

6-1967

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Bruce W. Steinhauer

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### Recommended Citation

Steinhauer, Bruce W.; Cox, Frank; Stobie, George H. C.; and Quinn, Edward L. (1967) "A Method of Hospital Infection Surveillance Incorporating the Use of the Computer," *Henry Ford Hospital Medical Journal* : Vol. 15 : No. 2 , 139-147.  
Available at: <https://scholarlycommons.henryford.com/hfhmedjournal/vol15/iss2/9>

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## **A Method of Hospital Infection Surveillance Incorporating the Use of the Computer**

**Bruce W. Steinhauer, M.D.**

**Frank Cox, M.D.**

**George H. C. Stobie, M.D.**

**Edward L. Quinn, M.D.**

*The records of all patients in the hospital on a particular date were studied for hospital-acquired infections. Results were compared with a continuing surveillance based on discharge reporting. Collection of data was programmed for analysis by using the hospital computer. Thirteen per cent of the patients manifested an infection after admission, but before or on the survey day. Results elsewhere are similar. Areas of the hospital with a relatively higher incidence of infection did not have clusters of particular pathogens.*

Bacterial infection occurring during hospitalization continues to be a significant clinical and epidemiologic problem. Various efforts have been made to quantitate and characterize this problem. A program of surveillance instituted in 1960 at Henry Ford Hospital involves a discharge reporting system to be completed by the physician for each patient. Linked to a highly efficient Medical Records department, this system has made possible a continuous survey of changes in the ecology of hospital infection. Based on these data, it is observed that the incidence of resistant staphylococcal infection has not decreased during this interval (in spite of the increased use of penicillinase penicillins), and that infections due to "enteric" organisms have become an increasing problem. This observation correlates with studies at other medical centers. (2,3,4).

A report in 1964 from the Boston City Hospital (5) describing a survey performed during a single week at that institution suggested that the validity of the Ford Hospital statistics could be checked by a spot survey using a few observers. The results of this study constitute the remainder of this report.

### **Materials and Methods**

The records of all patients in the Henry Ford Hospital (with the exception of the tuberculosis ward) on January 26, 1966, were reviewed. Three of the authors (B.W.S., F.C., E.L.Q.) studied these records for evidence of a hospital-acquired infec-

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tion. This was defined as a clinically active infection evidenced by purulent exudate or body fluid, abscess or cellulitis that was not present or recognized until after admission to the hospital. Such infections were separated into those that were present between the patient's date of admission on or before January 26, 1966 and those that occurred during the remainder of the hospitalization. In a second group, hospital-acquired infection was considered probable on the basis of evidence available at the time of the record review, but unequivocal supporting evidence was not present. In addition, information was obtained on all patients regarding antibiotic usage on the survey day and during the remainder of the admission.

The collection of data was programmed for analysis under the direction of Dr. Stobie, utilizing an IBM 360 System, Model 30 computer.

There is some variation in the total number of patients or organisms in the various tables for each aspect studied because in a few cases tabular data was not sufficient for programming.

*Results:* Of the 1051 patients on whom the data sheets were complete, 76% acquired no hospital infection, and 13% had a definite infection which became manifest after admission, before or on the survey date. Another 4% of the patients had probable infections and 7% developed infection after the survey date. (See Table I).

Table I

Hospital Infections	No. of Patients	Percentage
None	653	76
Definite	104	13
Probable	38	4
After survey date	57	7

In an effort to ascertain whether the patient who had an infection at admission was more likely to manifest a second infection during his hospitalization, these groups are compared in Table II. No significant difference was demonstrated between the group with infection at admission and the one without.

Table II

	Infection Absent on Admission		Infection Present on Admission	
	No.	Percentage	No.	Percentage
Total Group	673	79.0	179	21.0
Hospital Infection				
None	519	77.1	134	74.8
On Survey—Definite	79	11.7	25	13.9
—Probable	30	4.5	8	4.4
After Survey Date	45	6.0	12	6.7
Total Hospital Infections	154	22.8	45	25.0

Table III

	No. of Patients	Hospital Infection*	
		No.	Percentage
Males	432	105	24
Females	443	114	25

\*Hospital Infection in Tables 3 through 7 refers to all infections, definite and probable, manifested after admission to the hospital.

Further efforts to localize susceptible groups included comparisons of sex (Table III) and age (Table IV). Sex did not appear to affect susceptibility to infection. Age, in general, had little influence although the group of patients between ages 10 and 19 appeared to be relatively "immune" and three of four patients over age 90 had a hospital infection. A patient's status as "medical" or "surgical" appeared to have some influence on infection rate, that for the surgical patients being somewhat higher (Table V). The incidence of multiple acquired infections as seen in Table VI was only slightly influenced by whether the patient was medical or surgical.

Table IV

Age	No. of Patients	Hospital Infections	
		No.	Percentage
0-9	82	10	17
10-19	29	2	7
20-29	49	10	20
30-39	66	19	29
40-49	135	25	26
50-59	196	55	23
60-69	182	58	32
70-79	101	32	32
80-89	26	6	23
90-94	4	3	75
Total	870	220	25

Table V

	No. of Patients	Hospital Infections	
		No.	Percentage
Medical	481	96	20.0
Surgical	404	123	30.4

Table VI

	No. of Patients	Hospital Infections No. per Patient		
		Single	Two	Three
Medical	481	86	8	2
Surgical	404	107	14	2
Total		193	22	4



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The various sites of infection with percentages are listed in Table VII. The urinary tract was by far the commonest location, followed by wound infections.

Table VII

Type of Hospital Infection	No. of Patients	Percentage of all Patients
Urinary Tract Infection	86	9.6
Wound Infection (Clean Cases)	46	5.0
Wound Infection (Contaminated)	20	2.2
Postoperative Pneumonia	35	3.9
Bacterial Pneumonia	20	2.2
Nonspecific Respiratory Infection	13	1.4
Enteritis	1	0.1
Other	27	3.0

The various organisms are tabulated in Table VIII. "Coliforms" refer to lactose fermenting gram negative bacilli which were not typical *E. Coli* and in which detailed biochemical procedures were not carried out for purposes of identification. As can be seen, the *Enterobacteriaceae* accounted for 47% of the whole group, and gram negative organisms accounted for 52% of the isolated pathogens. Staphylococci accounted for 20% of the isolated organisms.

Table VIII

	No. of Organisms	Percentage of Infecting Cultured Strains
Staphylococci, Resistant*	23	14
Staphylococci, Sensitive*	9	6
Streptococci (beta hemolytic)	5	3
Pneumococci	3	2
Enterococci	20	12
<i>E. coli</i>	31	19
<i>Klebsiella-Enterobacter</i>	17	10
Coliform	14	9
Proteus species	15	9
<i>Pseudomonas aeruginosa</i>	8	5
<i>Candida albicans</i>	6	4
Other	12	7
Total	163	100%

\*Refers to susceptibility to penicillin G by disk method.

No clearly discernible pattern was seen in comparing the responsible services with the type of organism cultured. Of the 23 penicillin-resistant staphylococci, nine occurred on medical patients and 11 on surgical patients. Of the sensitive staphylococci, only one occurred on a medical patient; the remaining eight occurred in surgical patients. Enterococci had a different distribution with six of the 20 occurring on the gynecology service, eight on medical services and five on surgical services.

Table IX

Antibiotic Drug Usage During Hospitalization	No. of Patients	Percentage
Received antibiotics on day of survey	260	28.8
Received antibiotics while in hospital	454	50.3

*E. Coli* and coliforms were widely and generally distributed among the services with no discernible pattern. This was likewise the case with regard to the *Klebsiella* group. None of the typical *E. coli*, two of the 20 coliforms, and one of the 18 *Klebsiella* were isolated from urology service patients.

Certain floor units had relatively high incidence of apparent hospital infections. The highest figures (40-45%) were found on three floor units: One was an intensive care ward dealing primarily with seriously ill surgical patients. One was a floor unit with a high concentration of gynecology patients, and one had a high concentration of general surgery patients on whom unusually complex procedures had been carried out.

Of the five floor units with figures of 30 to 40% incidence, three were general medical, one was orthopedic and one was a general surgical floor. None of these floor units has a pure population of patients from any one service.

The organisms isolated on the "high incidence" floor units were found in approximately the same proportions as the organisms in the study as a whole. The ratio of gram negatives to staphylococci on the three highest incidence floor units was 9:4; for the entire study it was 85:32. Among the gram negatives, no one of them was found in disproportionate numbers on the high incidence wards.

As might be expected, the service caring for the patient had some influence on the site of infection. Thus, about 50% of the hospital infections on medical patients were of the urinary tract, whereas the corresponding figure for surgical patients was 35%. Yet the percentage of medical and surgical patients having a urinary tract infection was about the same. Wound infections occurred with only slightly greater frequency than urinary tract infections among general surgery patients.

Source of culture was compared with organism isolated but the numbers were too small for extensive comparisons. Of the wound infections occurring in clean operative wounds, 10 out of 45 isolates (22%) were resistant staphylococci and 18 (40%) were gram negative bacteria. Of the 17 isolates from contaminated or potentially contaminated wounds, two (12%) were resistant staphylococci, and eight (40%) were gram negative bacilli. Of the 108 isolates from the urinary tract, resistant staphylococci accounted for five (5%), enterococci for 15 (14%), *E coli* 30 (27%), *Klebsiella-aerobacter* 16 (14%), *Proteus* species 11 (10%), *Pseudomonas aeruginosa* 3 (3%). The total number of gram negative bacteria was 60 (54%). In some cases, cultures were not obtained.

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Table X

Number of Antibiotics Used During Hospitalization	No. of Patients	Percentage
None	454	49.7
1	205	22.7
2	129	14.3
3	78	8.6
4	14	1.5
5	2	0.2
6	3	0.3
Total	885	100.0

The isolates from the respiratory infections showed no discernible pattern. Only three out of 17 isolates from post-operative pneumonias were resistant staphylococci, six were gram negatives and three were *Candida albicans*.

Antibiotic usage on this group of patients is defined in Tables IX, X, and XI. On the survey day, almost 30% of these patients were receiving antimicrobial therapy. During the entire hospitalization 50.3% were being so treated.

There was some relationship between the services rendering care and the antibiotics used, e.g., the general medical services tended to use somewhat more of the antibiotic chloromycetin than the surgical services (for entire hospital stay: 16% vs. 10.6%).

## DISCUSSION:

A somewhat higher rate of hospital infection (approximately 25%) is suggested in the spot check study covered in this paper. Under the continuing surveillance system, the rate was approximately 3%. The difference could have a variety of explanations. The resident who indexes the record of the patient is often the last of a series of house officers caring for a patient over a protracted period. He is generally too limited in time to make a detailed record scrutiny such as was possible in this study.

Table XI

Antibiotic Drug Usage During Hospitalization	No. of Patients	Percentage
Penicillin	191	21.1
Penicillinase Resistant Penicillin	36	4.0
Cephalothin	17	2.0
Chloromycetin	70	2.7
Sulfa	135	15.0
Streptomycin	28	8.6
Tetracycline	100	11.1
Erythromycin	44	4.9
Kanamycin	17	2.0
Other	85	9.4



This study was not designed to define this discrepancy in reporting but similar differences have been noted by others. (6)

At first sight, the current study also reveals somewhat higher infection rate than that found in the Boston City Hospital study which inspired the current effort. Because of methodological differences, the figure which should be compared with the City Hospital study is that which was found for definite infections on or before the survey day. This was 13%, remarkably close to the Boston City Hospital figure of 13.5%.

The use of the computer in tabulating the data was of inestimable value in the more detailed comparisons, such as relating the ward or service to the organisms isolated.

The method of this study would tend to pick up a somewhat higher infection rate in patients with the most carefully documented observations. This may partly account for the higher incidence figures on intensive care and certain surgical units.

The figures comparing medical and surgical patients differ markedly from those at Boston City Hospital. At the City Hospital the surgical patients had nearly three times as many infections as the medical patients; the Ford Hospital medical and surgical patients were more nearly equal. The Ford Hospital figures showed more urinary tract infections than wound infections which may partly account for the difference. In addition, at the Ford Hospital, surgical patients are more dispersed among medical patients geographically and are in smaller units. This could possibly serve to the relative advantage of the Ford Hospital surgical patient.

The role of the staphylococcus in the current study is less than that in the 1964 Boston study. Furthermore, the increasing role of gram negative bacteria is suggested by this study. It is possible, however, that if an effort to quantitate the severity of the acquired infection were made, this would tend to bring out a relatively more important role of staphylococci than is suggested by the overall figures.

There were few clear cut concentrations of particular organisms on particular services, the exception being the enterococcus on the gynecology service. Work elsewhere (7) has shown that organisms such as *Klebsiella* may concentrate on particular services, such as urology. Although the numbers in this spot survey are small, there was no evidence that this was occurring presently at the Henry Ford Hospital.

The floor units with "high infection incidence" did not appear to harbor any concentrations of particular strains of bacteria. This might tend to suggest that the hospital infection phenomenon being observed does not represent an "epidemic" in the usual sense of the word. The risk of acquiring a hospital infection may be more directly related to the type of case rather than the service or geographical location of the patient. Cross infection would not appear to entirely account for the phenomenon observed. Concentrations of unusual numbers of high risk patients on several units may explain this observation.



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More gram negative bacteria were isolated from respiratory sources, including pneumonias, than had been expected. This might provide further support for the work of Tillotson and Lerner (8) suggesting the existence of pneumonias from relatively unexpected organisms. Definition of the specific etiology of the pneumonia in such cases is difficult.

Approximately 40% of the patients at the Henry Ford Hospital either had an infection on admission or acquired one after admission, or both. Antibiotic usage was somewhat higher at 50.3%. Part of this difference may represent routine use of antibiotics in certain types of cases or "prophylactic" antibiotics. No data on the possible merits or disadvantages of these practices is presented.

The fact that patients who entered the hospital with an infection had no higher incidence of acquired infection than patients who were admitted apparently uninfected leads to several different lines of speculation. It is likely that those patients who entered the hospital with an infection received antibiotics earlier in their hospital course. If so, this did not appear to have a favorable or unfavorable effect on their chances of acquiring a second infection. The results would also tend to suggest that the already infected patient is as resistant to hospital infections as the uninfected patient.

The method of survey in this report had the advantage of using a few observers with consistent criteria. Its disadvantage over a continuous survey was that, with the various subgroups, numbers were too small for valid comparisons. A continuous survey using the methodology in this study would require considerable effort and expense because of the man-power demands it would make. The intensive spot survey does appear to put the results of long term surveillance into perspective.

### Summary:

A method of surveillance of infections occurred during hospitalization at the Henry Ford Hospital is described and compared with the current method of discharge case reporting. It was found that, although the proportions of etiologic agents were similar, a considerably higher total number of cases were found by the detailed record scrutiny of all patients at this hospital on a single day.

Thirteen percent of the patients who were hospitalized January 26, 1966 manifested an infection after admission before or on the survey day. This is very similar to the results of a survey performed at another institution of comparable size in 1964. An additional 4% of patients had infections considered probable and 7% developed infection after the survey date.

Areas of the hospital with a relatively higher incidence of infection did not have clusters of particular pathogens. The implications of this finding are discussed. Gram negative bacilli numerically exceeded staphylococci as a cause of hospital infection.

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