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VARIATIONS OF AIR-BORNE BACTERIA IN A DEPARTMENT OF ORAL SURGERY

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The variation in the number of airborne bacteria before and after the reconstruction of an oral surgery department was determined in the policlinic and the operating theatre by means of sedimentation plates with bloodagar. The sedimentation plates were kept in analogous locations in both parts of the study and exposed for determined periods during the day. Along with the reconstruction, the hygienic standard was improved by introduction of several changes, such as obligatory use of oral/nasal mask, separated treatment units in the policlinic, decreased movement during surgical procedures, a better isolation of the operating theatre and overpressure ventilation with filtrated air. The results showed a generally significant variation ($p<0.01$) in the bacterial level correlated with the rate of activity in both parts of the study. Further results showed a very clear decrease in the number of bacteria for both localities. The percentage reduction was found to be 65 per cent in the operating theatre and 50 per cent in the policlinic (mean values).

Variations of bacterial air contamination have been observed under various forms of activity in hospital service (*Stenderup*, 1950; *Mollstedt & Nilsson*, 1957; *Mollstedt*, 1958; *Waldton*, 1960; *Mårtensson*, 1960; *Böe*, 1960; *Böe & Solberg*, 1963). Within the field of dentistry, it has been ascertained, that among other things, the use of high speed equipment, in particular, causes a wide spread of air-borne bacteria (*Rölla*, 1963).

In view of the strong relation of this problem to an oral surgery department, it was decided to study the variations in the number of air-borne bacteria on different days and hours, in various localities and sites within each room.

MATERIAL AND METHODS

The investigation was carried out at the Department of Oral Surgery, University of Bergen. The localities used were the policlinic and one operating theatre before and after the reconstruction of the department (Figs. 1 and 2).

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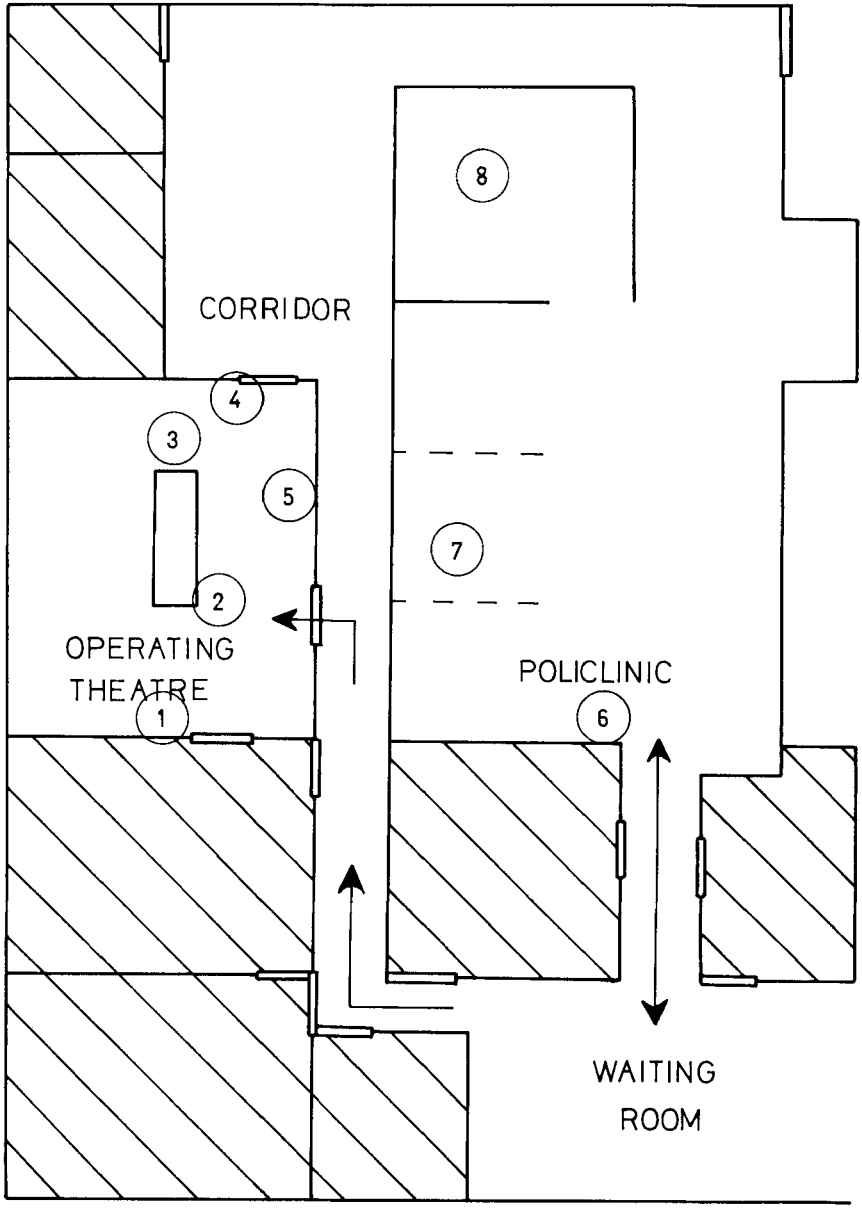

Fig. 1. Before reconstruction.

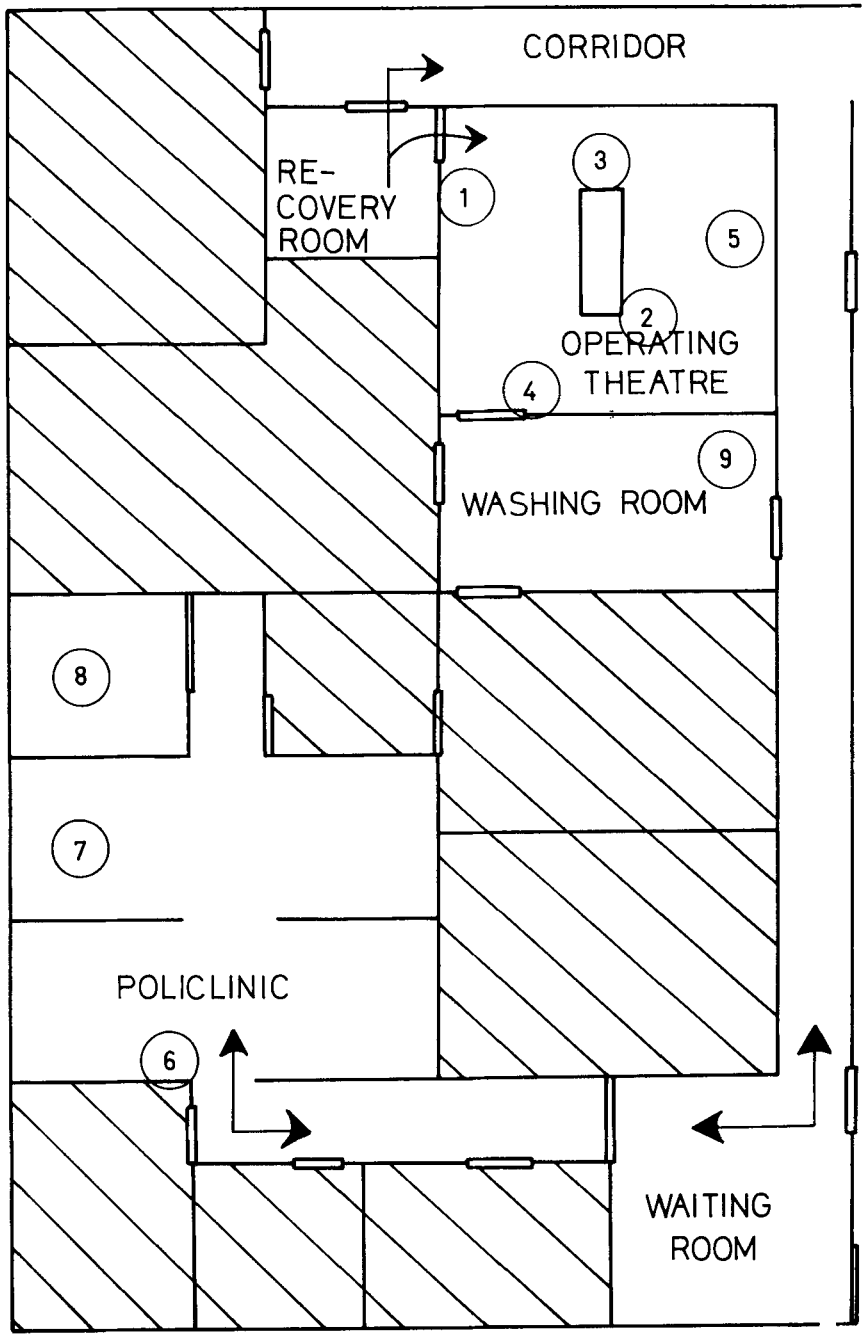

Fig. 2. After reconstruction.

During the investigation the following factors remained unchanged:

1. personnel
2. numbers of students in each working period
3. number of patients
4. working frequency
5. working intensity
6. methods of treatment

After the reconstruction the following changes were introduced:

I. In the policlinic:
   1. the operating units were separated by partitions,
   2. non-essential traffic through the policlinic was avoided,
   3. wearing oral/nasal mask was made obligatory for all personnel and students,
   4. the volume of the area included in the study was reduced due to technical reasons (from 170,5 m^3 to 100,5 m^3).

II. In the operating theatre:
   1. the operating theatre made a more systematically concentrated unit, separated from the other rooms by a washing-room and a recovery room,
   2. filtered and bacteria free air was blown in under pressure,
   3. all non-essential activity of the department personnel was kept to a minimum during the surgical procedures,
   4. the volume of the room was reduced (from 87,5 m^3 to 62,5 m^3).

The concentration of bacteria, at elected locations, in the department was studied by means of sedimentation plates. These consisted of open Petri-dishes with bloodagar (7.5 % human blood). Each sedimentation plate was exposed for two hours. The time of exposure for the different plates and the activity in the localities tested, is shown in Table I.

The sedimentation plates were placed at the same height above the floor as the patient's head and in similar locations before and after the reconstruction (Figs. 1 and 2). The locations were numbered 1—8 (Fig. 1), and 1—9 (Fig. 2). Five plates were exposed on each placement in the respective localities for two hours in each test period to enable a measurable quantity of bacterial colonies.

The bacterial investigation technique was as follows:

Medium. Blood agar plates with 7.5 % human blood. Before use all plates were checked for contamination (Incubation for 24 hours, 37°C, plates with growth were excluded).

Table I

Activity during the day in the policlinic and operating theatre, and exposure times for the sedimentation plates

Exposure times for sedimentation plates	Activity rate Policlinic	Operating theatre	Washing room
0700 am. — 0900 am.	None	None	None
0900 am. — 1100 am.	Full	Full	Full
1100 am. — 0100 pm.	Some	Some	Some
0100 pm. — 0300 pm.	Full	Full	Full
0300 pm. — 0500 pm.	Some	Some	Some

Incubation time. 48 hours, 37°C.

Counting. The number of colonies were counted in groups of five plates. These plates represented the minimum number of organisms (mostly bacteria, seldom fungi) which settled down at each placement during the exposure time. The countings of both series were taken by the same person. No attempt was made to differentiate the colonies grown. These were mainly white staphylococci and micrococci together with some aerobic sporeforming organisms.

RESULTS

The results were statistically analyzed by »two-way analysis of variance» and showed some general trends and some changes related to the reconstruction.

The significance of variance in the bacterial number was defined as follows:

Highly significant	$p<0.001$
Significant	$p<0.01$
Almost significant	$p<0.05$
Not significant	$p>0.05$

Table II shows a summary of the total numbers of bacteria, the air volumes and the concentration of bacteria per m^3 of air and placement in the different rooms before and after reconstruction together with the percentage reduction of these three parametres.

Below, the presentation of further particulars regarding the different rooms are given.

Table II.

Recorded values and percentage reduction of bacterial number, air volume and concentration of bacteria before and after the reconstruction

			Policlinic	Operating theatre
B	Number of bacteria		9289	10828
E	Air volume (m^3)		170.5	87.5
F	Number of sedimentation plates		3	5
O	Concentration			
R	per m^3		54.5	123.8
E	per sedimentation plate		18.16	24.75
A	Number of bacteria		5315	3124
F	Air volume (m^3)		100.5	62.5
T	Number of sedimentation plates		3	5
E	Concentration			
R	per m^3		52.9	49.9
	per sedimentation plate		17.62	10.00
R				
E	Volume		41.0	29.0
D				
U	Bac-	Mean value	50	65
C		Probability	$p<0.001$	$p<p.001$
T	te-	Concentration	3	60
I		Probability	$p>0.05$	$p>0.001$
O	ria			
N				

I. *Operating theatre (Tables III and IV)*

A. *Location of the sedimentation plate versus week-day before and after reconstruction* (Table III). By comparing the values for different locations of the sedimentation plates with those for the week-days, this resulted in an expected variation in the level of air-borne bacteria. A highly significant difference ($p<0.001$) was found between the week-days, before reconstruction, even after excluding the counts for Sundays. Table IIIa shows a clear top in the samples for Friday, which was significantly different from other days ($p<0.01$), showing relatively equal values.

The results after reconstruction showed a remarkable decrease in the number of bacteria, and smaller variations related to week-days; this time with a top for Wednesday. Although Sunday was excluded, the variation was almost significant ($p<0.05$), but the values for Saturday were unexpectedly high, which may explain the significant difference.

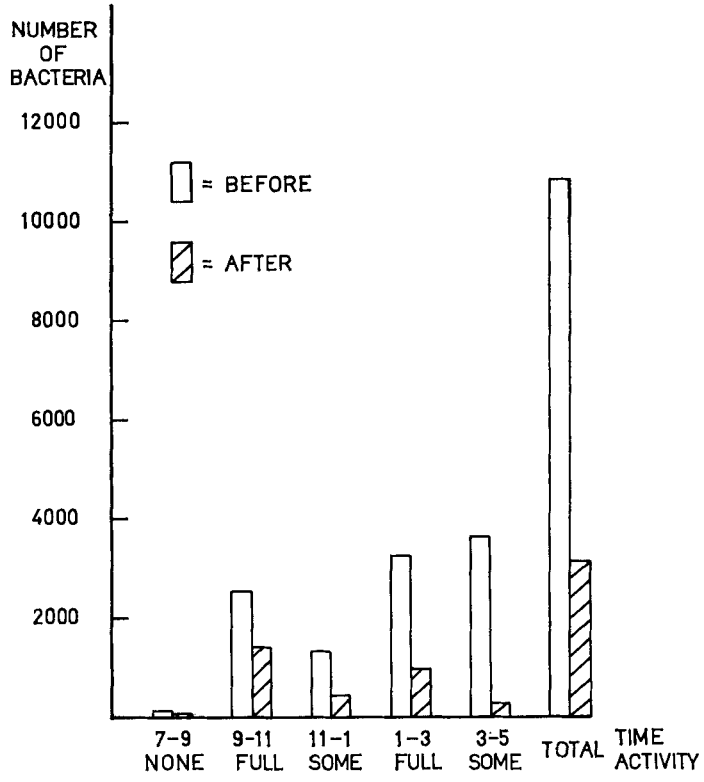

Fig. 3. Total number of bacteria during the day related to time and activity in the operating theatre.

Table III.

The variation in number of bacteria in relation to different days and locations of sedimentation plates in the operating theatre before (B) and after (A) reconstruction

Location	1		2		3		4		5		Total	
Day	B	A	B	A	B	A	B	A	B	A	B	A
Sunday	20	4	10	5	5	5	0	4	5	6	40	24
Monday	432	58	420	100	369	115	333	64	363	87	1917	424
Tuesday	452	73	422	82	353	113	317	47	338	75	1882	390
Wednesday	337	113	305	147	323	224	211	73	279	122	1455	679
Thursday	359	69	373	105	352	124	324	77	305	79	1713	454
Friday	525	88	556	131	500	148	359	76	501	100	2441	543
Saturday	333	122	336	100	251	179	220	87	240	122	1380	610
Total	2458	527	2422	670	2153	908	1764	428	2031	591	10828	3124

Table IV.

The variation in number of bacteria in relation to different days and exposure times in the operating theatre before (B) and after (A) reconstruction

Time	7–9 am.		9–11 am.		11 am.–1 pm.		1–3 pm.		3–5 pm.		Total	
Day	B	A	B	A	B	A	B	A	B	A	B	A
Sunday	15	5	0	3	10	8	5	3	10	5	40	24
Monday	6	3	520	228	304	76	291	104	796	13	1917	424
Tuesday	12	15	493	177	142	37	394	100	841	61	1882	390
Wednesday	9	5	153	382	34	29	453	198	806	65	1455	679
Thursday	9	10	470	211	230	17	368	128	636	88	1713	454
Friday	10	5	674	156	384	133	838	225	535	24	2441	543
Saturday	8	2	235	254	228	133	909	215	—	6	1380	610
Total	69	45	2545	1411	1332	433	3258	973	3624	262	10828	3124

Table V.

The variation in number of bacteria in relation to different days and locations of sedimentation plates in the policlinic before (B) and after (A) reconstruction

Location	6		7		8		Total	
Day	B	A	B	A	B	A	B	A
Sunday	35	4	15	0	20	1	70	5
Monday	596	341	608	609	248	237	1452	1187
Tuesday	744	322	716	198	512	323	1972	843
Wednesday	773	344	677	278	472	161	1922	783
Thursday	576	404	529	339	318	203	1423	946
Friday	545	322	513	369	338	191	1396	882
Saturday	336	282	428	241	290	146	1054	669
Total	3605	2019	3486	2034	2198	1262	9289	5315

Table VI.

The variation in number of bacteria in relation to different days and exposure times in the policlinic before (B) and after (A) reconstruction

Time	7–9 am.		9–11 am.		11 am.–1 pm.		1–3 pm.		3–5 pm.		Total	
Day	B	A	B	A	B	A	B	A	B	A	B	A
Sunday	20	3	5	0	25	1	10	1	10	0	70	5
Monday	30	10	515	293	237	110	452	645	218	129	1452	1187
Tuesday	27	7	800	216	270	69	526	350	349	201	1972	843
Wednesday	26	9	606	378	390	89	682	253	218	54	1922	783
Thursday	43	11	602	381	158	163	423	262	197	129	1423	946
Friday	25	22	560	362	196	77	485	326	119	95	1396	882
Saturday	7	7	549	178	378	219	120	204	—	61	1054	669
Total	158	69	3643	1808	1629	728	2 688	2041	1101	669	9289	5315

Table VII.

The variation in number of bacteria in relation to exposure time and different days, for the washing room after reconstruction

Time / Day	7–9 am.	9–11 am.	11 am.– 1 pm.	1–3 pm.	3–5 pm.	Total
Sunday	11	0	1	0	3	15
Monday	6	118	35	80	17	256
Tuesday	7	136	13	42	47	250
Wednesday	6	138	38	88	20	285
Thursday	11	124	11	133	81	360
Friday	1	94	27	53	13	188
Saturday	2	125	100	55	10	292
Total	44	735	225	451	191	1645

By comparing the variations in collected quantity of bacteria, at the placements, a significant difference ($p<0.01$) was found before reconstruction, with location no. 4 showing the lowest value. After reconstruction, the results also stated a highly significant difference, ($p<0.001$) with no. 5 showing the lowest value. Here it should be noted the extremely high number of bacteria collected at location no. 3 where even the reduction was very low compared to the others.

B. *Exposure-time versus week-day before and after reconstruction* (Table IV). The variations in number of bacteria showed almost significant difference between week-days, ($p<0.05$) before reconstruction, with the highest value on Friday. No significant reduction was found after reconstruction, with the exception of Sunday.

The variance in the number of bacteria related to exposure-times for the sedimentation plates before reconstruction, was found to be of significance ($p<0.01$). The values were in harmony with the activity-level in the operating theatre, with the exception of a remarkably high value between 3—5 p.m.

The difference, after reconstruction, proved a high significance ($p<0.001$) with the values reaching the highest level between 9—11 a.m., and between 1—3 p.m.

II. *Policlinic (Tables V and VI)*

A. *Placement of the sedimentation-plate versus week-day before and after reconstruction* (Table V). The observations reported for in Table V and VI were evaluated in the same way as those representing the operating theatre.

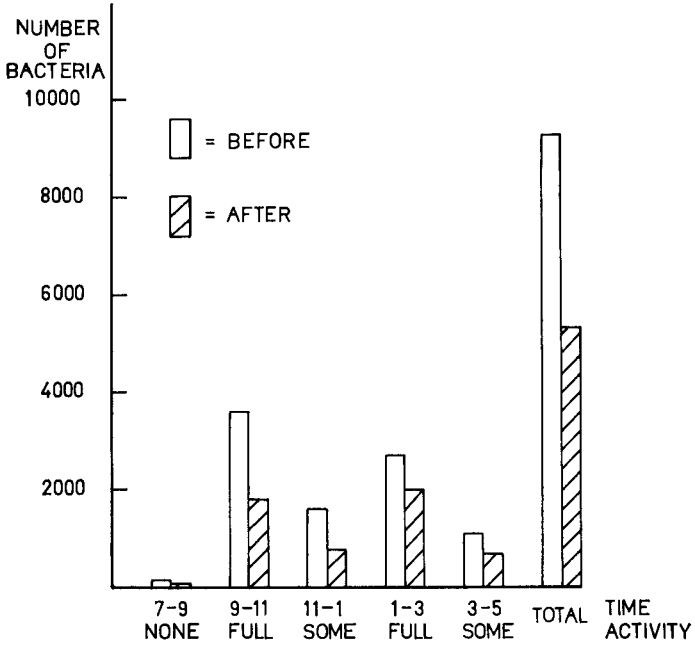

Fig. 4. Total number of bacteria during the day related to time and activity in the policlinic.

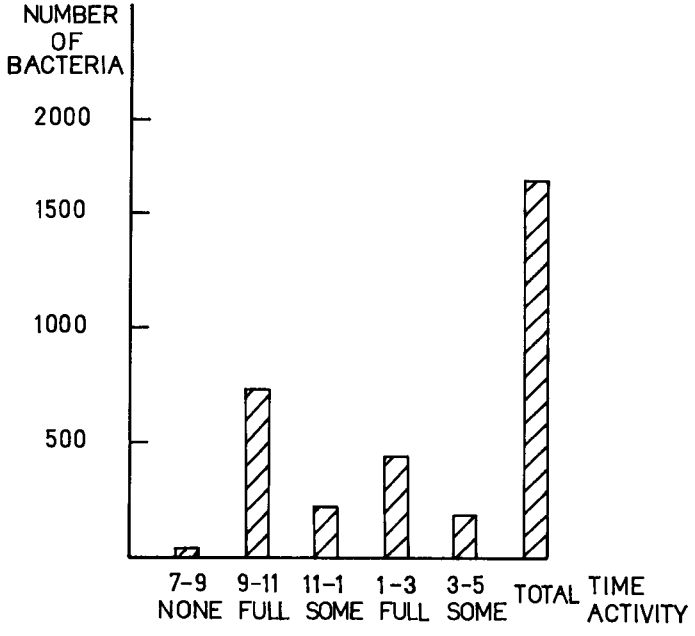

Fig. 5. Total number of bacteria during the day related to time and activity in the washing room.

A highly significant variance was found ($p<0.001$) in the values for the week-days before reconstruction, even when Sunday was excluded. Tuesday and Wednesday differed significantly from the other days.

After reconstruction, no significant differences between the days were found, although the highest values were on Monday and Thursday.

As regards the locations, the value for location no. 8 differed significantly from the two others ($p<0.01$) before reconstruction. After reconstruction, no significant variance could be found, although location no. 8 stated the lowest value.

B. *Exposure-time versus week-day before and after reconstruction* (Table VI). The highest value of bacteria was found on Tuesday and Wednesday before the reconstruction, and on Monday and Thursday after the reconstruction, but none of these values stated a significant variance.

The variation in the number of bacteria collected, at each exposure-time, was highly significant before and after the reconstruction with equal »highs» in the 9—11 a.m. values and the 1—3 p.m. values.

III. *Washing room* (Table VII).

No variance was found in the week-days relating to the numbers of bacteria. A highly significant difference ($p<0.001$), however, was seen between the exposure-times with a maximum between 9—11 a.m. and a minimum between 7—9 a.m.

DISCUSSION

The investigation was limited to a partly quantitative evaluation of the number of air-borne bacteria, concentrating on some elected locations under varying conditions in a department of oral surgery. The method of using sedimentation plates limited the registration of air-borne bacteria to a certain degree, but has been shown to give measurable values (*Wilson & Miles*, 1955).

The results confirmed the findings of earlier investigations, showing the variability of the number of air-borne bacteria under various activities on week-days and times of the day in different locations and places within (Tables III—VII).

As a general trend, the bacterial level was found to follow the rate of activity during the day for the policlinic, operating theatre and the washing-room (Figs. 3, 4, 5). There was, however, an unexpected high value for the time between 3—5 p.m., in the operating theatre, before reconstruction.

This can be explained by the fact that the main cleaning of the room took place every day at the end of this exposure-period. This »activity», however, was not included in the second part of the study.

Regarding the time-periods, this reflected the real rate of activity in each locality (Table I).

The values for the periods where the heaviest rate of working activity and personnel traffic was found seemed to vary significantly (Tables IV, VI, VII), especially for the policlinic and the washing toom. Further, expected significant variation in the bacterial number was noted at different locations, with the exception of the policlinic (Tables III, V). The highest values were found near the main entrance of the rooms and close to the operating field, where drilling instruments were often used. In the operating theatre, location no. 3 indicated the head of the patient, and no. 2 the other end of the operating table, where the main traffic took place in this room. Remarkably high values were found at location no. 5, where the assistent nurse had her equipment containers. The lowest number of bacteria, were sampled in the separated room of the policlinic in both parts of the study.

The main change, related to the reconstruction of the department, was stated in the significant reduction of the total number of sampled bacteria (Table II). The mean value in reduction for the policlinic was 50 %, and for the operating theatre 65 %. The improvements made in the standard of hygiene, has greatly improved the bacteriological conditions within the department. The values measured are, however, to be considered as relative. As mentioned before, the volume of the localities was reduced in the second part of the study with 41 % for the policlinic and 29 % for the operating theatre. This would indicate an even greater improvement if the results of *Waldton* (1960) are taken into consideration. He found a converse proportion between the bacterial content and the volume of the locality.

By expressing the decrease in number of bacteria in this study, as a percentage reduction of the bacterial concentration per m^3 air volume and placement (Table II), the following interesting values were found. The reduction was 60 % ($p<0.001$) in the operating theatre, but only 3 % in the policlinic, which was not significant.

This further confirmed the statement mentioned by *Waldton* (1960), when the percentage reduction in volume of each locality is regarded. These last findings are not comparable with the first presented reduction of 50 % respectively 65 % (mean value). It is also questionable to make the same calculation relevant, knowing the limits of the sampling method used, to give representative values for the real bacterial concentration within a locality.

After reconstruction, however, the lowest number of bacteria was found in the operating theatre contrary to the findings before reconstruction. This was not due only to the minor reduction in volume. The many changes made to improve the bacterial conditions must be mentioned as well. Here the overpressure ventilation, with filtrated air, and the introduction of separate washing room and recovery room played a most important role. Furthermore, this will partly explain the minor bacterial reduction in the policlinic and make a decrease of 50 % (mean value) more realistic.

Some minor changes in results due to the reconstruction are still to be mentioned. The significance in variation of day values for the localities was found to be very low, mostly none, in the second part of the study. This can partly be explained by a general improvement of the bacterial conditions. A change in the days showing the highest number of bacteria was also seen, but this is more the result of an occasional variation in the cases treated.

In the operating theatre, a locality where the bacterial concentration was kept very low, placements of high activity could easily be marked, and this might be a reasonable explanation for the very high significance especially after reconstruction. A contrast was found in the policlinic, where the variation among placements showed no significance. This expressed the poor conditions in a room with a high activity and a small volume.

The results in relation to the washing-room, further proved the general tendency; showing a clear significance in the variation of sampled bacteria at different exposure times. Furthermore, the relative high total number of bacteria; concerning the fact that one location for sampling was used exclusively (Table VII). This emphasized the importance of the principle of separating the operating theatre by introducing various zones of increasing hygienic levels (*Laurell & Olsson*, 1965).

Although this investigation was carried out in a local situation, the results might be of interest when planning and constructing other surgery departments.

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