# Infections and Use of Antimicrobials in an 800-Bed Hospital

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A DEQUATE surveillance of hospital associated infections and the use of antimicrobial drugs is difficult. The Public Health Service Hospital in Staten Island, N.Y., has used a surveillance system that depended on review of bacterial culture reports. When pathogens were noted in a report, a questionnaire was sent to the attending physician to determine if there was clinical evidence of the patient's infection. The hospital's infections committee believed that gross underreporting occurred with this review system of surveillance. Survelliance of antimicrobial use had not been attempted.

Brachman has stated that as many as 40 percent of hospital associated infections are not cultured (1). In an effort to ascertain the frequency of hospital associated infections and the extent that antimicrobials were being used at the hospital, this study was carried out. The term "hospital associated infections" used in this paper refers both to infections with onset in the community and infections with onset in the hospital.

During the 1-month period of study, 52 percent of our hospital patients were U.S. seamen, 11 percent uniformed services' dependents, 7 percent U.S. Coast Guard, 6 percent Federal

Dr. Edwards, formerly a medical resident at the Public Health Service Hospital, Staten Island, N.Y., is now a fellow in infectious diseases at Presbyterian-St. Luke's Hospital, University of Illinois College of Medicine, Chicago. employees, and the remaining 24 percent were other patients eligible for care at Public Health Service hospitals. Only 15.3 percent of the study population was female. The 1,465 patients discharged had an average stay of 11.8 days.

#### Methods

The charts of all inpatients were reviewed during the week before February 1, 1968. Infection reports were filled out on all patients with infections receiving therapeutic antimicrobials and all patients receiving prophylactic antimicrobials who were still hospitalized on February 1. During February all wards were visited five times per week. The medication index was reviewed to ascertain which patients were receiving antimicrobials. The charts of these patients were then reviewed to determine which ones had clinical evidence of an infection. Charts of discharged patients also were reviewed to complete data on patients on prophylactic antimicrobials and patients on therapeutic antimicrobials with infections and to find patients with infections who did not receive antimicrobials. A final review of all charts of inpatients was performed in late February. From this review, prevalence data were obtained for all patients still hospitalized on February 29. An infection report was filled out on all patients in the tuberculosis ward and the surgical isolation ward. These patients were included in both prevalence and incidence studies.

Infections were designated as hospital onset if they became clinically evident 72 hours or longer after the patient's admission, if the infection was related to a hospital procedure performed within 72 hours of admission, or if the infection was related to a previous hospitalization at the hospital. All other infections were designated as community onset.

Urinary tract infections were defined by a colony count greater than 100,000 colonies per cubic centimeter. Two patients were included who had lesser counts, but for these patients, the same organism was isolated on two consecutive cultures. All diagnoses of pneumonia were confirmed by chest X-ray. The diagnosis of bronchitis required a recent increase in sputum production, and all these patients were treated with antimicrobials.

#### Results

During the 29-day incidence study, hospital associated infections were recorded for 24.2 percent of the 1,465 patients. In the 1-day prevalence study, 30.7 percent of 569 patients hospitalized on February 29 had hospital associated infections.

	Patients with infections		
Study and place of onset	Number	Percent	
29-day study	. 355	24. 2	
Community	. 241	16.4	
Hospital	. 92	6. 3	
Both	. 22	1.5	
1-day study	. 175	30. 7	
Community	. 114	20. 0	
Hospital	. 48	8.4	
Both	. 13	2.3	

Based on data obtained from the incidence study, morbidity, as reflected in length of hospital stay, was determined for selected categories of patients (table 1). The most common infection with community onset was tuberculosis (table 2). Data on these 75 patients were evaluated for bacteriologically proved cases and antituberculosis therapy.

	Ward				
Patient's status	Tuber- culosis	Medical	Surgical		
Positive culture Negative culture On antituberculosis	35 6	11 14	8 1		
therapy	40	14	8		
Not on antituber- culosis therapy	1	11	1		

All 21 patients with negative cultures had chest X-rays which were suggestive of tuberculosis. Since the study was carried out in 29 days and cultures for *Mycobacterium tuberculosis* require 3 to 8 weeks for growth, it is likely that further followup of these 21 patients would have yielded more positive cultures.

Thirty-two patients with surgical wounds had infections with onset in the hospital. Cultures were made in 30 instances and yielded 37 different isolates. Twenty isolates were gram positive (11 of these were staphylococci, coagulase positive) and 17 were gram negative (no predominant organism).

There were 17 patients with 22 episodes of venereal disease and 27 patients with 33 gastrointestinal infections. The infections in each of these groups were distributed as follows:

Infection	Number
Venereal :	
Treponema pallidum	7
Neisseria gonorrhoeae	7
Haemop'hilus ducreyi	4
Lymphogranuloma venereum	3
Other	3
Gastrointestinal :	
Infectious hepatitis	14
Parasites	11
Other, predominantly viral gastroenteritis	8

Table 1. Average length of stay and average age of patients with infections with onset in community and onset in hospital, Public Health Service Hospital, Staten Island

Patient category	Number of patients	Average age (years)	Average length of stay (days)
All patients at risk Infection, community	1, 465		11. 8
berculosis)	183	44 7	23 4
Tuberculosis	75	50. 7	77.6
SetAll surgical patients at	104	52. 3	51.4
risk	800		12. 0
set, preoperative stay_ Infection, hospital on-	1 56		22. 1
set, surgical, overall stay	<sup>1</sup> 56		55.6

<sup>1</sup> Same patients.

T 6	Medicine <sup>1</sup>		Surgery <sup>2</sup>		Total	
Infection	Community	Hospital	Community	Hospital	Community	Hospital
Respiratory tract	14. 8	4.8	1. 1	7.2	15. 9	12. 0
Tuberculosis	15.2	0	2.1	0	17.3	0
Genitourinary tract	3.9	1.6	5.6	6.0	9.5	7.6
Skin and subcutaneous	2.8	1.1	6.0	2.1	8.8	3. 2
Gastrointestinal tract	5.3	. 5	1.4	. 5	6.7	1. 0
Surgical wounds	0	0	0	7.4	0	7.4
Venereal disease	3.4	0	1.6	0	5.0	0
Other	2.8	. 5	1.8	. 5	4. 6	1. 0
- Total	48. 2	8. 5	19. 6	23. 7	67.8	32. 2

#### Table 2. Rates of infections with onset in community and onset in hospital of 355 patients, by hospital service, Public Health Service Hospital, Staten Island

<sup>1</sup> General medicine, medical subspecialties, and medical pediatrics.

There were three upper respiratory tract infections; 118 respiratory infections were acute exacerbations of bronchitis or pneumonia. Following are the data on these infections by hospital service and place of onset.

	Service			
Infection and site of onset	Medicine	Surgery		
Bronchitis: Community Hospital	$\begin{smallmatrix}28\\6\end{smallmatrix}$	5 15		
Community Hospital	$\begin{array}{c} 34 \\ 14 \end{array}$	0 16		

There were two bladder infections caused by *Trichomonas vaginalis* and one case of epididymitis. The remainder of the genitourinary infections were divided between prostatitis (13 with onset in the community) and urinary tract infections (25 with onset in the community and 33 with onset in the hospital).

Bacteremia was documented in five patients, two of whom died. In three instances the organism was *Escherichia coli*, in one, beta hemolytic *Streptococcus* and in one, *Staphylococcus*, coagulase positive.

Nine other patients that had infections died. The cause of death for each of these patients was primarily related to the underlying disease. Two deaths were related to cardiac disease, one to gastrointestinal bleeding, and the remaining six were of patients with malignancies and gram-negative pneumonia.

Cultures were indicated for infections of 312 patients; some had more than one infection.

 $^{\rm 2}$  General surgery, surgical subspecialties, and pediatric surgery.

Cultures were not done for 49 infections (15.8 percent).

Of 160 patients with bacterial pathogens isolated, 78 patients had infections with onset in the hospital, 69 had infections with onset in the community, and 13 had infections with onset in both places (table 3). The ratio of hospital onset to community onset infections for *E. coli* was 1.18 to 1.00; for *Klebsiella* and *Aerobacter*, 1.60 to 1.00; staphylococci, coagulase positive, 2.64 to 1.00; and enterococcus, 2.84 to 1.00. The ratios were corrected for the average number of positive cultures in each group. Pathogens isolated from the respiratory tract and the urinary tract are listed in table 4.

#### Table 3. Bacterial isolates from infections of 160 patients, by place of onset, Public Health Service Hospital, Staten Island

Organism	Com- munity onset	Hospital onset	Total
Escherichia coli	20	31	51
Klebsiella and Aerobacter	12	$\tilde{27}$	39
Diplococcus pneumoniae	$\overline{20}$	15	35
Pseudomonas species	13	$\overline{21}$	34
Staphylococci, coagulase	6	17	23
Staphylococci, coagulase	Ū		20
negative	6	9	15
Enterococci	3	12	15
Proteus species	$\overline{5}$	9	14
Mixed gram-negative	4	5	9
Mixed other	6	$\tilde{2}$	8
Beta hemolytic streptococci.	3	4	7
Other single	4	4	8
_ Total	102	156	258

Of 24 patients in the isolation ward, the 12 with hospital-onset infections had an average stay of 46.7 days; the 12 with community-onset infections had an average stay of 27.8 days. Only 15 of the 24 had cultures taken. Wound infections were noted in nine patients, three had skin ulcers, two had infected burns, three had osteomyelitis, three had perianal abscesses, and three had cellulitis.

Table 5 lists the prophylactic antimicrobials used in the hospital. One course was given to 162 patients and 36 patients received multiple courses—a total of 198 patients, or 13.5 percent of the study population. Of the 213 courses given 174 surgical patients, 37 (17.4 percent) did not prevent serious clinical infections.

Table 6 details use of antimicrobials for therapy. It is based on 224 patients who received one course and 85 who received multiple courses. Thus 309 patients, or 21 percent of the study population, received therapeutic antimicrobials. However, only 443 patients, or 30 percent of the study population actually received antimicrobials; 64 patients received them for both therapy and prophylaxis.

## Discussion

There are three major problems in classification of patients by the site of acquisition of their infections-the hospital or the community. These are variable rates of transfer from patient to patient for each organism, variable incubation periods, and difficulty ascertaining whether the patient has had recent contact with the hospital before admission. Kessner and Lepper (2) used rigid criteria in their study of gram-negative bacilli in the community and hospital, which resulted in 94 percent of patients with an indeterminate classification. Since there is a paucity of data on organism transfer rates, incubation periods vary for each organism, and information about recent hospital contact is not given on most charts, it is not feasible to use such criteria of classification for general surveillance. The criterion of time of onset after admission to the hospital for such a classification, as used in this study, was the most practical for purposes of general surveillance.

During the study it was ascertained that 309

patients received therapeutic antimicrobials and 355 patients had infections. Thus 87 percent of patients with infections were detected by screening the medication index on each ward. The additional 13 percent was found by thorough screening of charts of discharged patients. Under the reporting system used from October 1967 through February 1968, an average of 120 patients per month had 158 significant isolates, excluding patients with tuberculosis. Returns on followup questionnaires sent to attending physicians varied from 5 to 70 percent each month. During the 1-month study, 280 infected patients (excluding those with tuberculosis) were found. Thus, intensive surveillance revealed the number of hospital associated infections to be more than double that obtained by surveillance based solely on review of bacteriological reports.

The prevalence data for February 29 showed 10.7 percent of the patients had hospital-onset infections and 22.3 percent had community-onset infections. For the 29-day incidence study, the rates were 7.8 percent hospital onset, and 17.9 percent community onset. As discussed by Thoburn and co-workers (3), prevalence rates tend to be higher than incidence rates. A prevalence study by Barrett and co-workers (4) at Boston City Hospital showed 15.5 percent of the patients had hospital-acquired infections and 26.3 percent had community-acquired infections. Our patient population, predominantly adult male "world travelers," differs from that of Boston City Hospital and may account for the differences observed. Our pediatric and obstetric-gynecology services are small, 42 and 79 patients, respectively, during the study period.

Morbidity, as reflected by age of the patient and length of hospitalization, was markedly different between the two categories of patients. Excluding patients with tuberculosis, the group with hospital-onset infections was 7.6 years older. Also, the hospital-onset infection group had a stay more than twice that of patients with community-onset infections. The average preoperative stay for patients in whom infections developed in the hospital was almost twice as long as the average total stay of surgical patients. Host factors are involved, and patients

## Table 4. Bacterial isolates from 73 patients with respiratory tract infections and 55 patients with urinary tract infections, by place of onset, Public Health Service Hospital, Staten Island

0	Medicine <sup>1</sup>		Surgery <sup>2</sup>		Total	
	Com- munity	Hospital	Com- munity	Hospital	Com- munity	Hospital
Respiratory tract	45	15	3	25	48	40
Diplococcus pneumoniae	<b>20</b>	8	0	8	20	16
Pseudomonas species	5	1	0	6	5	7
Klebsiella and Aerobacter	5	1	0	4	5	5
Escherichia coli	1	0	<b>2</b>	1	3	1
Proteus species	1	1	0	0	1	1
Beta hemolytic streptococcus	3	1	0	1	3	2
Staphylococci, coagulase positive	<b>2</b>	<b>2</b>	0	<b>2</b>	<b>2</b>	4
Staphylococci, coagulase negative	<b>2</b>	1	0	0	<b>2</b>	1
Mixed gram negative	4	0	0	3	4	3
Mixed other	1	0	1	0	$^{2}$	0
Haemophilus influenzae	1	0	0	0	1	0
Urinary tract	6	12	20	28	26	40
Escherichia coli	3	5	10	11	13	16
Klebsiella and Aerobacter	1	3	6	6	7	9
Pseudomonas species	<b>2</b>	<b>2</b>	3	3	5	5
Enterococci	0	<b>2</b>	0	6	Ó	8
Proteus species	0	0	1	2	1	2

 $^{1}$  General medicine, medical subspecialties, and medical pediatrics.

 $^{2}$  General surgery, surgical subspecialties, and pediatric surgery.

with more devastating diseases or those requireing major surgery are generally hospitalized longer than other patients. Nevertheless, prolonged exposure to the microbiological flora of the hospital probably is a factor in the morbidity indicated by these findings.

The relative distribution of respiratory, genitourinary, skin and subcutaneous, and wound infections was comparable to that found by others (4, 5). Thoburn and co-workers (3), in analyzing hospital-onset infections, placed pneumonia third, after genitourinary and wound infections. They excluded cases of bronchitis, and this omission probably accounts for this difference in observations.

Prophylactic antimicrobials, as used by the surgical services, were started 12 to 24 hours before surgery and were usually continued for 5 to 15 days postoperatively. Table 5 indicates that 17.4 percent of the prophylactic attempts by the surgical services were ineffective in preventing serious postoperative infections (wound infections, pneumonia, urinary tract infections, bacteremia, and so forth). The most commonly used agents were sulfisoxazole as prophylaxis for urinary catheter use (ineffective seven of 87 times), penicillin and streptomycin in combination for major chest or abdominal surgery (ineffective 10 of 26 times), and penicillin and chloromycetin in combination for major vascular surgery (ineffective four of five times).

The efficacy of prophylaxis for these purposes

## Table 5. Courses of antimicrobials used for prophylaxis, by hospital service, Public Health Service Hospital, Staten Island

A., 41	Number o used	Number of courses	
Antimicrobiai	Medi- cine <sup>1</sup>	Sur- gery <sup>2</sup>	ineffec- tive <sup>3</sup>
Sulfisoxazole	5	87	7
Mandelamine	6	17	0
Tetracycline	0	19	<b>2</b>
Furadantin	1	17	4
Penicillin	<b>2</b>	13	4
Isoniazid	6	3	0
Other single	4	13	1
Combinations	0	44	19
 Total	24	213	37

<sup>1</sup> General medicine, medical subspecialties, and medical pediatrics.

<sup>2</sup> General surgery, surgical subspecialties, and pediatric surgery.

<sup>3</sup> Surgical services only.

is questionable. In a study at five university centers ( $\delta$ ) prophylactic antibiotics were given to 4,642 (30.7 percent) of 15,144 patients who had postoperative infections. A higher rate of infection was observed in those who received prophylactic antibiotics (14.3 percent) than in those who did not (4.4 percent). Statistical adjustment was made for wound classification, hospital involved, duration of operation, duration of preoperative hospitalization, urgency of operation, diabetes, steroid therapy, obesity, and malnutrition without significant change in these percentages.

Weinstein (7) stated concerning chemoprophylaxis: "The degree of success has varied with the purpose for which prophylaxis has been applied; it has been highest when the prevention of specific infections has been attempted and lowest when protection against infection in general has been its aim." Weinstein has also reviewed pertinent, selected literature on this problem (8). Almost uniformly, infection rates were higher among patients who received prophylactic antimicrobials than in those who did not.

Continuing surveillance has the potential of providing epidemiologic clues for further definitive study of infections, preventing many hospital-onset infections, provoking more judicious use of antimicrobials, and providing educational data for the staff of a hospital. Some workers  $(\mathcal{J}, \mathcal{G})$ . have suggested that the nurse epidemiologist is most effective for carrying out long range surveillance.

#### Summary

A month-long survey of hospital associated infections and use of antimicrobials at the Public Health Service Hospital, Staten Island, N.Y., revealed that 17.9 percent of 1,465 patients had infections with onset in the community and 7.8 percent had hospital-onset infections. The hospital-onset group had an average stay more than twice as long as the average stay of the community-onset group.

Infections were designated "hospital onset" if they were clinically evident 72 hours or longer after a patient's admission, if the infection was related to a procedure performed within 72 hours of admission, or if the infection was

### Table 6. Courses of antimicrobials used for therapy, by hospital service, Public Health Service Hospital, Staten Island

Antimicrobial	Med- icine <sup>1</sup>	Sur- gery <sup>2</sup>	Total
Penicillin	46	38	84
Tetracycline	45	25	70
Sulfisoxazole	12	22	<b>34</b>
Ervthromycin	16	5	21
Furadantin	5	16	21
Ampicillin	9	11	20
Cephalothin	13	$^{2}$	15
Isoniazid	6	4	10
Other single	23	12	35
Isoniazid plus PAS or			
ethambutol	52	3	55
Other combinations	$\overline{8}$	40	48
 Total	235	178	413

<sup>1</sup> General medicine, medical subspecialties, and medical pediatrics.

<sup>2</sup> General surgery, surgical subspecialties, and pediatric surgery.

related to a previous stay at the hospital. All other infections were designated "community onset."

Antimicrobials were given to 30 percent of the patients; 13.5 percent of them were given antimicrobials for prophylaxis. The prophylactic antimicrobials were used predominantly in the surgical services where 17.4 percent of the courses administered did not prevent serious postoperative infections. Therapeutic antimicrobials were administered to 21 percent of the patients.

Surveillance was accomplished by filling out infection reports on all patients receiving antimicrobials for therapy, prophylaxis, or both. The medication index was reviewed, and all wards were visited five times a week. Charts of all discharged patients were also reviewed.

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## Science Information Exchange Announces Services and Fee Schedule

Smithsonian Institution Science Information Exchange services, previously restricted to Government users because of cost, are now available to non-Federal users in research and development at nominal fees. The fees became effective in December 1968 for non-Federal users, and will be extended to Federal agency requesters as of July 1969.

The services include subject searches in current research fields, computer listings, compilations, printouts, catalogs of ongoing research, and automatic selective dissemination of information.

Requests for a broad variety of services by non-Government users, however, have been increasing steadily at a time when costs for computer operations, labor, and equipment have also been rising sharply. This combination of factors dictated the decision to establish a charge system providing for both expanded service outside the Government and partial cost recovery.

The SIE registers Notices of Research Projects (NRP's) of current ongoing basic and applied research supported by Federal and nongovernmental organizations. The exchange's current records include 100,000 NRP's in all areas of life, physical, and social and engineering sciences. This service helps research administrators, as well as individual scientists, to identify research requirements, unwarranted duplication, and program strengths and weaknesses before rather than after the fact.

A few examples of the varying services and fees follow:

Subject search question involves requests

for all NRP's related to a specified subject. They are comparable to a bibliographic search. Fee per question: \$60, screened; \$30, unscreened.

Periodic mailing involves quarterly mailing of NRP's on a continuing arrangement. It is a type of selective dissemination provided as an extension of the subject request service. Fee: \$60 for initial mailing; \$30 for each quarterly mailing.

Investigator search involves requests for all NRP's associated with a given name (investigator). Fee per name searched: \$3 (\$9 minimum).

Accession number retrieval involves requests for NRP's identified by agency accession (or contract) number or by SIE accession number. Fee per accession number: \$1 (\$5 minimum).

Recently the exchange introduced a new and improved method of information handling of its NRP's. The new system employs an IBM data cell with an IBM 360-30 computer. All records will be maintained in the cell rather than on tape and disk units previously and commonly employed. Programing for the new data cell was developed on a modular basis and provides a shortened response time.

Further description of the expanded services now available and details for the use of the new service and costs can be obtained by writing to the Director, Science Information Exchange, Smithsonian Institution, 1730 M Street NW., Room 209, Washington, D.C. 20036.



**Psychological and Social Aspects of** Human Tissue Transplantation. An annotated bibliography. PHS Publication No. 1838; by Jacquelyn H. Hall and David D. Swenson: 1968: 57 pages; 40 cents. Contains 176 references to literature on the psypsychiatric, ethical. chological, moral, social, and legal aspects of human tissue transplantation, and the artificial maintenance of life. The references also include reporting of medical advances to the public, psychological factors in surgery, and medical experimentation on human subjects.

Social Security Programs in the United States. Social Security Administration. March 1968; 120 pages; 55 cents. Revises and brings up to date an earlier monograph of the same title, published in January 1966. Brings together information on the historical development and present status of all the major income-maintenance programs in the United States and on the health insurance and medical assistance programs and the Social Security Act. Includes not only old-age, survivors, disability, and health insurance, but also the railroad retirement program, now closely integrated with OASDHI, retirement systems for government employees, and veterans' compensation and pensions. Covers the State and railroad unemployment insurance and temporary disability insurance programs and workmen's compensation. Includes a summary of the State-Federal public assistance programs and briefly discusses private pension and other employee-benefit plans.

Studies of the Incomes of Physicians and Dentists. By Louis S. Reed. December 1968; 133 pages. Published by the Social Security Administration, Office of Research and Statistics. Contains two separate but closely related studies on physicians' and dentists' incomes and on their relationship to incomes of certain other professions. Part A presents and analyzes data on the receipts and net income of physicians and dentists from self-employment practice, as shown in the statistics of income compiled from the business tax returns by the Internal Revenue Service since 1945. Part B deals with the occupational characteristics of eight selected health professions (including medicine and dentistry) and seven selected professions outside the health field.

**Reimbursement Incentives for Hos**pital and Medical Care. Objectives and alternatives. Social Security Administration, Office of Research and Statistics, Research Report No. 26. 1968; 80 pages; 45 cents. Presents papers gleaned from discussions of a group of economists and policymakers with and in the Social Security Administration who met to exchange ideas on the kinds of incentives for efficiency, economy, and effectiveness that could be introduced into the reimbursement formulas. The first paper provides a review of the historical and legislative development of reimbursement formulas over the past half century. The second provides an analysis of various types of reimbursement schemes together with the economic framework in which they can be viewed. The final three papers present specific schemes for incentive reimbursement plans and describes how they can be evaluated.

Food Composition Table for Use in Africa. Produced by the Nutrition Program of the Health Services and Mental Health Administration, Public Health Service, and the Nutrition Division of the United Nation's Food and Agriculture Organization 1968; 306 pages. Brings together for the first time analytical data on 1,624 of the most commonly consumed foods in Africa by English, French, and scientific names. Includes bibliographies that refer to African food composition and botanical nomenclatures. Also includes a table which provides basic food composition data essential to the effective evaluation and improvement of African nutrition. Copies of the English edition are available upon request, from the Nutrition Program, Health Services and Mental Health Administration, 9000 Rockville Pike, Bethesda, Md. 20014.

Questions and Answers-Medical Assistance, Medicaid. MSA-201-68. June 1968; 23 pages; 15 cents. Gives a comprehensive picture of the Federal-State program of medical assistance known as Medicaid. Updates an earlier version to include changes in the program required by the 1967 amendments to Title XIX of the Social Security Act. Describes who is eligible, which services must or may be paid for, how providers of medical care and services are paid, and the relationships between patients and Medicaid programs. Explains the relationships between Medicaid and Medicare, the Federal program of health insurance for persons 65 and older.

If You Must Smoke. 5 ways to reduce the risks of smoking. *PHS Publication No. 1786; folder; August 1968; 5 cents, \$2.50 per 100.* Cites the physical risks of cigarette smoking. Gives 5 positive steps that may be taken to lower the intake of cigarette smoke. Cautions that anything short of quitting completely is merely a compromise.

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