RESISTANT BACTERIA AND INFECTION CONTROL IN THE NURSING HOME AND HOSPITAL

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FOR many years there has been substantial interest in the epidemiology and control of multiply-resistant bacteria in hospitals.[1,2] Initial attention was prompted by epidemic strains, but we are now beginning to focus on endemic resistance in hospitals.[3,4] In contrast, the study of infections and infection control in nursing homes is in its infancy.[5-10] Nursing home studies are important because of the expected increase in the elderly population, the recent recognition of potentially widespread problems with resistant bacteria in nursing homes, and the impact of these problems on hospitals. This article will review selected aspects of bacterial resistance in hospitals, contrast what is known about antibiotic resistance in nursing homes, and present control strategies for hospital and nursing home settings.

SITES AND PATHOGENS

Several pathogen-antibiotic resistance combinations have been problems in recent years (Table I). Although only very general data are available for nursing homes, the sites involved (Table II) and pathogens (Table III) have differed somewhat from acute care settings (Table IV). Of particular interest have been the apparent tropism of *Providencia stuartii*[5,6,9-12] for nursing home patients and the striking flux in uropathogens, individual nursing home patients in one study acquiring a new strain on the average of every two weeks.[12]

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TABLE I. RESISTANCE PROBLEMS

Setting	*Bacteria*	*Key resistances*	*Comments*
General hospital	Enterobacteriaceae (especially *Klebsiella, Enterobacter, Serratia)*	Aminoglycosides, new cephalosporins	Emergence of resistance to the "2nd and 3rd generation" cephalosporins may occur during therapy of *Enterobacter* and *Serratia*
	Pseudomonas aeruginosa	Aminoglycosides, antipseudomonal penicillins	Cross-resistance to more than one aminoglycoside is common; resistance to newer beta-lactams, fluoroquinolones, and thienamycins may occur during therapy
	Staphylococcus aureus	Methicillin	Increasing frequency in many areas. Strains often introduced from the community
	Coagulase-negative staphylococci	Methicillin	Problem for patients with vascular catheters and implanted prostheses
	Streptococcus pneumoniae	Penicillin	At present, uncommonly recognized in the United States
Oncology units	Enterobacteriaceae	Trimethoprim-sulfa	Often see resistance to the most frequently used antibiotics, especially those used prophylactically
	JK diphtheroids	Multiple	Increasingly common for these "avirulent" bacteria to be pathogens; require therapy with vancomycin
	Coagulase-negative staphylococci	Multiple	
Geriatric units, nursing homes	*Providencia, Proteus* and *Morganella*	Aminoglycosides	Nursing home patients are subject to all of above, and especially to these bacteria. Colonized patients may transfer resistant bacteria between hospitals

In addition to the generic problems, specific wards or hospitals may harbor "problem bugs." Thus, one intensive care unit may be plagued by *Acinetobacter* and another by *Serratia*. Care must be taken not to generalize only from these parochial situations lest we inflate estimates of antibiotic resistance and give a skewed view of resistance problems, e.g., is one "bug" being shared by many patients or are there many different "bugs"?

TABLE II. NURSING HOME-ACQUIRED INFECTION RATES*

Site	*Prevalence*
Urinary tract infection (indwelling catheter)	>75%
Skin and soft tissue	2-11%
Lower respiratory tract	1-10%
Eye	1-3%
Diarrhea	1%
Total rate	5-21%

*Summary of four studies of 21 nursing homes[5,8-10]

TABLE III. BACTERIURIA IN LONG-TERM CATHETERIZED PATIENTS*

Organism	*% by specimen*
Providencia stuartii	38
Escherichia coli	43
Proteus mirabilis	44
Pseudomonas aeruginosa	20
Enterococcus	28

*Summary of eight surveillance reports, 1976-1984, representing 215 patients with 1,158 specimens and 658 organisms.[11]

TABLE IV. GENTAMICIN-TOBRAMYCIN RESISTANT ENTEROBACTERIACEAE, MICHAEL REESE HOSPITAL, JANUARY 1984-JULY 1985

	Number of infected patients in hospital		
Site	*Total*	*Hospital acquired*	*Comunity acquired**
Urine	47	22	25
Sputum	16	13	3
Wound	7	4	3
Blood	4	2	2
Other	13	10	3
Total	87	51	36

*Majority represent patients cultured at time of transfer from nursing homes.

Sources And Modes of Transmission

Asymptomatic colonized patients seem to serve as a major reservoir of resistant Gram-negative bacilli and methicillin-resistant *Staphylococcus aureus* in hospitals.[1,13] Major sites of colonization for Gram-negative organisms are usually the gut and/or urinary tract and, for staphylococci, the axillae, perineum, and nares. Bacteria are usually spread from patient to patient by

the hands of hospital personnel. Recognition has been growing that multiply-resistant bacteria, especially aminoglycoside-resistant Enterobacteriaceae (Table IV) or *Pseudomonas aeruginosa* and methicillin-resistant *S. aureus* are often brought into the hospital by readmission of chronic carriers or nursing home patients.[1,3,4,6,14] The importance of other reservoirs and sources, such as food, air, and environmental contaminants, has not been clear.

Sources and modes of transmission of resistant bacteria in nursing homes are presumed to be similar to that in hospitals, although little data confirm this. Moreover, the ability of patients to interact directly is greater in nursing homes, which adds another dimension to the risk of cross-infection.

Factors Facilitating Occurrence and Spread of Resistant Bacteria

Bacterial factors that may lead to spread of resistant strains are gradually being elucidated. One series of studies has suggested a correlation between the ability of some multiply-resistant Klebsiella to survive on the hands of hospital workers and the potential for epidemic spread.[15] Other potentially important bacterial factors, such as resistance to disinfectants, warrant study.

The presence of resistant bacterial subpopulations may also facilitate emergence of resistance in settings with high rates of antibiotic use. We have found that patients in our intensive care unit are frequently colonized by clinically unrecognized aminoglycoside-resistant subpopulations of *P. aeruginosa* that readily emerge during aminoglycoside therapy.[3,4] Similarly, we have found that hospital-acquired coagulase-negative staphylococci are often present as mixed populations of methicillin-sensitive and methicillin-resistant strains; the latter usually begin in small numbers but rapidly emerge as a predominant population after the patient has been exposed to antibiotic therapy.[16] Overgrowth of spontaneously occurring mutations during cephalosporin therapy has been cited as a cause of broad-spectrum cephalosporin resistance in Enterobacteriaceae, particularly in *Enterobacter* and *Serratia.*[17] While several case reports support this scenario, the frequency with which this occurs on an endemic basis is unknown. One retrospective study suggested that in deep-seated, high inoculum infections resistance emerged frequently;[18] however, careful prospective studies will be needed to determine the true frequency.

A variety of *institutional factors* may contribute to occurrence and spread of (resistant) bacteria. Of special concern in some nursing homes[5,7] are high patient-to-staff ratios; large number of "skilled beds"; use of nonprofessional

TABLE V. NURSING HOME PATIENT RISK FACTORS[5,6,8-10]

Factor	*Prevalence*
Bladder incontinence	30-50%
Bladder catheter	<10-40%
Bowel incontinence	35-70%
Decubitus ulcers	20-45%
Nonambulatory	40-90%
Recent antibiotics	10-40%
Recent hospitalization	40%
Confusion	≥30%
Diabetes mellitus	15%
Old age	80 years (average)

personnel; frequent job turn-over; and lack of or inappropriate infection control procedures, e.g., poor attention to asepsis, routine irrigation of bladder catheters, use of antibiotics for asymptomatic urinary infections in catheterized patients,[19] and poor housekeeping practices that could lead to reservoirs of resistant organisms, as when infected urine is left standing in measuring containers.

Many *host factors* have been associated statistically with acquisition of resistant bacteria during nosocomial outbreaks.[1] Some factors are especially common in nursing home patients, although the variability is great (Table V). The relative importance of such host factors, compared to lapses in aseptic technique, bacterial factors, and antibiotic exposures is difficult to judge; in most cases a complex interaction of many factors probably leads to emergence of resistant strains. In one study, a discriminant analysis suggested that presence of bladder incontinence or catheter, residence in a large nursing home, and recent antibiotic use were independently important in predicting colonization with multiply-resistant Gram-negative bacilli in nursing home patients.[6]

Approaches to Control

The traditional approach to control of epidemic resistance[20] involves improving asepsis, identifying bacterial reservoirs, isolating colonized and infected patients, eliminating any common sources, separating susceptible patients, modifying host factors when possible, and in some settings controlling antibiotics (Table VI). Experimental measures have included use of bacterial interference and topical and environmental antiseptics and antimicrobials.

We have tried to stress intervention before outbreaks occur. We have found that use of barrier precautions (see figure) has helped to control the endemic

TABLE VI. SITUATIONS WHERE ANTIBIOTIC CONTROL MAY BE HELPFUL

Setting	*Rationale*
Intensive care unit	Closed, high density population at high risk for selection and spread of resistant organisms
"Plasmid epidemic"	Eliminate selective advantage of plasmidborne resistance
Other	More appropriate dosing to avoid subinhibitory levels
	Control of antibiotics selecting for progressively more resistant bacterial populations

TABLE VII. EXAMPLES OF URGENT INFECTION CONTROL NEEDS FOR NURSING HOMES

Infection control personnel interested in:
Surveillance—determine high risk sites and antibiotic resistance patterns
Policies and procedures (e.g., immunizations, PPD skin testing, bowel and bladder training)
Inservices (e.g., on asepsis and skin, decubitus, eye, and urinary catheter care)
Room control (e.g., separate catheterized patients, avoid crowding of high risk patients, isolation precautions)
Discontinue unneeded or hazardous procedures (e.g., routine bladder irrigation and unwarranted bladder catheterization)
Antibiotic utilization review (e.g., avoid repeated treatments of asymptomtic urinary infections, especially in catheterized patients)

spread of aminoglycoside-resistant Enterobacteriaceae.[14,20,21] Resistance in *Pseudomonas* has been more difficult to control, apparently due to the common carriage of clinically undetected multiply-resistant subpopulations that emerge during aminoglycoside therapy. Since strains of *P. aeruginosa* resistant to even the newest antimicrobials have emerged readily, control of resistance will require very innovative approaches.[4]

The approaches outlined above can be tried empirically in nursing homes experiencing problems with resistant bacteria, although the efficacy of most of these measures has never been tested rigorously in either hospital or extended care settings. Nursing homes must be appraised of the isolation status of patients transferred to them, and nursing home patients admitted to hospitals must be evaluated as potential sources of resistant bacteria.[6] Finally, the primitive state of infection control in many nursing homes warrants serious remedial efforts (Table VII).

ANTIBIOTIC RESISTANCE PRECAUTIONS

HANDS-WASH! BEFORE AND AFTER PATIENT CONTACT

GLOVES-WORN! FOR ALL PATIENT OR SECRETION CONTACT

ROOM - 1- OR 2- BED ROOM : NO ROOMMATE WITH DRAINAGE TUBES OR FOLEY.

ARTICLES - MUST HAVE OWN URINE MEASURING CUP: RINSE BEFORE AND AFTER USE AND LEAVE AMPHYL IN BOTTOM WHEN NOT IN USE. DISCARD ALL SECRETIONS IN PLASTIC BAGS.

Isolation placard placed on door to patient's room and on wall above patient's bed.

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