Bacteriological Effect of Ultraviolet Light on a Surgical Instrument Table

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THE INCIDENCE of surgical wound infections in hospitals is reported to have risen appreciably in the 1950's. Investigations aimed at determining the cause for this increase have revealed a number of potential causative factors.

Reports of studies of airborne bacteria and air currents in operating rooms have been useful to those interested in the control of postoperative infections. Reduction of the number of airborne bacteria in the surgical suite has been emphasized. Published reports (*1–5*) indicate that the number of bacteria in the air can be reduced by limiting the number of persons in the operating room, minimizing the movement of persons and equipment, changing face masks frequently, changing air repeatedly through effective filters, and cleaning rooms and equipment thoroughly.

The extent to which these measures can be effected is somewhat limited. Since it is inevitable that a significant number of bacteria will be present in the environment and there are limitations to efforts to reduce this number, it seems timely to direct attention toward reducing the number that are carried into the wound from the environment.

The reserve instrument table therefore assumes a particular importance. Most of the sterile instruments and supplies used during surgery and introduced into the wound throughout the operation are kept on this table. If the reserve instrument table can be kept free from contamination by airborne bacteria throughout the operation, the number of organisms carried into the wound by instruments and other supplies will be reduced.

A means was sought by which this could be accomplished effectively, economically, and without encumbrance to the instrument nurse and other members of the operating team. Ultraviolet germicidal lights were considered.

Published reports by men who pioneered in the field of ultraviolet irradiation as a method of decontamination in hospitals were reviewed (*6*). The conclusion by Hart and associates was that ultraviolet irradiation is the most effective available method of sterilizing the air and should be used to protect the wound and sterile supplies until some other equally efficient and more desirable method is discovered. The improvement in postoperative results with the introduction of ultraviolet irradiation in the operating rooms at Duke University Hospital was reported by Hart and Upchurch. The work done at that hospital over a period of 23 years relating to the use of ultraviolet lights in the operating room resulted in the recommendation that bactericidal ultraviolet irradiation be used continuously as an addition to aseptic operating room technique (*7*).

Evidence in the studies reviewed indicates that ultraviolet germicidal lights are effective in reducing the number of airborne bacteria in the operating room. However, irradiation has an adverse effect on members of the operating team, and the additional clothing, hoods, and eye shields or glasses required for protection of personnel are cumbersome and costly.

It was envisioned that the lights might be

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strategically located so that irradiation is confined to the equipment introduced into the wound. This idea seemed sound; the real concern is not the number of bacteria in the room but the number that are introduced into the wound, since a concentration of bacteria in the wound can constitute a real hazard.

Bacteriological effectiveness, practicability, safety, and economy were considered necessary criteria for the means used to put this new concept into practice.

Problem and Purpose

The problem was to develop and test a unit, composed of a mechanical appliance attached to a reserve instrument table, that would reduce contamination of equipment and supplies introduced into the wound, confine irradiation, and not impede the operating team.

The broad objective was to aid in reducing postoperative infection of clean surgical wounds. The specific aim was to provide a means for maintaining the sterility of instruments and other equipment and supplies introduced into the wound throughout the operation.

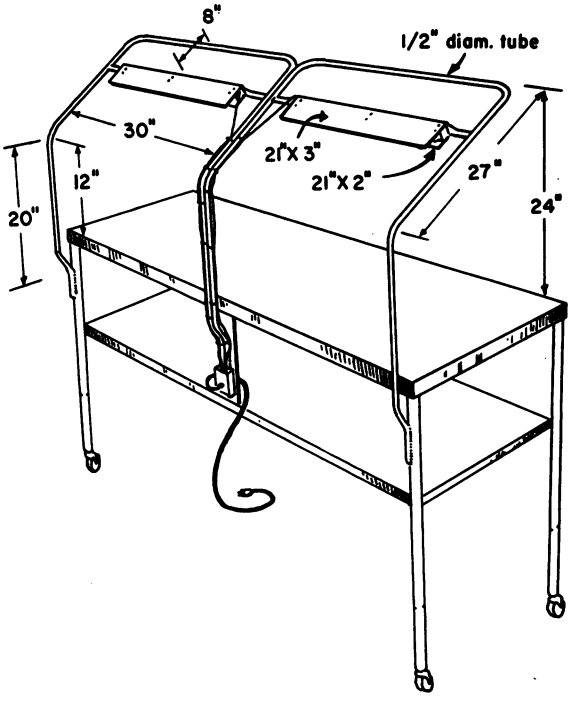
Design of Table and Drape

A stainless steel reserve instrument table, 60 inches by 24 inches by 40 inches, used routinely for major operations in the institution where this investigation was carried out, was modified by attaching an upright frame equipped with ultraviolet germicidal lights. The frame of two sections was constructed of stainless steel tubing one-half inch in diameter. It was attached to the horizontal axis of the table, 10 inches below the table top to facilitate draping.

A fixture for installation of one 15-watt ultraviolet germicidal lamp is incorporated in the center of each section. The greatest distance from the lights to the table top at any given point is 2 feet. At this distance irradiation with sufficiently intense ultraviolet, 2,537 Ångstrom units, is lethal to most micro-organisms (*8,9*). A metal shield is attached above and below each lamp to confine irradiation to the table (fig. 1).

Fabrication of a satisfactory drape for the frame was the next step. The drape was so

Figure 1. Instrument table fitted with ultraviolet lights



designed that it would completely cover the frame on the exterior and inferior surfaces except for the opening necessary to expose the ultraviolet lamps, be applicable by one nurse with no threat to sterility, permit immediate access to contents of the table and confine irradiation.

Four fitted muslin drapes were made for the frame. One tube, 31 inches by 42 inches, open on both ends, was used to drape the lower part of each section of the frame. The top part of each section was covered by a 31-inch by 10-inch tube open on one end. A muslin sheet, 108 inches by 72 inches, was placed over the entire frame so that it extended down 6 inches in front to provide necessary shielding. The tent-like arrangement was completed and the irradiation further confined by placing a 36-inch by 42-inch muslin sheet on either side. The front of the table was left open (fig. 2).

Tests of Ultraviolet Intensities

Tests were made to determine whether the intensity of the ultraviolet radiation escaping from the draped table was safe for operating-

room personnel. The routine apparel of the members of the operating team restricts exposure of the skin to the region of the eyes and the back of the neck. Thus, ultraviolet intensities at eye level were considered the most significant. Intensities at eye level were measured during an operation in which the table was used (fig. 3).

Because the instrument nurse occupies the area in which the ultraviolet intensities are the highest, it was necessary to determine the average amount of exposure she was receiving at eye level. Recordings over a 4-hour period showed that the instrument nurse faced the table 103 times for an average of 3 seconds each time, receiving an average exposure of 1.3 minutes per hour to an intensity of 3.0 to 6.0 microwatts per square centimeter. Maximum exposure of the instrument nurse for an average operation would be 5.2 minutes. Exposure to an intensity of 3.0 to 6.0 microwatts per square centimeter for 5.6 minutes could not be considered significant in view of the recommended standards (*10*).

Bacteriological Testing and Usability

When construction of the frame, fabrication of a satisfactory drape, and measurement of ultraviolet intensities outside the canopy were completed, tests for bacteriological effects and usability were conducted. For the purpose of brevity the table will be referred to as the canopy table. This table was used for nonselective major operations in order to provide information which would not be restricted to one particular type of operation, one physical area, or a constant number of people. It was used for open and closed heart surgery, radical and simple cancer surgery, and general surgery, including infectious cases. It was placed in four different operating rooms. The number of

Figure 2. Draped instrument table with detail of tubular drape

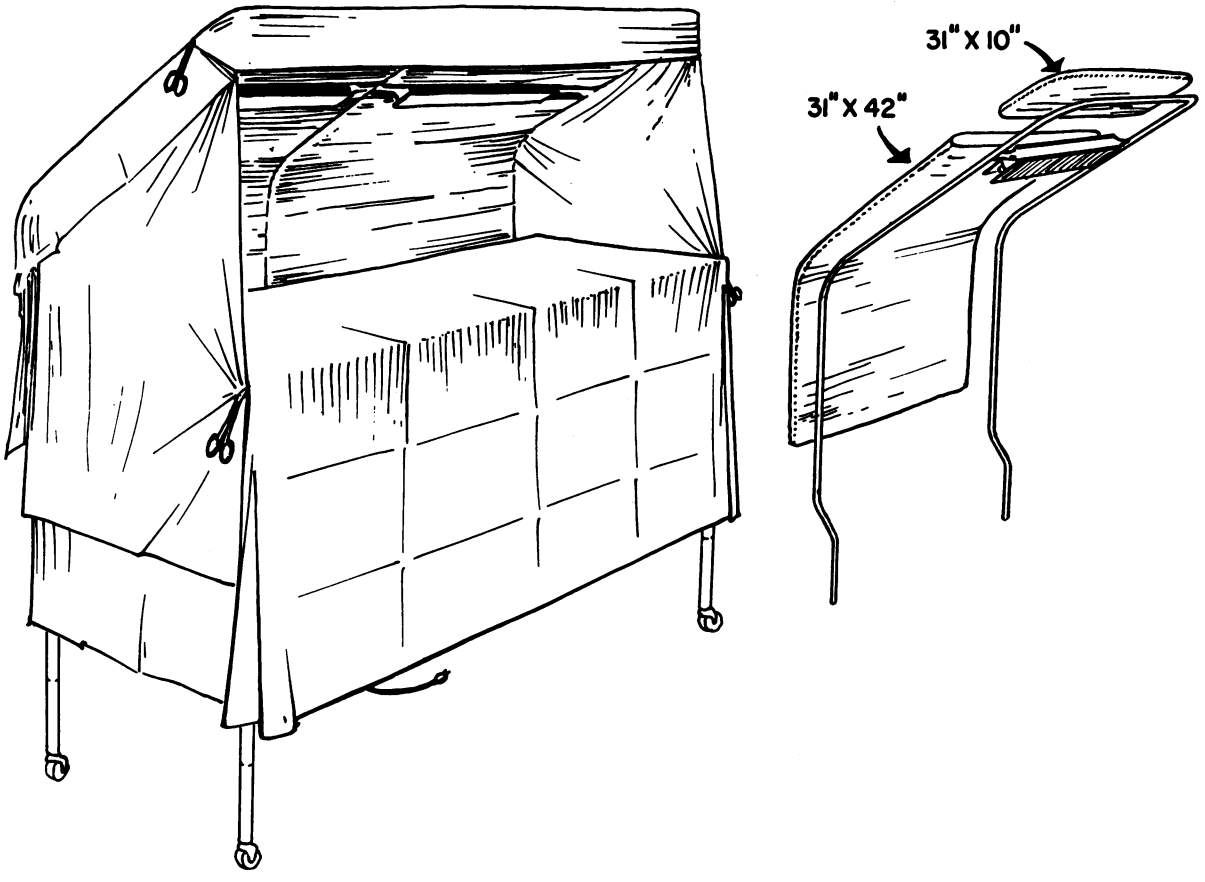
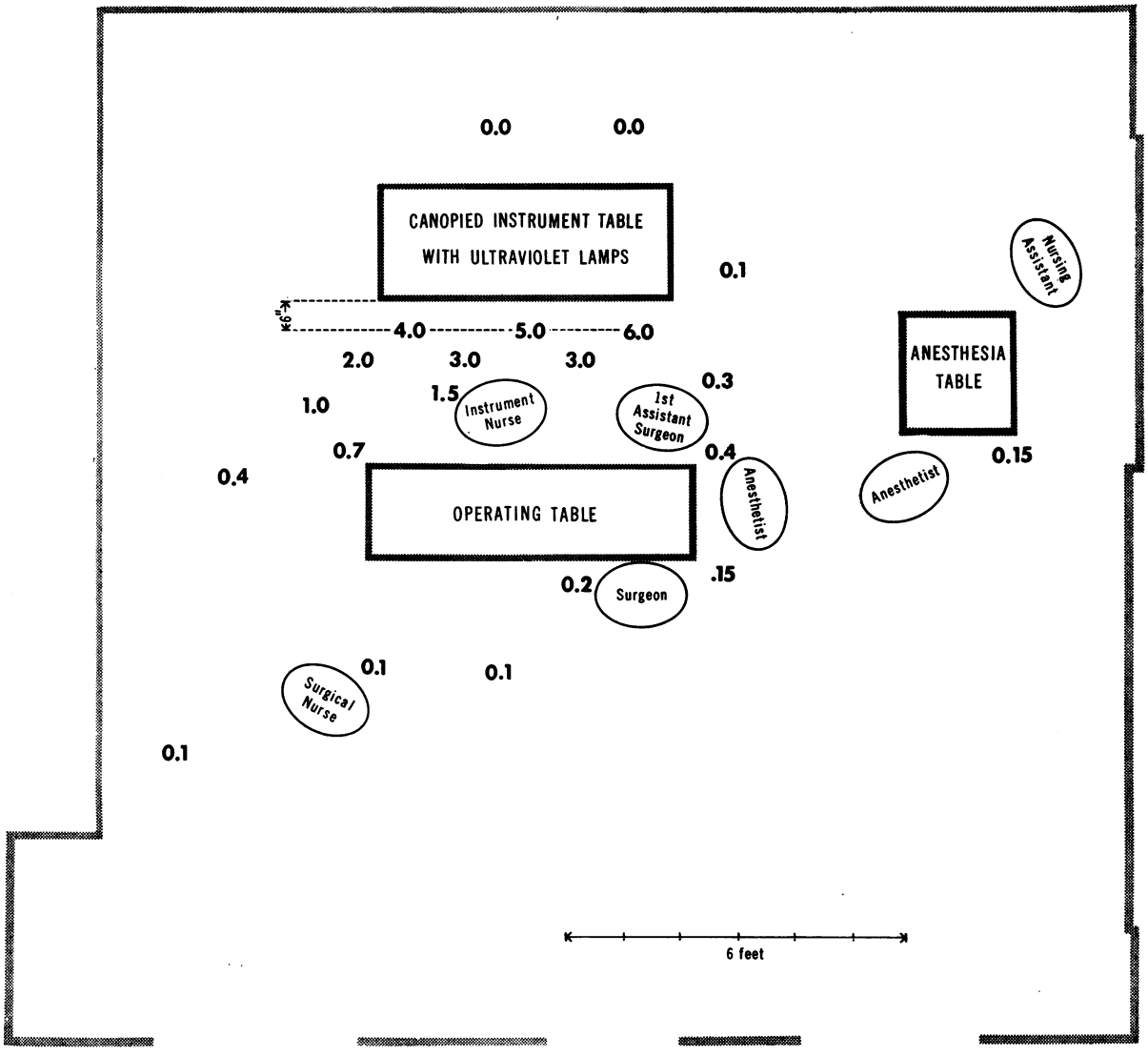


Figure 3. Ultraviolet intensities at eye level in microwatts per cm² during an operation



NOTE: Variations in the general pattern of decreasing intensities of ultraviolet light at increasing distances from the table are caused by reflections of light from the canopy and instruments and the position of the meter.

persons in the operating room ranged from 5 to 20.

Nurses were assigned in the usual manner to keep deviation from normal routine at a minimum and to provide different viewpoints on the usability of the canopy table.

The same general method for the bacteriological testing was used in two series of tests. The first series included 10 operations using the canopy table with the ultraviolet lights off; the second series consisted of 30 operations using the canopy table with the ultraviolet lights on.

Petri dishes, 9.8 square inches in surface area, containing approximately 10 cc. of culture medium were used to determine the fallout of bacteria. The medium used was trypticase soy agar, a general purpose solid medium which supports growth of a wide variety of microorganisms (*11*).

After the sterile equipment was set up and prior to starting the operation, the instrument nurse was given sterile petri dishes. One or two petri dishes, depending on the series, were placed at random on the canopy table and on an

open sterile tray on either side of the canopy table and at the same height. Insofar as possible the tray was subjected to the same environmental conditions as the table with the exception of exposure to ultraviolet irradiation. Lids were removed from the dishes simultaneously and placed inside down beside the respective medium at the time the incision was made. The lids were replaced simultaneously when the wound was closed.

The exposure time ranged from 1 to 8 hours, depending on the length of the operation. The plates were incubated immediately following exposure, at a temperature of 37° C. for 48 hours. Following the incubation period, colony counts were done by two nurses independently of each other and recorded on a master sheet. It was found that the average difference between the counts made by the two nurses was less than one colony per plate. Therefore, the readings by only one nurse are given in the presentation and interpretation of data.

The general procedure was followed in both series of tests.

In the first series, in which the ultraviolet lights were off, one petri dish was placed on the canopy table and one on the open tray. Upon completion of the operation each plate was identified as to the date, exposure time, and location.

The second series included the following additional steps:

1. Immediately before setting up the sterile equipment the ultraviolet lights on the canopy table were wiped with 70 percent alcohol to remove any film which might have accumulated.
2. Five petri dishes containing medium were distributed. Two dishes were placed at random on the canopy table, two at random on the sterile tray. The remaining one, a control plate, was put on the unsterile utility table, and its cover was not removed, so that possible contamination when pouring the medium could be determined.
3. The ultraviolet lights were activated when the incision was made.
4. The petri dishes were marked with the code number, exposure period, date, and the name of the scrub nurse.

The practicability of the canopy table was investigated at the same time the table was being tested for the bacteriological effects. The time required to drape the table was observed and recorded, and the utility of the canopy table was discussed periodically with each nurse who participated in the tests.

Results

Data collected during the bacteriological testing of the canopy table without activation of the ultraviolet lamps are given in table 1. There is no evidence that the canopy table without ultraviolet irradiation reduced the number of colonies. The colony counts on plates in operations 1 and 5 show higher colony counts on the table than on the open tray. Results indicate that a canopy without ultraviolet irradiation is not effective in reducing the contamination of sterile equipment and supplies on the reserve instrument table by airborne bacteria.

Data collected during 30 operations using the canopy table with ultraviolet irradiation are recorded in table 2. All plates on the open tray showed growth with the exception of plate A in operation 15 which gave a negative result in an exposure period of 1 hour. Colony counts ranged from 1 to 121. No relationship could be shown between the number of colonies and the length of exposure.

Of the 30 pairs of plates used for testing the canopy table with irradiation, 26 were negative for growth on both plates. Three pairs of

Table 1. Colony counts from plates on open tray and canopy table without ultraviolet irradiation

Operation No.	Hours of exposure	Number of colonies per plate	
		Open tray	Canopy table
1	3	24	48
2	7	50	43
3	3	18	12
4	3	9	7
5	3	4	9
6	2½	11	10
7	2½	7	4
8	5	61	59
9	5	49	40
10	4	31	30
Total		264	262

Table 2. Colony counts from plates on open tray, canopy table with ultraviolet irradiation, and utility table

Operation No.	Hours of exposure	Number of colonies per plate				
		Open tray		Canopy table		Utility table
		A	B	A	B	
1	3½	60	51	0	0	0
2	2¼	16	20	0	0	0
3	¾	6	11	0	0	0
4	2	52	65	1	0	2
5	6	57	82	0	0	0
6	2½	18	17	0	0	0
7	4	23	29	0	0	0
8	4¼	71	59	0	0	0
9	3¼	20	30	0	0	0
10	2½	25	15	1	0	0
11	4	55	46	0	0	0
12	2¾	66	51	1	1	0
13	3	14	6	0	0	0
14	3½	6	8	0	0	0
15	1	0	1	0	0	0
16	5	23	21	0	0	0
17	3	16	14	0	0	0
18	1¾	33	37	0	0	0
19	8	107	121	0	0	0
20	2	7	16	0	0	0
21	2½	23	25	0	0	0
22	4	17	19	0	0	0
23	1	14	13	0	0	0
24	2	4	6	0	2	0
25	2	15	17	0	0	0
26	2½	8	14	0	0	0
27	1¾	8	11	0	0	0
28	2½	8	12	0	0	0
29	2	9	7	0	0	0
30	2½	27	16	0	0	0
Total		808	840	3	3	2

plates showed growth on one plate; one pair showed growth on both plates. The exposure time of the five plates ranged from 2 to 2¾ hours. In operation 4, where one plate on the canopy table showed growth, the control plate also showed growth. Therefore, it is possible to speculate that the contamination on this plate may have been introduced in the preparation of the plates.

Since plates on the canopy table showed growth in 4 of the 30 consecutive operations, the claim of complete bactericidal action is not tenable. However, it is obvious that there was a very marked bactericidal effect.

Practicability

The practicability of the table was determined from the recorded time required to drape the table and a summary of the comments of the 10 instrument nurses who used the table. Initially, the 10 nurses required from 6 to 10 minutes to drape the table. Repeated draping of the table reduced this time to an average of 3 minutes for each nurse.

Conversation with the four nurses who used the table most frequently revealed their reactions to the introduction of a new device and procedure. At first, all nurses were reluctant to use the table. They expressed a feeling of lack of freedom, attributable to the change from a completely exposed surface area to an exposure in the front only. They considered the initial time required for draping the table undesirable. Some stated that it was difficult to see when arranging instruments and preparing sutures under the canopy table before the lights were turned on.

After they had used the table three or more times, the nurses indicated that the initial problems were solved. To overcome the seeing difficulty, the spotlight was focused on the table while setting up. In a final discussion all nurses expressed a feeling of security in regard to the sterility of instruments, supplies, and equipment when using the canopy table with irradiation.

Summary and Conclusions

A canopy table with ultraviolet irradiation as a means for maintaining the sterility of instruments and materials introduced into the wound throughout a surgical operation has been designed and evaluated.

Alteration of the reserve instrument table used routinely in the operating room to the canopy table is simple and inexpensive. The drape for the table is easily made and one nurse can arrange it to provide complete sterile coverage.

Irradiation is confined to the table to the degree that it is not necessary for any member of the operating team to have protective clothing, shields, or glasses.

Results of the bacteriological tests show that the canopy table with ultraviolet irradiation produces a significant bactericidal effect. The canopy alone is not an effective means for reducing contamination of equipment and sup-

plies on the reserve instrument table by airborne organisms.

Information supplied by the nurses who used the table and periodic observations indicate that the canopy table is practical.

This study serves to emphasize the concept that it may be timely to direct attention to confining irradiation to equipment and materials introduced into the wound rather than to irradiate the entire room. Further studies related to this concept may be profitable.

REFERENCES

(1) Walters, C.: The aseptic treatment of wounds. New York, Macmillan Co., 1948.

(2) Blowers, R.: Wound infections in operations theatres. Bristol, England, Wright & Sons, Ltd., 1958.

(3) Decker, H., Hoffman, R., and Wedum, A.: Air sampling and other control techniques in study of hospital staphylococcal infections. Am. J. Pub. Health 49: 947–948 (1959).

(4) Adams, R., et al.: Control of infections within hospitals, special reference to prevention within operating rooms. J.A.M.A. 169: 1557–1567 (1959).

(5) Wolf, H., Harris, M., and Dyer, W.: *Staphylococcus aureus* in air of an operating room. J.A.M.A. 169: 1983–1987 (1959).

(6) Committee on the Study of the Use of Ultraviolet Rays as a Sterilization Agent in Hospitals: Ultraviolet rays as a sterilization agent in hospitals. Bull. No. 203. Chicago, American Hospital Association, 1940.

(7) Hart, D.: Bactericidal ultraviolet radiation in the operating room. J.A.M.A. 172: 1019–1028 (1960).

(8) Frobisher, M.: Fundamentals of microbiology. Philadelphia, W. B. Saunders & Co., 1957.

(9) A.M.A. Council on Physical Therapy: Acceptance of ultraviolet lamps for disinfecting purposes. J.A.M.A. 122: 503–504 (1943).

(10) U.S. Public Health Service: Short courses for industrial hygiene engineers and chemists. PHS Pub. No. 614. Washington, D.C., U.S. Government Printing Office, 1958.

(11) Baltimore Biological Laboratory, Inc.: Products for the microbiological laboratory. Ed. 4. Baltimore, 1956.

Training in Epidemiology for Nurses

Four 2-week courses in principles of epidemiology for nurses held during the summer of 1960 were so well received that the Public Health Service plans to continue its support of such workshops.

The courses were held at Catholic University in Washington, D.C., St. Anselm's College, Manchester, N.H., Texas Woman's University, Denton, and Incarnate Word College, San Antonio, Tex. Registered nurse participants meeting the requirements set by the colleges and universities received 2 hours credit toward either the bachelor's or master's degrees.

Subjects covered included basic principles of epidemiology and of statistics, the role of the laboratory in epidemiology, epidemiology of specific chronic and communicable diseases, and other related topics. Participants had an opportunity to apply theory learned to simulated field situations in group problem-solving sessions. Pertinent audiovisual aids and literature handouts were also utilized.

Faculty included staff from the schools of nursing, State health departments, and the Public Health Service. Special Public Health Service consultants included Dr. Leonard Schuman, professor of epidemiology, University of Minnesota School of Public Health, and Dr. Kirk Mosley, associate dean in charge of special training, research program, University of Oklahoma. A total of 167 nurses representing hospital nursing, public health nursing, and nursing education attended the workshops.

Schools accredited by the National League for Nursing, Inc., and interested in conducting programs of this kind are invited to make inquiries to the Chief, Communicable Disease Center, Attention: Chief, Training Branch, Atlanta, Ga.

Secretary of Health, Education, and Welfare

Abraham Ribicoff, Secretary of Health, Education, and Welfare, was the first Cabinet appointment by President John F. Kennedy.

As Governor of Connecticut, Ribicoff administered a budget in his last term which devoted a third of its funds to education and two-fifths to health and welfare. Under his leadership the State experienced the following gains in these programs:

- Consolidation of formerly independent agencies dealing with public health and medical treatment programs into one State department of health, with resulting improvement in the care and treatment of the mentally retarded, the chronically ill, and the disabled.
- An increase from $27,900,000 in the 1953–55 biennium to $45,200,000 in 1959–61 in expenditures for mental health, and bond authorization of more than $20 million for capital construction at mental institutions.
- Modernization of the public welfare program by elimination of county care of neglected children in favor of a State-directed child care program, enactment of a comprehensive adoption law, an improved foster home placement program, and an easing of the financial burden on relatives of institution patients.
- Creation of a State Commission on Services for Elderly Persons.
- Adoption of legislation prohibiting discrimination in employment because of age.
- Adoption of a $6 million program of construction of low-cost housing designed for the aged.
- Adoption of one of the Nation's most comprehensive medical care programs for the aged.
- Strict regulation of convalescent homes.
- Strengthening of the vocational rehabilitation program for handicapped persons.
- An increase in State aid to towns for education.
- An increase for higher education capital construction.
- Establishment of a minimum salary for teachers in State institutions.
- Adoption of a statewide teacher tenure law.

Ribicoff had been in office less than a year when Connecticut was hit by two of the worst natural disasters in its history. In 100 of Connecticut's 169 towns there was flood damage running into many millions of dollars. The Governor rallied recovery forces and encouraged urban redevelopment of flood-stricken communities with supporting legislation.

The year 1955 also saw 324 people lose their lives in traffic accidents. Despite misgivings by those who feared a tough policy would be political suicide, the Governor stuck to his plan to deprive every convicted speeder of his license for 30 days. Now the State has the Nation's lowest death rate for miles traveled. When the National Governors' Conference created a Highway Safety Committee in 1956, Ribicoff was unanimous choice for chairman.

Other accomplishments included:

- Abolition of county government, labeled by Ribicoff an anachronistic holdover from horse and buggy days.
- Enactment of a half-billion dollar highway construction program, taking full advantage of authorized Federal grants.
- Consolidation of State government structure, eliminating 46 separate and independent agencies.
- Enactment of an anti-erosion program to protect and improve beaches.

In 1955, he won the Governorship after a campaign which he devoted to describing his plans for the State. He won a second term in 1958.

Born in New Britain, Conn., April 9, 1910, he began working for a living while he was in grade school. Graduated from high school at the age of 16, he worked for a Connecticut manufacturer, attended New York University for a year, and then, while he continued working as a salesman, prepared to study law at the University of Chicago, where he was a member of the Law Review. He was graduated cum laude in 1933 and began practice in Hartford, home of Ruth Siegel, his wife since 1931. Elected to the legislature in 1938 and 1940, Ribicoff was appointed judge of the Hartford Police Court and headed a commission to study the relation of alcoholism and crime. In 1947, Ribicoff was appointed by Governor James L. McConaughy as a hearing examiner for the State Interracial Commission, now the Civil Rights Commission. He was a member of Congress in 1948 and 1950.