USE OF ULTRAVIOLET RADIATION IN REDUCTION OF RESPIRATORY CROSS INFECTIONS

IN A CHILDREN'S HOSPITAL: FINAL REPORT

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Following the installation in this hospital of a new operating room equipped with a battery of eight Westinghouse Sterilamps and an air changing system, counts were made of the bacteria in the air of this room. Either of these agents reduced the number of air borne bacteria, and the combination of the two was very effective.[1] This suggested the possibility of using similar means to reduce the number of cross infections in the infant ward.

In order to test the efficacy of various barriers to the spread of air borne bacteria, an experimental room was set up in the laboratory.[2] It consisted of a series of open door cubicles the entrances of which were 4 feet wide and 6 feet 2 inches high. Around the cubicle entrances, General Electric Ultraviolet Germicidal lamps (15 watt, T8) were mounted with baffles in front and behind them so that a narrow curtain of ultraviolet radiation was thrown across the entrances. The number and arrangement of the lamps and the extent of the partitions at the sides of the cubicles were varied until a satisfactory combination was found. Their effectiveness was determined by spraying diluted cultures of Bacillus prodigiosus into the air and taking air samples with a Wells air centrifuge[3] in various parts of the room. An air changing system was also installed and the best positions for the supply and exhaust vents were similarly determined.

Very few organisms passed from one cubicle to another with the following arrangements:

1. Six ultraviolet lamps mounted around the cubicle entrances.
2. Partitions above the entrances extending to the ceiling.
3. Side partitions from floor to ceiling.
4. An air inlet near the floor at the back and an exhaust on the ceiling near the front of each cubicle.

Shorter partitions and fewer lamps were less effective.[4]

RESULTS WITH ULTRAVIOLET RADIATION BARRIERS IN THE INFANT WARD

A room in the infant ward was then remodeled embodying the information obtained in this preliminary study. It provided accommodation for 6 infants under 6 months of age. The floor plan is shown in figure 1. Six ultraviolet lamps were mounted around the outer door which led into the vestibule used by the nurses, 6 more around the inner door which led into the room proper and 6 more around each of the cubicle entrances where there were no doors. The details of the positions of the lamps and reflectors are shown in figure 2. The room was heavily insulated but since there was no cooling apparatus in the system there were great variations in the temperature and humidity. A small basin with foot controlled taps was installed near the front of each cubicle. A cubicle is shown in figure 3.

Before this ward was put into use, experiments were carried out to check the efficiency of the radiation barrier. The Wells test for sanitary ventilation was used, with B. prodigiosus as the test organism, as described in a previous paper.[2] The efficiency of the lamps was found satisfactory when no air changing was used or when the air was changed four, six or nine times an hour. Nine air changes an hour were therefore used.

When the apertures of the boxes in which the ultraviolet lamps were mounted were 3 inches wide, the bactericidal effect was excellent, but the nurses suffered from burning of the skin. The apertures were therefore reduced to 1½ inches. They were still effective but no longer caused burning provided the inside walls of the boxes were painted a dull black. The reflectors behind the lamps were made of aluminum.

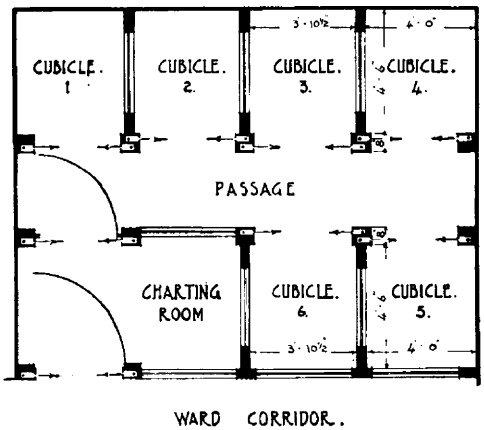

Fig. 1.—Plan of room equipped with ultraviolet lamps. Arrows show direction of ultraviolet rays.

Dr. L. R. Koller of the Research Laboratory, General Electric Company, Schenectady, N. Y., determined the amount of ultraviolet radiation in various parts of the room. At the back of the cubicle where the baby's cot was placed there was so little that it could not be measured. All members of the staff wore untinted glasses when working in this room. No other precautions were necessary for their protection. The nurses were instructed not to hold any infant near the doorway of the cubicle, and no case of burning or conjunctivitis occurred.

Four ultraviolet lamps, two on each side, were mounted in the air duct, which was 14 inches by 14 inches in cross section. This duct carried outside air into the room. The air passed the lamps at a rate of 218 linear feet a minute. To test the bactericidal power of these lamps, diluted broth cultures of B. prodigiosus were sprayed directly into the duct 2 feet ahead of the first lamps. Samples of duct air before and after passing the lamps were then taken simultaneously with two Wells centrifuges. The results obtained in one test are shown in table 1.

Similar results were obtained in five other tests, and it was concluded that the air entering the room through

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1. Robertson, Elizabeth C., and Doyle, M. Elizabeth: On the Control of Air Borne Bacteria in Operating Rooms and Hospital Wards, Ann. Surg. **111**: 491 (March) 1940.
2. Robertson, Elizabeth C.; Doyle, M. Elizabeth; Tisdall, F. F.; Koller, L. R., and Ward, F. S.: Air Contamination and Air Sterilization, Am. J. Dis. Child. **58**: 1023 (Nov.) 1939.
3. Wells, W. F., and Wells, Mildred: Measurement of Sanitary Ventilation, Am. J. Pub. Health **28**: 343 (March) 1938.
4. Much of the apparatus used in this work was either lent or donated by the Canadian General Electric Company or the General Electric Company, and members of the research and engineering staffs of these companies assisted the authors on numerous occasions.

the air conditioning system was practically sterile. Previous Wells samples of outdoor air, taken at the level of the air intake, showed 2 to 3 organisms per cubic foot. No recirculated air was used in this room, but the ultraviolet lamps were mounted in the ducts in case there were some leaks in the system.

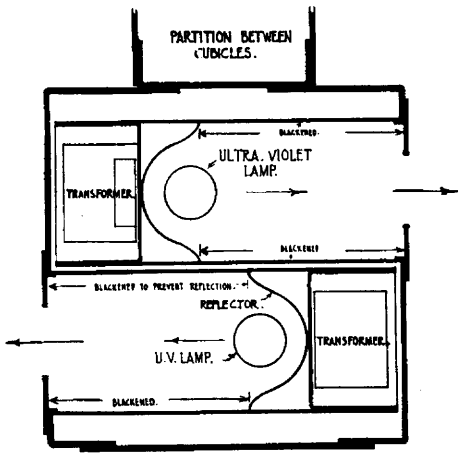

Fig. 2.—Mounting of ultraviolet lamps in posts between cubicles.

To show whether this type of room was effective in practice, we compared the incidence of respiratory cross infections among infants treated in it with that among similar infants in one of our usual unpartitioned rooms of the same size where the 6 cots were spaced around the walls. This room was ventilated by two windows and a transom over the door. This was called the first open control. The same physicians, nurses and maids worked in the two rooms. The nurses did not work elsewhere. After the babies in these two rooms were under observation for about five months, a second of the usual open rooms which accommodated 6 infants was used as another control. This was known as the second open control room. The babies in this room were nursed under the usual ward conditions, which meant frequent changes of nurses.

The admissions were divided between the three rooms, and most of the babies were "clean," that is free from respiratory or other infections, when admitted. If a baby

TABLE 1.—*Bactericidal Effect of Lamps in Air Duct*

	Number of Colonies per Cubic Foot of Air		
	Before Passing Duct Lamps	After Passing Duct Lamps	Percentage Killed
1st samples	14,330	12,460	Lamps off
2d samples *	13,060	351	Lamps on
3d samples	14,700	397	97
4th samples	13,580	368	97
5th samples	12,500	426	97

* The ultraviolet lamps were turned on immediately after the first samples were taken.

came in suffering from a respiratory disease which apparently cleared up, we did not consider the appearance of pyrexia, running ears, running nose, bronchitis or pneumonia within two weeks of the apparent recovery as due to a fresh infection. If the baby was clear of infection for two weeks and then developed an infection (for diagnosis see the criteria mentioned later), this was counted as a fresh infection. Most of the babies were in the rooms for more than two weeks.

For babies who were admitted without signs of infection or were free of these for the preceding two weeks, we used as our criterion for a hospital infection the following points:

1. If the baby developed an infection within the first three days in the hospital it was said to have been acquired before admission. Infections appearing in a "clean" baby after the third day were taken as hospital infections. This is an arbitrary rule, but it appears likely that the incubation period for the common cold is not more than three days.

2. If a baby showed any of the following signs—definite nasal discharge; a swollen, red throat; postnasal drip; discharge from the ears, or signs of bronchial or pulmonary disease—a diagnosis of a respiratory infection was made, even when there was a normal tempera-

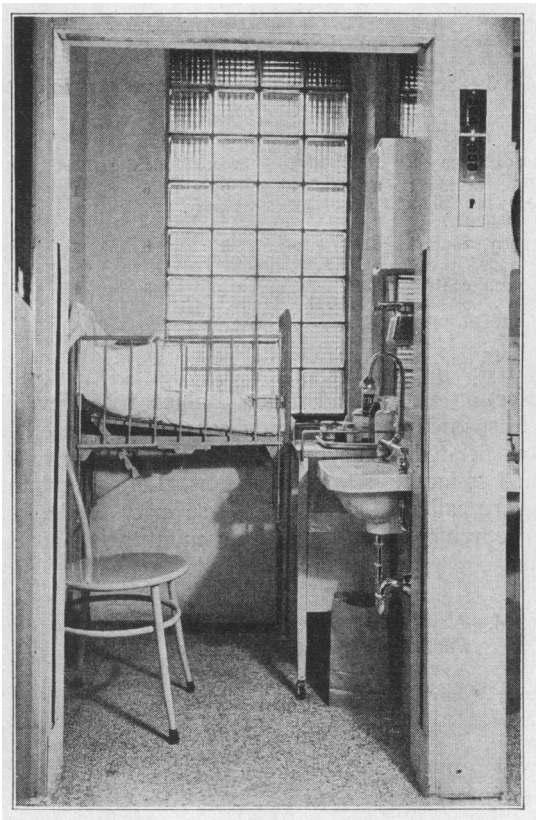

Fig. 3.—Cubicle in ultraviolet equipped room.

ture. The prompt administration of sulfathiazole when symptoms of respiratory infection appeared may have been responsible for keeping the temperature at normal levels.

3. A temperature of 101 F. or higher for one day or 100 F. for two days in succession was taken as indicating a respiratory infection unless some other cause for this fever was discovered.

The following precautions were in force throughout the whole ward: All members of the staff wore masks made of one layer of fine flannelet, and they washed and applied a hand disinfectant (Dettol) which had been tested and found effective before attending a baby. Visitors were not allowed in the rooms and the floors were invariably cleaned by washing (no sweeping).

SERIES 1.—*Comparison of Infections Occurring in Ultraviolet Equipped Room and Open Control Rooms.*—The clinical results of the first nine months are shown in table 2.

These infections were also classified as to their severity. A child who had a temperature of 100 F. for two successive days or of 101 F. for one day, but no signs of respiratory infection, was classified as having pyrexia, provided a thorough physical and laboratory examination failed to reveal any other cause for the fever. If he had signs of nasopharyngitis but no fever, the infection was called mild. Babies who developed bronchitis, pneumonia, running ears or prolonged high fevers associated with symptoms of nasopharyngitis were classified as having severe infections. Less severe infections were called moderate. The severity of the infections occurring in the first nine months is shown in table 3.

TABLE 2.—*Number of Infections in Ultraviolet Equipped and Open Control Rooms*

Type of Room	Date	Number of Babies	Number of Babies Developing Infections	Percentage of Babies Developing Infections
Ultraviolet equipped (complete partitions and air changing)	11/13/39 to 7/29/40	46	8	17
First open control	11/13/39 to 7/29/40	34	17	50
Second open control	3/1/40 to 7/29/40	23	12	52

TABLE 3.—*Severity of Infections in Ultraviolet Equipped and Open Control Rooms*

Type of Room	Date	Severe	Moderate	Mild	Pyrexia
Ultraviolet equipped (complete partitions and air changing)	11/13/39 to 7/29/40	0	5	1	2
First open control	11/13/39 to 7/29/40	3	8	3	3
Second open control	3/1/40 to 7/29/40	2	3	4	3

TABLE 4.—*Number of Infections in Ultraviolet Equipped, Partitioned and Open Control Room (July 29, 1940 to June 20, 1941)*

Type of Room	Number of Babies	Number of Babies Developing Infections	Percentage of Babies Developing Infections
Ultraviolet equipped (complete partitions and air changing)	56	12	21
Partitioned control	63	31	49
Second open control	60	36	60

TABLE 5.—*Severity of Infections in Ultraviolet Equipped, Partitioned and Open Control Rooms (July 29, 1940 to June 20, 1941)*

Type of Room	Severe	Moderate	Mild	Pyrexia
Ultraviolet equipped (complete partitions and air changing)	2	2	3	5
Partitioned control	9	10	9	3
Second open control	9	15	10	2

In this series the infants treated in the open control rooms had three times as many infections as those in the room equipped with ultraviolet lamps, and more of these infections were severe.

SERIES 2.—*Comparison of Infections Occurring in the (1) Ultraviolet Equipped, (2) Partitioned and (3) Open Control Rooms.*—The figures in table 3 show that the babies in the room equipped with ultraviolet lamps had definitely fewer infections than those treated in the open control rooms. Possibly the fewer infections in the room equipped with ultraviolet lamps were due to the partitions which were also present, and, in order to rule this out, partitions running up 8 feet from the flood were put in the control room, thus dividing it into six cubicles. The partitions were not run to the ceiling, which was 10 feet high, because artificial ventilation was not provided. There was only one sink in this room. The nursing personnel was still the same in this room as in the room equipped with ultraviolet lamps. This was called the partitioned control room (fig. 4).

The number of infections occurring in the room equipped with ultraviolet lamps, the partitioned control and the second open control room during the next eleven months are shown in table 4 and the severity of these infections in table 5.

More than twice as many infections occurred among the control babies as among those in the room equipped with ultraviolet lamps. The babies in the partitioned control room developed fewer infections than those in the second open control room. Partitions alone, therefore, seem to play some part in preventing these hospital infections. There were also fewer severe and moderate infections among the babies in the room with the ultraviolet lamps.

TABLE 6.—*Number of Infections* in Completely Partitioned Room with Air Conditioning, Partially Partitioned Room and Open Control Room (June 20, 1941 to April 6, 1942)*

Type of Room	Number of Babies	Number of Babies Developing Infections	Percentage of Babies Developing Infections
Completely partitioned with air-changing system	77	21	26
Partitioned control	71	26	37
Second open control	77	26	34

* During 1941-1942, fewer babies developed infections and hemolytic streptococci and pneumococci were isolated less frequently than during the year 1940-1941.

TABLE 7.—*Severity of Infections in Completely Partitioned Room with Air Conditioning, Partially Partitioned Room and Open Control Room (June 20, 1941 to April 6, 1942)*

Type of Room	Severe	Moderate	Mild	Pyrexia
Completely partitioned with air conditioning	4	7	9	1
Partitioned control	8	10	5	3
Second open control	9	9	6	2

SERIES 3.—*Comparison of Infections Occurring in Rooms with (1) Complete Partitions and Air Changing, (2) Partial Partitions and (3) No Partitions.*—The room equipped with ultraviolet lamps also had complete partitions and an air changing system, both of which the control rooms lacked. In order to determine what part the complete partitions and air changing had in the results obtained, the ultraviolet lamps were turned out and for the next nine months the number of infections occurring (1) in the room with complete partitions and air changing, (2) in the room with partial partitions and (3) in the second open control room were compared. The results are shown in table 6 and the severity of these infections in table 7.

There were slightly fewer infections occurring in the room with the complete partitions and the air changing system than in the partially partitioned and the second open control room. The difference, however, was slight.

The much better infection records of the babies in the room equipped with ultraviolet lamps, completely partitioned and air changed, in the first two series were therefore almost entirely due to the ultraviolet radiation barriers.

EVIDENCE OF TRANSFER OF BACTERIA

1. *Bacteriologic Investigation of Upper Respiratory Tract.*—Cultures of both tonsillar areas and the posterior pharyngeal wall were taken of each infant on admission and at weekly intervals throughout his stay in the hospital. Nasal cultures were also taken if any nasal discharge was present. Frequent cultures (usually daily) were taken of any baby who showed a rise in temperature or signs of infection of the upper respiratory tract. Cultures were also taken whenever possible of any other infected areas. The throats of the staff, interns and nurses were swabbed as a routine once a week and whenever any respiratory infection developed.

The cultures were planted as soon as possible on moist human blood agar plates and incubated in an atmosphere of approximately 10 per cent carbon dioxide at 37.5 C. for eighteen hours.[5] Colonies suspected of being pneumococci or hemolytic streptococci were picked to fresh plates for isolation. The pneumococci were identified by the bile solubility test and typed by agglutination. The hemolytic streptococci which fell into group A (Lancefield[6]) were typed.[7] To determine the group to which the strain belonged a method combining the technics of Fuller[8] and Brown[9] was used. The typing serums[10] were prepared according to the method of Mueller and Klise,[11] and the technic of Neisser[12] was used in the preparation of the antigen for agglutination.

Over a period of twenty-nine months cultures were taken of 674 babies. Sixty-seven strains of group A hemolytic streptococci (all but seven of which were typable) and one hundred and four strains of pneumococci were isolated. Cultures were taken of 291 members of the staff. These yielded seventy-five strains of group A hemolytic streptococci (all but seven of which were typable) and thirty strains of pneumococci. If the same type was recovered more than once from an individual it was counted as only one in the figures given. If a person had two different types of streptococci (always on different days) this was counted as two. In all, 4,356 cultures, the great majority of which were from throats, were taken.

The interns and nurses frequently carried hemolytic streptococci, usually without any symptoms of infection. These organisms were rarely recovered from cultures taken of the staff physicians. The carrier rate reached a peak during the late winter months and fell to practically zero during the summer. The prevalent type of streptococcus differed from time to time. For instance, toward the end of 1940 type 3 was very common and types 12 and 5 were only occasionally encountered. In the next three months type 3 persisted with fair frequency but type 12 became very common. A few weeks later type 5 became very prevalent and type 12 almost disappeared. Both streptococci and pneumococci were carried for months without any apparent ill effects. One intern harbored hemolytic streptococcus type 10 from December 1939 until June 1940, when he left the hospital. Another intern carried pneumococcus type XIX for over a year. This was the most common type of pneumococcus encountered, and this intern may possibly have been the source of infection of 2 infants in the open control room.

Of the two hundred and seventy-six strains of group A hemolytic streptococci and pneumococci which were isolated, only eighteen were passed from baby to baby, from staff to baby or from baby to staff. Therefore according to our technic this is a rare occurrence. One such transfer occurred in the room equipped with ultraviolet lamps, two in the open control room, six in the partitioned control room (partial partitions) and nine in the second open control room. These are shown in table 8.

Fig. 4.—Half of the partitioned control room.

TABLE 8.—*Transfer of Organisms*

Type of Room	Date	From Baby to Baby	From Staff to Baby	From Baby to Staff	Total
Ultraviolet equipped (complete partitions and air changing)	November 1939 to June 1941 (19 mos.)	0	1	0	1
Partitioned control	August 1940 to April 1942 (21 mos.)	3	1	2	6
First open control	November 1939 to August 1940 (9 mos.)	0	2	0	2
Second open control	March 1940 to April 1942 (25 mos.)	6	3	0	9
Complete partitions and air changing	June 1941 to April 1942 (10 mos.)	0	0	0	0
Total		9	7	2	

8. Transfer from baby to baby is the commonest mode of spread, and this appears to occur most frequently in the open control rooms, although the figures are so

5. Auger, W. J.: A New Method of Culturing Sputum on Solid Media Using Carbon Dioxide for the Isolation of Pneumococci, Brit. J. Exper. Path. **20:** 439 (Dec.) 1939.

6. Lancefield, Rebecca C.: A Serological Differentiation of Human and Other Groups of Hemolytic Streptococci, J. Exper. Med. **57:** 571 (April) 1933.

7. Griffith, F.: The Serological Classification of Streptococcus Pyogenes, J. Hyg. **34:** 542 (Dec.) 1934.

8. Fuller, A. T.: The Formamide Method for Extraction of Polysaccharides from Hemolytic Streptococci, Brit. J. Exper. Path. **19:** 130 (April) 1938.

9. Brown, J. H.: A Simplified Method for Grouping Hemolytic Streptococci by the Precipitin Reaction, J. A. M. A. **111:** 310 (July 23) 1938.

10. Drs. Frieda Fraser and Helen Plummer of the Connaught Laboratories, University of Toronto, supplied the type cultures.

11. Mueller, J. H., and Klise, K. S.: A Method for the Agglutination of Hemolytic Streptococci, J. Immunol. **22:** 53 (Jan.) 1932.

12. Neisser, Hedwig: The Serological Typing of Streptococcus Pyogenes and Its Application to Certain Infective Conditions, J. Path. & Bact. **48:** 55 (Jan.) 1939.

small that no definite conclusion is justifiable. Two instances of the transfer of organisms are reported here:

1. Baby F. was admitted to the second open control room on October 7. No pathogenic organisms were found in his cultures until November 13, when a pure culture of type VI pneumococcus was isolated from his nose. The original source of this organism is not known. On November 20, Baby McC., who was in the same room, showed the presence of pneumococcus type VI in his throat culture. Baby McC. had been in this room for six weeks and had never previously shown this organism. On November 26 Baby T., who had been in the same room nearly a month, developed an upper respiratory infection with type VI pneumococcus. Again this organism had not previously been found in his throat. The last two babies were evidently infected from Baby F.

2. Baby G. was admitted on February 4 to the partitioned (partial partitions) control room and carried pneumococcus type XIX in his throat until his discharge on March 16. Baby H., who had been in the same room for three weeks, developed a respiratory infection on February 6 and type XIX pneumococci were cultured from his throat on February 16 and 23 and March 2, which he apparently acquired from Baby G.

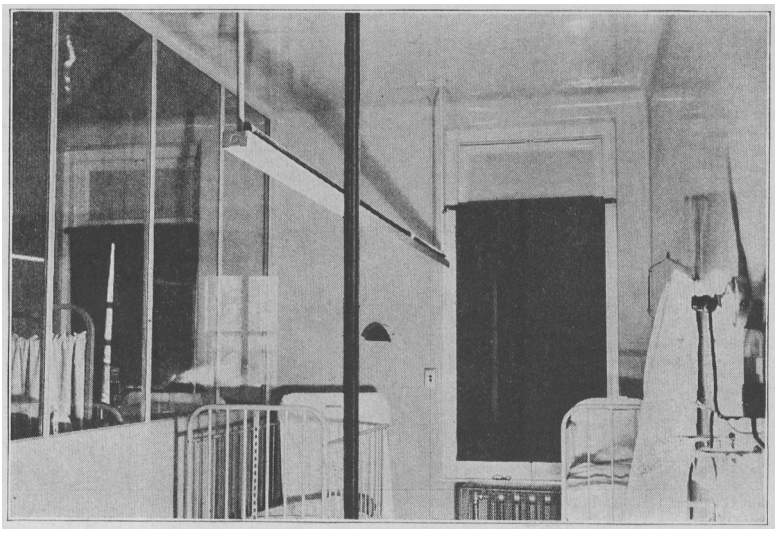

Fig. 5.—Room with ultraviolet irradiation of upper air.

Baby L., after more than five weeks in this room, contracted a type XIX infection on February 21, presumably from Baby G. or Baby H.

In these studies 506 babies have been under observation and 188, or 37 per cent, of these contracted clinical infections. In only 16, or about 10 per cent of these, did we obtain evidence that these infections were due to bacteria. Assuming that the bacteriologic examinations were made sufficiently frequently, one would infer that virus infections were responsible for much of the disease of the upper respiratory tract encountered. Wells [13] and also Andrewes and Glover [14] have studied experimental air borne virus infection in ferrets. Wells [15] and Greene, Barenberg and Greenberg [16] have described epidemics of virus diseases which were apparently air borne and which were controlled by ultraviolet radiation of the air.

2. *Presence of Organisms in the Air.*—Counts were also made on numerous occasions from September 1940 to April 1942 of the number of bacteria in the air of the experimental rooms. Blood agar plates were exposed for varying periods of time simultaneously in all three rooms, and 10 cubic feet samples of air were taken with the Wells air centrifuge. The average counts are shown in tables 9 and 10.

TABLE 9.—*Bacteria in Air (September 1940 to June 1941)*

	Ultraviolet Equipped Room	Partitioned Control Room	Second Open Control Room
Blood agar plates: number of colonies per plate (average)....	109	288	264
Wells centrifuge: number of colonies per 10 cu. ft. (average)	99	121	163

In table 9 it is seen that the plates exposed in the control rooms showed more than twice as many organisms as those exposed in the room equipped with ultraviolet lamps. The Wells centrifuge counts also showed that the air in this room contained fewer organisms.

From table 10 it is evident that there is no significant difference between the air bacterial counts made in the completely partitioned room with air changing, the partially partitioned control room and the open control room.

RESULTS OF ULTRAVIOLET IRRADIATION OF THE UPPER AIR IN ROOMS

Encouraged by the previous results, a simpler method of indirect irradiation was tried out in three smaller rooms (12 by 8 by 10 feet). Three 36 inch 30 watt General Electric Germicidal lamps were hung in an aluminum reflector trough down the center of the room 3 feet, 3 inches from the ceiling (see figure 5). The rays were deflected upward and provided a reservoir of clean air near the ceiling. No direct rays from the lamps reached the patients or the nurses and therefore precautions were not necessary to avoid burning of the skin or eyes. One of these rooms which usually contained four infants' cots or three larger cribs is shown in figure 5. One of these rooms was used exclusively for premature babies and will be discussed later. The other two rooms, with similar control rooms without the ultraviolet lamps, were used for babies up to 2 years of age. In these rooms it was not possible to admit only babies free from respiratory infection. Many were admitted with such infections and discharged within a short time. Unless the infant remained in the hospital for two weeks following his recovery from his respiratory infection he was not included in these records. The doors

TABLE 10.—*Bacteria in Air (June 1941 to April 1942)*

	Completely Partitioned Room with Air Changing	Partially Partitioned Control Room	Second Open Control Room
Blood agar plates: number of colonies per plate (average)....	134	193	116
Wells centrifuge: number of colonies per 10 cu. ft. (average)	58	68	76

13. Wells, W. F., and Henle, W.: Experimental Air Borne Disease: Quantitative Inoculation by Inhalation of Influenza Virus, Proc. Soc. Exper. Biol. & Med. **48**: 298 (Oct.) 1941.

14. Andrewes, C. H., and Glover, R. E.: Spread of Infection from the Respiratory Tract of the Ferret: I. Transmission of Influenza A Virus, Brit. J. Exper. Path. **22**: 91 (April) 1941.

15. Wells, W. F.; Wells, Mildred W., and Wilder, T. S.: The Environmental Control of Epidemic Contagion: I. An Epidemiologic Study of Radiant Disinfection of Air in Day Schools, Am. J. Hyg. **35**: 97 (Jan.) 1942.

16. Greene, David; Barenberg, L. H., and Greenberg, Bernard: Effect of Irradiation of the Air in a Ward on the Incidence of Infections of the Respiratory Tract with a Note on Varicella, Am. J. Dis. Child. **61**:273 (Feb.) 1941.

and windows were frequently left open to improve the ventilation, and therefore the conditions in these rooms varied considerably. The clinical results in these rooms are shown in tables 11 and 12.

It is obvious that the ultraviolet lamps in these rooms did not reduce the spread of cross infection. The custom of leaving the corridor door open, resulting in a rapid movement of air past the ultraviolet lamps, may have been a factor in the unsatisfactory results.

Premature Rooms.—A room used exclusively for 3 or less premature infants was also equipped with three General Electric Germicidal lamps as described. The temperature was kept between 77 and 85 F. and the humidity at about 50 per cent. The doors and windows were always kept closed. A similar room without the lamps was used as a control. The same nurses worked in the two rooms. The number of infections occurring in these two rooms is shown in table 13.

TABLE 11.—*Number of Infections in Rooms with Indirect Irradiation and Control Rooms (March 1941 to March 1942)*

Type of Room	Number of Babies	Number of Babies Developing Infections	Percentage of Babies Developing Infections
Ultraviolet equipped with indirect radiation	58	22	38
Control	64	22	34

TABLE 12.—*Severity of Infections in Rooms with Indirect Irradiation and Control Rooms (March 1941 to March 1942)*

Type of Room	Severe	Moderate	Mild	Pyrexia
Ultraviolet equipped with indirect irradiation	6	11	2	3
Control	5	9	6	2

TABLE 13.—*Number of Infections Among Premature Babies in Rooms with Indirect Irradiation and Control Rooms (March 1941 to March 1942)*

Type of Room	Number of Babies	Number of Babies Developing Infections	Percentage of Babies Developing Infections
Ultraviolet equipped with indirect irradiation	28	8	29
Control	24	12	50

The premature babies in the control room had nearly twice as many infections as those in the room equipped with ultraviolet lamps. Unfortunately a small number of babies were admitted to these cubicles during the year owing to their long stay in the hospital. While the numbers are not large enough to draw definite conclusions, this method of irradiation reduced considerably the spread of cross infections among the premature infants.

Routine throat cultures of the children in these three rooms and their controls were made from April 12 to June 26, 1941. No bacteriologic evidence of the spread of pathogenic organisms from one to another was encountered. However, in February 1942, in a special investigation undertaken when 2 of 3 premature infants in the control room developed severe respiratory infections on the same day, throat cultures were taken of these infants and the staff attending them. Cultures from both sick babies showed hemolytic streptococcus type 3, and pneumococcus type VI was isolated from 1 of them as well. An intern attending these babies showed a heavy growth of hemolytic streptococcus type 3 in her throat culture at this time, and it may be presumed that the 2 infants acquired their streptococcic infection from her. A nurse who had come on duty in the room when the infants were showing the first signs of the infection had a slight sore throat when cultures were taken five days later, and at this time many colonies of pneumococci type VI were isolated from her. The nurse may have been responsible for the pneumococcus type VI isolated from the infant or, conversely, she may have acquired it from him. The patient infected with only hemolytic streptococcus type 3 died.

TABLE 14.—*Severity of Infections Among Premature Babies in Rooms with Indirect Irradiation and Control Rooms (March 1941 to March 1942)*

Type of Room	Severe	Moderate	Mild
Ultraviolet equipped with indirect irradiation	0	4	4
Control	4	4	4

BACTERIA IN THE AIR IN ROOMS WITH IRRADIATION OF THE UPPER AIR AND CONTROL ROOMS

The air in the irradiated rooms used for older infants contained as many bacteria as the air of the corresponding control rooms. In the rooms used for the premature infants the results are shown in table 15.

It is evident that the premature infants in the control rooms were exposed to three to four times as many air borne organisms as those in the irradiated rooms.

CONCLUSIONS

1. Infants treated in open six bed rooms or in a room with 8 foot partitions between the infants developed two to three times as many respiratory infections as babies in a room divided into cubicles with partitions running to the ceiling, a curtain of ultraviolet radiation across their entrances and an air changing system.

2. When the ultraviolet lamps were turned off and the progress of the babies in this room, which had complete partitions and an air changing system, was compared with that of other babies in the room with partial partitions, it was found that those in the latter room had only slightly more infections.

3. The curtains of ultraviolet radiation between the babies were therefore the major factors in the decided reduction of respiratory cross infections described in conclusion 1.

TABLE 15.—*Bacteria in Air in Rooms with Indirect Irradiation and Control Rooms (Premature Infants)*

	Indirect Ultraviolet Irradiation	Control Room
Blood agar plates: number of colonies per plate (average)	46	197
Wells centrifuge: number of colonies per 10 cu. ft. (average)	22	63

4. Two hundred and seventy-six strains of group A hemolytic streptococci and pneumococci were recovered from the staff and the babies. In only 18 instances was the transfer of these organisms from patient to patient, from staff to patient or vice versa demonstrated.

5. Infants treated in rooms in which the upper air was irradiated showed approximately the same number of infections as babies treated in rooms similar but with-

out ultraviolet irradiation. The doors and windows in these rooms were frequently left open.

6. Premature infants treated in the regular premature room had nearly twice as many respiratory infections as similar infants in a room in which the upper air was irradiated. The doors and windows were kept closed in these rooms.

7. During the last two and one-half years the progress of 682 babies has been followed. Two hundred and fifty-eight, or 38 per cent, have developed respiratory infections, many of which were mild.

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VITAMIN B_1 THERAPY IN DIABETIC NEURITIS

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In a previous article [1] an attempt was made to determine the relationship, if any, between states of vitamin B_1 deficiency and diabetic neuritis. For this purpose a quantitative study of the vitamin B_1 content of the diet of patients with diabetic neuritis was made and found to be quite adequate, as judged by the Cowgill formula. The evidence, clinical and pathologic, in favor of a vascular etiology in diabetic neuritis was mentioned, but the possibility that avitaminosis nevertheless played a role in producing the neuritic syndrome was not ruled out, since defective absorption or utilization of the ingested vitamin had still to be considered. Further evaluation of these factors, it was stated at that time, was not feasible until tests for the metabolism of vitamin B_1 had been elaborated. Since then such a test has been introduced, and the results it has yielded will be discussed here.

The present study represents an attempt to tackle the problem of the relationship between avitaminosis and diabetic neuritis from a different angle, by observing the effects of vitamin B_1 therapy on the neurologic picture. Eleven cases were included at the outset, but in 4 of these cooperation was not sufficiently satisfactory to allow of regular and prolonged follow-up. A neurologic examination was made in each of the other 7 cases before therapy was instituted, then 10 to 15 mg. of thiamine hydrochloride was given daily, and examinations were made again at intervals of a month. The average period of observation extended for five and a half months. The salient features of these cases are now presented:

REPORT OF CASES

CASE 1.—A. L., a man aged 69, who entered the Mount Sinai Hospital on Jan. 28, 1941, had been found to have diabetes mellitus five years previously, and it had been controlled by dieting. In October 1940 he began to complain of weakness and numbness of the hands. Shortly thereafter progressive weakness of the legs and paresthesias in the feet set in. During the period from Oct. 3 to Nov. 12, 1941 he received, according to his private physician, 28 cc. of thiamine hydrochloride, half intravenously and half intramuscularly, each cubic centimeter equal to 0.0333 Gm.; eight injections of concentrated liver extract; four injections of 1 cc. of a vitamin B preparation, each cubic centimeter equal to 0.006 Gm. of thiamine hydrochloride, 0.050 Gm. of nicotinamide, 0.0001 Gm. of riboflavin and 0.0001 Gm. of vitamin B_6. Orally the patient received six tablets of yeast concentrate daily.

The physical examination disclosed cardiac enlargement and a systolic murmur at the apex of the heart. There was moderate sclerosis of the blood vessels. The blood pressure was 148 mm. of mercury systolic and 88 diastolic.

Neurologic examination showed a shuffling gait and a positive Romberg sign; there was slight ataxia in all limbs; motor power was impaired in the upper and lower limbs; the arms and forearms showed some atrophy; the biceps, radial and ulnar reflexes and the patellar and ankle jerks were absent; the abdominal and premasteric reflexes were absent; there were fibrillations in the muscles of the calf; pain, touch and temperature sensation were diminished over the lower limbs, the hands and forearms; vibration was diminished in the upper and lower limbs, and position sense was impaired in the fingers and toes. The muscles were tender to pressure.

The blood sugar was 230 mg. per hundred cubic centimeters. The blood count and blood Wassermann reaction were negative. Free hydrochloric acid was present in the gastric analysis. The cerebrospinal fluid showed a 4 plus Pandy reaction and a total protein of 192 mg. per hundred cubic centimeters; the dynamics were normal. Roentgen examination disclosed calcification in both posterior tibial arteries.

A tolerance test for vitamin B_1 was carried out but proved unsatisfactory owing to the fact that the patient had been receiving massive doses of the vitamin.

The condition was considered one of diabetic neuritis with some evidence of involvement of the spinal cord in addition.

On a diet of 100 Gm. of carbohydrate, 80 Gm. of protein and 80 Gm. of fat the urine was free of dextrose.

He was given five tablets of yeast every four hours and 30 mg. of thiamine hydrochloride intramuscularly every day. A week after this regimen there was diminution in tenderness of the muscles, but no other change in the neurologic status. He continued to receive thiamine hydrochloride 30 mg. a day orally after leaving the hospital. Neurologic examination at monthly intervals for a period of eight months disclosed no significant alteration in the findings. Weakness was more apparent and paresthesias persisted.

CASE 2.—B. M., a woman aged 54, was observed in the diabetic clinic of the hospital in 1935, when diabetes mellitus was detected. Since that time the diabetes had been controlled by dietary regulation plus 10 or 20 units of insulin daily. She was admitted to the hospital in July 1938, at which time she showed moderate sclerosis of the blood vessels and a blood pressure of 110 systolic and 74 diastolic. The neurologic examination disclosed a somewhat broad based gait; there was some ataxia in the left lower limb; the right ankle jerk was feeble, the left ankle jerk, the hamstring reflexes and the reflexes in the upper limbs were not elicited; there was a glove and stocking distribution of hypalgesia; vibratory sense was absent at the knees and the left iliac crest, diminished at the feet and in the hands; position sense was impaired at the toes. She was considered to have diabetic neuritis.

When observed in the hospital in May 1939 her blood pressure was 180 systolic and 110 diastolic and she presented evidence of hypertensive and arteriosclerotic heart disease, as well as diabetes mellitus and diabetic neuritis.

A tolerance test for vitamin B_1 performed some time later yielded figures slightly below normal.

A neurologic examination in June 1941 disclosed the following positive findings: The deep reflexes in the upper limbs were absent; the ankle jerks were absent, even with reenforcement; there was bilateral calf tenderness; pain, touch and temperature sensation were diminished below the middle of the legs; vibration sense was diminished at the feet and knees and absent at the iliac crests. Subjectively the patient complained of pains in the legs and a sensation of heaviness in the feet and hands. She was placed on the usual amounts of thiamine hydrochloride.

Periodic examination up to December 1941 showed no essential changes in the objective neurologic findings. The patient stated that she felt stronger generally and that the paresthesias were less troublesome. Tenderness of the calves persisted and was well defined.

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1. Needles, William: Vitamin Studies in Cases of Diabetic Neuritis, Arch. Neurol. & Psychiat. **41**: 1222 (June) 1939.