ "	"
12	2½ "	127
13	3 "	101

It is seen that, although the bacterial content of the air is less than in the ordinary army hut, still the number of colonies obtained is very considerable both at ground level and at 3 feet.

Experiment XI.

Comparison of condition in a half hut, type 230/14, when 5 feet was allowed between each bed, the men being carriers of meningococcus.

Plates exposed 13.10.17, 10.0 p.m.

Plates removed 14.10.17, 6.30 a.m.

Temperature: Maximum 38° F., Minimum 36° F.

Plates	Level	Colonies
10	Ground	540
11	"	496
12	"	450
13	"	450
1	1 foot	Overgrown
2	1 "	546
3	1½ feet	304
4	1½ "	? slightly overgrown
5	2 "	308
6	2 "	300
7	2½ "	300
8	2½ "	276
9	3 "	250

Meningococci were present in No. 4. In all cases where meningococci are stated to be present, they were proved by agglutination to be genuine strains.

Meningococcus

Experiment XII.

To show the presence of meningococci in the air. Patients were all known carriers.

Plates exposed 11.10.17, 10.0 p.m.

Plates removed 12.10.17, 6.30 a.m.

Temperature: Maximum 53° F., Minimum 47° F.

Plates. Six exposed on ground level, in intervals between beds. All showed innumerable colonies. Meningococci present, but only one plate showed several colonies.

Experiment XIII.

More exact experiment on conveyance of meningococcus. Chronic carrier lying on trestle for 5 minutes, coughing periodically. Plates arranged on the ground at different distances from his mouth, which was 1 foot 9 inches above the floor. The room had been previously sprayed with formalin and the floor scrubbed and cresoled.

Plates	Distance from subject in feet	Meningococci
1, 2	6	overgrown
3, 4	7	"
5, 6	8	"
7, 8	9	"
9, 10	10	negative
11, 12	11	"
13, 14	12	overgrown
15, 16	13	positive
17, 18	14	overgrown

Experiment XIV.

Chronic carrier sleeping with face towards plates. Plates all on ground level. Same preparation of room as in Experiment XIII.

Plates exposed 12.10.17, 10.0 p.m.

Plates removed 13.10.17, 6.30 a.m.

Plates	Distance in feet	Meningococci	Colonies
1	3	? not proven	Uncountable
2	3	+	320
3	5	+	276
4	5	+	360
5	6	overgrown	
6	6	"	
7	7	"	
8	7	-	372
9	8	-	288
10	8	-	204
11	9	-	172
12	9	-	190
13	10	overgrown	
14	10	"	
15	11	-	160
16	11	-	140
17	12	overgrown	
18	12	-	146

Experiment XV.

Exact repetition of Experiment XIV.

Plates exposed 9.10.17, 10.0 p.m.

Plates removed 10.10.17, 6.30 a.m.

Plates 1, 3 and 4 showed meningococci, i.e. at distances of 3 and 5 feet.

Experiment XVI.

Same as preceding. Plates at different distances and levels from face of carrier.

Plates exposed 15.10.17, 10.0 p.m.

Plates removed 16.10.17, 6.30 a.m.

Temperature: Maximum 53° F., Minimum 50° F.

Plates	Level	Colonies	Meningococci
7 (1 foot from subject)	2½ feet	45	+
20 "	4 "	40	-
13 "	5 "	overgrown	
3 "	1½ "	"	
11 "	3½ "	44	+
6 (2 feet from subject)	6 "	overgrown	
2 "	1 "	30	-
15 "	5½ "	38	+
8 "	3 "	45	+
4 (3 feet from subject)	5 "	overgrown	
18 "	3½ "	54	+
14 "	3 "	overgrown	
12 "	5½ "	"	
17 "	1½ "	smashed	
16 (4 feet from subject)	2½ "	overgrown	
5 "	4½ "	"	
1 "	2 "	150	+
19 (5 feet from subject)	4 "	60	-
9 "	4½ "	overgrown	
21 "	2 "	56	-
22 "	1 "	56	-
10 "	6 "	overgrown	

SUMMARY.

Experiments I-VIII.

I shows that under the conditions shown the plates were covered with innumerable colonies 7 feet above ground level to ground level. The beds and trestles were used to keep the hut always uniform.

II shows that 8 feet above ground, i.e. on top of the crossbeams, the same conditions obtain.

III, IV, V, and VI show that the same condition exists in the area between the beds or trestles. The beds make no difference, better or worse.

VII shows practically the same condition high up on the beam between the beds. The inverted plates naturally show less colonies, as the organisms mostly fall on to the plates.

VIII confirms the above.

There is only one conclusion to draw from these experiments, and that is that practically speaking there is no difference in the number of organisms on the ground floor and 8 feet above it, in the ordinary men's sleeping huts, Barrack Design 230/14.

Experiments IX–XII are shown for comparative reasons.

IX shows a better condition in a broader hut, although more men were sleeping in it.

X shows the superiority of the ward buildings. The beds were only 2 feet apart and chosen specially to show effect of overcrowding.

XI shows effect of bed space and low temperature. It also shows possibility of transfer of meningococci. The meningococci were proved by agglutination tests.

XII was a control on XI. The effect of the higher temperature is seen, also possibility of spread of meningococci.

Experiments XIII–XVI.

These are more exact experiments on distance to which meningococci can be carried. "Spraying capacity of patient."

XIII. By coughing it was carried 13 feet. Several like experiments were done, but owing to overgrowth by *subtilis*, etc., this was the only one where the organism could be proved by agglutination. Others showed suggestive colonies but they could not be isolated.

XIV. This showed that in ordinary sleep a carrier can spray to a distance of 5 feet.

XV confirms above, and from these two and several other negative experiments it seems justifiable to conclude that the "spraying capacity" of a carrier during ordinary sleep is 5 feet along the level or just below it.

XVI shows that meningococci are carried during sleep:

	1 foot at a height of 2 ft 6 in.
1	3 ,, 6 ,,
2	5 ,, 6 ,,
2	3 ,, —
3	3 ,, 6 ,,
4	2 ,, —
5	nothing above ground level

so that we may say that in ordinary sleep the organism is not carried more than 5 feet, but in violent coughing it may be carried three times this distance.

The conclusions to be drawn from the above experiments, limited as they are, seem to be the following:

(1) In the ordinary infantry sleeping hut, there is a stagnant well of infected air in which the men sleep.

(2) This dead space extends up to 8 feet above the ground level.

(3) The wider the hut and the lower the temperature, the better the condition of the air.

(4) More adequate ventilation is needed; probably this could be obtained by ground ventilation.

(5) The meningococcus can be carried at night from a carrier to his neighbours unless the bed space is more than 5 feet.

(6) The spraying capacity of a carrier varies between 5 and 15 feet, but is 5 feet during ordinary sleep.

(7) The meningococcus is carried in the spray to a much shorter distance than many other organisms.

In conclusion, I have the pleasant task of thanking those who have helped me to carry out this piece of work. Colonel Morse, R.A.M.C., arranged for the use of the hut and the discipline of the subjects. Capt. Welsford, Senior Sanitary Officer, interested himself in the work and obtained for me the services of Lt. Hasnip who provided the diagrams of the huts. Finally, Colonel Mervyn Gordon criticised the earlier experiments and supplied suggestions for new work, which unfortunately I was unable to carry out.