SPECIAL ARTICLE

Clinical Pharmacy Services and Hospital Mortality Rates

C. A. Bond, Pharm.D., FASHP, FCCP, Cynthia L. Raehl, Pharm.D., FASHP, and Todd Franke, Ph.D.

We evaluated the associations between clinical pharmacy services and mortality rates in 1029 United States hospitals. A data base was constructed from Medicare mortality rates from the Health Care Financing Administration and the National Clinical Pharmacy Services data base. A multivariate regression analysis, controlling for severity of illness, was employed to determine the associations. Four clinical pharmacy services were associated with lower mortality rates: clinical research ($p<0.0001$), drug information ($p=0.043$), drug admission histories ($p=0.005$), and participation on a cardiopulmonary resuscitation (CPR) team ($p=0.039$). The actual number of deaths (lower) associated with the presence of these four services were clinical research 21,125 deaths in 108 hospitals, drug information 10,463 deaths in 237 hospitals, drug admission histories 3843 deaths in 30 hospitals, and CPR team participation 5047 deaths in 282 hospitals. This is the first study to indicate that both centrally based and patient-specific clinical pharmacy services are associated with reduced hospital mortality rates. This suggests that these services save a significant number of lives in our nation's hospitals.
(Pharmacotherapy 1999;19(5):556–564)

The vision statement of the American College of Clinical Pharmacy (ACCP) states, "We will be the recognized leader in initiating, fostering, and disseminating pharmacotherapy innovations that will optimize patient care outcomes."[1] In addition, the 1998–2000 ACCP strategic plan considers "research that assesses the value of clinical pharmacy services" to rank fifth of 57 objectives.[1] Although substantial numbers of clinical studies found improved patient care and, in some cases, reduced costs at individual clinical sites,[2-27] few attempted to evaluate clinical pharmacy services in several sites or in an entire health care system. Such studies are critical to determine how these services affect health care.

In addition, a significant limitation of site-specific demonstration studies is that the results may be influenced by the patients, health care professionals, health care delivery system, or other site-specific factors. Thus, the benefits of the services may not be readily transferable to other clinical sites or settings. Hospital-based mortality rates are an important health care outcome measure, applicable to most hospital settings.

A literature review back to 1966 found four studies that evaluated the impact of clinical pharmacy services on mortality rates for hospitalized patients.[18, 28-30] Two of them[18, 28] examined the effect of a clinical pharmacist on mortality rates in an individual hospital, and neither concluded that a statistically significant effect existed. According to the other two studies, mortality rates were reduced with increased pharmacist staffing and provision of drug information services in 718 hospitals[29] and with increased pharmacist staffing in 3763 hospitals.[30] In the latter, the reduced mortality

From the Departments of Pharmacy Practice (Drs. Bond and Raehl) and Psychiatry (Dr. Bond), Schools of Pharmacy and Medicine, Texas Tech University Health Sciences Center–Amarillo, Amarillo, Texas; and the Department of Biostatistics and Biometrics, School of Public Policy and Social Research, University of California at Los Angeles, Los Angeles, California (Dr. Franke).

Address reprint requests to C. A. Bond, Pharm.D., Department of Pharmacy Practice, Texas Tech University Health Sciences Center-Amarillo, 1300 South Coulter Street, Amarillo, TX 79106.

was independent (specific contribution of pharmacists) of staffing levels of other health care professionals.[30]

Other studies were limited to exploring the associations among demographics, teaching affiliation, ownership, staff education and training, disease, quality of care, staffing, and fiscal characteristics.[31-38] Although hospital mortality is not a specific measure of quality of care, it does have a close association with quality.[35-39] Outcome measures must adjust for the influence of patient characteristics.[35, 37, 40, 41] If outcome measures (e.g., hospital mortality rates) do not adjust for severity of illness, conclusions for hospitals that treat severely ill patients would be inaccurate, leading to erroneous conclusions about the quality of care provided in those institutions.

We tested the association between mortality rates adjusted for severity of illness for Medicare patients in 1029 hospitals in the United States and 14 clinical pharmacy services.[42] This is one of the first studies to explore this relationship.

Methods

Sources of Data

The Medicare Hospital Mortality Information data tape for 1992 was purchased from Health Care Financing Administration (HCFA) and provided individual hospital Medicare mortality rates.[43] Methods used by HCFA to calculate mortality rates are published elsewhere.[44] Data for 14 clinical pharmacy services were obtained from the 1992 National Clinical Pharmacy Services (NCPS) data base, which is the largest hospital-based pharmacy data base in the United States.[42] The NCPS survey was updated from previous surveys[45, 46] and pretested by 25 directors of pharmacy. It was then mailed to the director of pharmacy in each acute care, general-medical surgical hospital listed in the American Hospital Association's (AHA) Abridged Guide to Health Care.[47] Study methodology, variables, and demographic results of this study are available elsewhere.[42] These two data bases were integrated into one, and SAS, release 6.11, implemented on a personal computer (Pentium 166 Mz), was used for statistical analysis.[48]

The HCFA provided 1992 Medicare mortality data for 5505 hospitals in 1992 (general medical-surgical, pediatric, psychiatric, alcohol and drug rehabilitation, etc.).[43] The AHA listed 4822 general medical-surgical hospitals in 1992.[47] Data from AHA and HCFA mortality data bases were able to be matched for 3763 hospitals, which constituted 100% of hospitals that could potentially be included in the study population. Hospitals included in this study had information on Medicare mortality rates and 14 clinical pharmacy services obtained from the NCPS data base.[42] Only general medical-surgical hospitals were used, to provide more homogeneous hospital and patient populations. Mortality rates for psychiatric, alcohol and drug rehabilitation, or rehabilitation hospitals would not be appropriate outcome measures of care. From the 1597 hospitals in the NCPS data base[42] and the 3763 hospitals matched from the HCFA and AHA data bases,[43, 47] data were matched for 1029 hospitals based on the presence of both Medicare mortality data and 14 clinical pharmacy services. These 1029 hospitals constituted the study population.

Variables and Analysis

Centrally delivered clinical pharmacy services used in the analysis were drug use evaluation (DUE), in-service education, drug information, poison information, and clinical research. Patient-specific clinical pharmacy services were adverse drug reaction monitoring, pharmacokinetic consultations, drug therapy monitoring, drug protocol management, total parenteral nutrition team participation, drug counseling, cardiopulmonary resuscitation (CPR) team participation, medical rounds participation, and admission drug histories. We defined clinical services specifically to indicate active participation by pharmacists in patient care. The Appendix gives definitions of clinical pharmacy services.

Simple and multiple regressions were used. Severity of illness was controlled by forcing three variables into the regression analysis model: percentage of intensive care unit (ICU) days (calculated as ICU days divided by total inpatient days), annual number of emergency room visits divided by the average daily census, and percentage of Medicaid patients (calculated as Medicaid discharges divided by total discharges). These variables were previously validated as measures of severity of illness in similar studies.[29, 30, 37-42] We chose them because they are the only ones validated as adjusters for severity of illness using these national data bases.[29, 30, 37, 38] Although other variables have been used to adjust for severity of illness with smaller patient populations (e.g., Acute Physiology and Chronic Health Evaluation [APACHE] scores, specific

Table 1. Severity of Illness, Clinical Services, Clinical Service Eligibility, and Increase or Decrease in Clinical Services in 1029 Hospitals

		% of Patients Who May Receive the Service[a]	% Increase in Service[b]
Severity of illness	Mean ± SD		
ICU days/total inpatient days	0.05 ± 0.04		
Number of emergency room visits/ADC	193.38 ± 114.63		
Medicaid discharges/total discharges	0.13 ± 0.09		
Predicted mortality/1000 admissions	87.51 ± 11.44		
Clinical pharmacy services	No. (%)		
Central clinical pharmacy services			
Drug use evaluation	978 (95.0)	5.3 ± 9.6	5.6
In-service education	687 (66.8)	8.6 ± 28.1	4.6
Drug information	237 (23.0)	4.1 ± 17.9	50.0
Poison information	161 (15.7)	0.2 ± 11.5	7.1
Clinical research	108 (10.5)	2.7 ± 8.9	44.5
Patient-specific clinical pharmacy services			
Adverse drug reaction monitoring	690 (67.1)	66.9 ± 44.0	47.8
Pharmacokinetic consultations	544 (52.9)	48.9 ± 44.5	35.0
Drug therapy monitoring	441 (42.9)	56.0 ± 39.4	7.3
Drug protocol management	355 (34.5)	48.0 ± 44.1	48.0
TPN team participation	325 (31.6)	55.1 ± 45.5	42.9
Drug counseling	310 (30.1)	33.8 ± 40.3	30.8
CPR team participation	282 (27.4)	67.6 ± 40.6	20.0
Medical rounds participation	153 (14.9)	27.3 ± 27.5	38.5
Admission drug histories	30 (2.9)	38.8 ± 43.0	50.0

ADC = average daily census.
[a]If the clinical service was present, the percentage of patients who were eligible to receive it.
[b]Percentage increase in hospitals offering service compared with the 1989 National Clinical Services data base.[46]

patient case mix, patient age, number of surgical patients, physician experience, length of shifts, patient workloads), they were not available through national data bases. Diagnosis-related groups are not reliable severity of illness adjusters since many hospitals have inflated these measures.

Statistical Analysis

A weighted least-squares regression was used to estimate and test relationships between clinical pharmacy services and observed mortality rates. The weight used in the analysis was the inverse of the variance for the observed mortality rate, $N/\{p \times (1 - p)\}$, where N was the number of Medicare admissions to the hospital and p was HCFA's expected mortality rate for each hospital. Parameter estimate 95% confidence intervals (CIs) were calculated for both simple and multiple regression analyses.

Regression results were calculated in two steps. First, parameter estimates for severity of illness variables were calculated by entering each variable into the model separately. Second, the remaining parameter estimates were calculated by entering them into the model separately after severity of illness variables were entered. Thus, all subsequent parameter estimates were adjusted for severity of illness indicators. This created a more accurate analysis of individual measures of association with mortality rates.

For multiple regression analysis, stepwise procedures were used to select variables for the model.[49, 50] Severity of illness variables were forced into the multiple regression model before other variables were allowed to enter. After their forced entry, stepwise regression was used to select the remaining variables. Variables selected through this method were confirmed by both forward- and backward-regression techniques, both of which selected the same set of variables. This analysis was used with severity of illness variables, because HCFA's mortality rates do not include accurate measures of severity of illness.[51, 52]

The correlation matrix for the independent variables and the variance inflation factor were used to examine the possible effects of multicollinearities among the variables. These indicated that there were no apparent problems among the set of independent variables. A detailed report of the analysis methods employed

Table 2. Simple Regression Analysis Controlling for Severity of Illness

Clinical Pharmacy Service	Slope	SE	Significance	95% CI
Severity of illness variables				
ICU days/total inpatient days	-0.003513	0.01	0.0001	-0.065, -0.005
Number of emergency room visits/ADC	0.000002	0.001	0.0001	0.000, 0.000
Medicaid discharges/total discharges	0.00157	0.001	0.011	0.004, 0.028
Central clinical pharmacy services				
Drug use evaluation	-0.000000	0.001	0.22	0.000, 0.000
In-service education	-0.000405	0.001	0.001	-0.006, -0.002
Drug information	-0.000881	0.001	0.0001	-0.011, -0.007
Poison information	-0.000157	0.001	0.0001	-0.004, 0.001
Clinical research	-0.001369	0.001	0.001	-0.016, -0.011
Patient-specific clinical pharmacy services				
Adverse drug reaction monitoring	-0.000358	0.001	0.001	-0.006, -0.001
Pharmacokinetic consultations	-0.000409	0.001	0.001	-0.006, -0.002
Drug therapy monitoring	-0.000407	0.001	0.0001	-0.006, -0.002
Drug protocol management	-0.000143	0.001	0.17	-0.004, -0.001
TPN team participation	-0.000572	0.001	0.0001	-0.008, -0.004
Drug counseling	-0.000631	0.001	0.001	-0.008, -0.004
CPR team participation	-0.000541	0.001	0.001	-0.008, -0.003
Medical rounds participation	-0.000945	0.001	0.0001	-0.012, -0.007
Admission drug histories	-0.00155	0.002	0.0001	-0.020, -0.011

ADC = average daily census.

with this study is published elsewhere (4864 hospitals and 3763 hospitals).[29, 30] Multiple regression analysis allowed us to determine which clinical pharmacy services explain mortality rates in United States hospitals. The intent was to build a multiple regression model to determine if these services were associated with hospital mortality rates.

A comparison of clinical pharmacy services that were statistically significant in the multiple regression model was developed further. Mean number of deaths/hospital/year, based on whether the hospital provided the clinical pharmacy service, is presented. Only services that had statistically significant associations with mortality rates (multiple regression model) were included in the analysis. The number of deaths/year was calculated from the difference in death rates (per admission) x mean number of admissions per hospital offering this service x number of hospitals offering the service. The a priori level of significance for all tests was set at 0.05.

Results

A total of 1029 hospitals (64%) of the 1597 general medical-surgical hospitals from the NCPS data base were matched from the 3763 hospitals from HCFA and AHA data bases (potential pool of study hospitals). These 1029 hospitals (27%) constituted the study population. The mean number of admissions/year/hospital was 8174 ± 6803, or 8,411,387 total admissions (35% of total U.S. admissions).[53] The mean annual mortality for hospitals was 89.09 ± 18.97 deaths/1000 admissions, or 728 deaths/hospital/year.

Table 1 shows severity of illness, clinical pharmacy services, extent that services were available to patients, and clinical pharmacy service growth. The presence of these services varied between 3% of hospitals providing drug admission histories and 95% providing DUE. Availability of clinical services also varied, with 12.7% of patients involved with pharmacist-conducted clinical research and 95% of patients provided with DUE services. All clinical pharmacy services increased (% of hospitals offering service) between 1989 and 1992.[42, 46] Services with the lowest and greatest increases were DUE (5.6% increase) and drug admission histories (50%), respectively.

Table 2 shows simple regression analysis for severity of illness, clinical pharmacy services, and mortality rates described as slope, standard error (SE), probability, and CI. The slope measures the rate of change for the variable and is expressed as either positive (presence of this service was associated with higher mortality rates) or negative (presence of this service was associated with lower mortality rates). All 14 clinical pharmacy services were associated with lower mortality rates, but these differences were not statistically significant for DUE and drug protocol management.

Table 3. Multiple Regression Analysis[a] for Clinical Pharmacy Services

Clinical Pharmacy Service	Slope	SE	Significance	95% CI
Severity of illness variables				
ICU days/total inpatient days	-0.36	0.014	0.009	-0.64, -0.01
Number of emergency room visits/ADC	0.00005	0.001	0.0001	0.000, 0.022
Medicaid discharges/total discharges	0.010	0.006	0.069	-0.004, 0.019
Central clinical pharmacy services				
Drug use evaluation	0.00001	0.000	0.11	0.000, 0.000
In-service education	0.001	0.001	0.616	-0.002, 0.003
Drug information	-0.002	0.001	0.043	-0.005, 0.000
Poison information	0.002	0.001	0.08	0.000, 0.000
Clinical research	-0.008	0.001	0.0001	-0.010, -0.005
Patient-specific clinical pharmacy services				
Adverse drug reaction monitoring	0.001	0.001	0.519	-0.003, 0.001
Pharmacokinetic consultations	0.001	0.001	0.544	-0.002, 0.003
Drug therapy monitoring	0.0005	0.001	0.64	-0.002, 0.003
Drug protocol management	-0.0003	0.001	0.759	-0.003, 0.002
TPN team participation	-0.001	0.001	0.48	-0.003, 0.001
Drug counseling	-0.001	0.001	0.254	-0.003, 0.001
CPR team participation	-0.002	0.001	0.039	-0.004, 0.000
Medical rounds participation	-0.003	0.001	0.054	-0.005, 0.000
Admission drug histories	-0.006	0.002	0.005	-0.010, -0.001

ADC = average daily census.
[a] R^2 = 22.4%, adjusted R^2 = 21.8%.

Table 3 shows multiple regression analysis for severity of illness variables, clinical pharmacy services, and mortality rates. For each parameter estimate, slope (rate of change), SE, probability, and CI are presented. Two clinical pharmacy services approached statistical significance, poison information (p=0.08) and medical rounds participation (p=0.054). Statistically significant associations were found with drug information services, clinical research, CPR team participation, and admission drug histories. These 4 provided the best regression equation (fit) for the 14 services studied. This regression model accounted for 22.4% of the total explainable variance associated with hospital mortality rates in the 1029 hospitals.

Table 4 shows the mean number of deaths/hospital/1000 admissions for hospitals having the four clinical pharmacy services that had a statistically significant association with reduced mortality (multiple regression analysis). The difference between the number of deaths (lower, calculated from Table 4) for hospitals having these four services was 195.61 deaths/year/hospital that had clinical research services, 44.15 deaths/year/hospital that had drug information services, 128.10 deaths/year/hospital that had drug admission histories, and 17.90 deaths/year/hospital that had CPR team participation. Hospitals that had these services had up to 40,478 fewer deaths (summed from number of deaths for each service) than those that did not.

Discussion

This study determined associations between clinical pharmacy services and mortality rates adjusted for severity of illness. All 14 services were associated with lower mortality rates in the simple regression model, but these differences were not statistically significant for DUE and drug protocol management. Four services were associated with lower hospital mortality rates in the multiple regression analysis: drug information services, clinical research, CPR team participation, and admission drug histories. Since mortality rates are associated with quality of care, these services are likely quality of care indicators for both hospitals and pharmacies.[35–39]

Reasons why clinical research was associated with reduced mortality rates are unknown. One possible explanation is that clinical research was primarily done in academic health care centers, as teaching hospitals are associated with lower mortality rates.[29, 36–40, 54] However, only 51 (47.2%) hospitals that had pharmacist-conducted clinical research were members of the Council of Teaching Hospitals. This suggests that other factors may be more important in explaining the association. Another possible explanation is that

Table 4. Deaths per Hospital with and without Clinical Pharmacy Services/1000 Admissions and Actual Number of Deaths/Year

Clinical Pharmacy Service	No. of Hospitals	No. of Admissions/Hospital/ Year with this Service (mean ± SD)	No. of Deaths/Hospital with this Service (mean ± SD)	No. of Deaths/Hospital without this Service (mean ± SD)	Total No. of Deaths/Year[a]
Clinical research	108	16,819 ± 8741	78.68 ± 20.45	90.31 ± 18.42	21,125
Drug information	237	11,349 ± 9311	86.09 ± 21.16	89.98 ± 18.18	10,463
Admission drug histories	30	14,878 ± 8365	80.73 ± 22.71	89.34 ± 18.80	3843
CPR team participation	282	8522 ± 7742	87.56 ± 21.99	89.66 ± 17.68	5047

[a]Calculated from the difference in death rate/admission (presence or absences of the clinical service) x mean number of admissions/hospital/year offering this service x number of hospitals offering the clinical service.

departments of pharmacy that conduct research may employ more highly educated and trained pharmacists (Pharm.D., residency, fellowship, etc.). Although no data on education and training levels and staffing were sought, directors of pharmacy who have earned a Pharm.D. degree provide higher levels of clinical pharmacy services in their hospitals compared with directors with other degrees.[42, 45, 46, 55]

The 195.61 deaths/year/hospital difference between hospitals that had pharmacist-conducted clinical research and those that did not resulted in 21,125 fewer deaths/year in the 108 hospitals that had pharmacist-conducted clinical research. If extrapolated to all of the 3763 hospitals in the potential pool of study hospitals, this would result in 736,080 fewer deaths possibly being associated with the presence of this service. The median yearly pharmacist salary cost/hospital for conducting clinical pharmacy research was $5656 and the mean yearly grant funding was $79,765 ± $128,641/hospital, a cost:benefit of 1:14 (every $1 of salary time resulted in $14 of grants).[56] Given the economic benefits to the hospital and the association with reduced mortality rates, more study seems warranted to determine why clinical research produces these benefits.

We do not know why pharmacist-provided drug information services were associated with lower mortality rates. An unbiased source of drug information may promote better patient care and thus reduce the number of deaths. Improved hospital information systems may reduce mortality rates.[57] The presence of this service may also indicate a medical staff more open to input from pharmacists. Finally, drug information services may indicate better formulary control of drug therapy with improved patient care.

The 44.15 deaths/year/hospital difference between hospitals that had pharmacist-provided drug information services and those that did not resulted in 10,463 fewer deaths/year in the 237 hospitals in which pharmacists provided the services. If extrapolated to all of the 3763 hospitals in the potential pool of study hospitals, this would result in 166,137 fewer deaths possibly being associated with the presence of the services. The median yearly pharmacist salary cost/hospital for providing drug information services was $8679, or $82/occupied bed/year.[56] This translates to $1.06/admission, or $196.58/additional death ($8,679/44.15).

The reason pharmacist-provided drug histories were associated with lower mortality rates is unknown. The service itself could account for this association, as up to 28% of all hospital admissions were attributed to drug-related morbidity and mortality.[58] In addition, studies suggest that adverse drug events in hospitals are often preventable if detected early,[59] and could be reduced by better information systems.[57] Perhaps pharmacists are better able to detect drug-related problems than other health care professionals.

The 128.10 deaths/year/hospital difference between hospitals that had pharmacist-provided drug histories and those that did not resulted in 3843 fewer deaths/year in the 30 hospitals that had the service. If extrapolated to all of the 3763 hospitals in the potential pool of study hospitals, this would result in 482,040 fewer deaths possibly being associated with this service. The median yearly pharmacist salary cost/hospital for providing drug histories was $8967, or $5/patient having an admission drug history.[56] This translates to $1.10/admission, or $70.00/additional death ($8967/128.10). Given the low cost of this service and the number of hospitalizations associated with drugs,[57-59] it is not clear why so few directors of pharmacy have implemented the service.

Nor do we know why pharmacist participation

on the CPR team was associated with lower mortality rates. Perhaps having a pharmacist on codes promotes better drug therapy and saves more lives. The presence of this service may also indicate a medical staff more open to pharmacist input on drug therapy in critical care settings.

The 17.90 deaths/year/hospital difference between hospitals that had pharmacist participation on the CPR team and those that did not resulted in 5047 fewer deaths/year in the 282 hospitals that had such participation. If extrapolated to all of the 3763 hospitals in the potential pool of study hospitals, this would result in 67,358 fewer deaths possibly being associated with the presence of this service. The median yearly pharmacist salary cost/hospital for pharmacist participation on a CPR team was $639, or $8/patient receiving CPR.[56] This translates to $0.08/admission, or $35.70/additional death ($639/17.90).

Up to 40,478 deaths/year (lower) were seen in hospitals that had these clinical pharmacy services. Some caution should be advised in interpreting this number since this study was designed to show association, not cause and effect. In addition, we were able to obtain information only about clinical pharmacy services, and information about the services of physicians, nurses, and other health care professionals could not be obtained or evaluated. Nevertheless, the impact of these services should not be underestimated. If 22.4% of deaths were directly attributable to the services (R^2 for multiple regression model was 22.4%), the result is 9067 deaths (22.4% x 40,478).

This is the first study to demonstrate that both centrally based and patient-specific clinical pharmacy services are associated with reduced hospital mortality rates. It is also the first to quantify the potential impact (number of deaths) of the services.

Better models for adjusting mortality rates for severity of illness using more precise clinical and socioeconomic variables may be developed in the future. The total variance explained by our regression model (22.4%) was consistent with other studies: 11%,[34] 14–25%,[60] 17.26%,[30] and 21%.[40] Since this is one of the first studies comparing clinical pharmacy services with mortality rates in a large number of hospitals, the findings must be replicated in future studies. Caution should be employed in applying our findings to individual hospitals.

In summary, four clinical pharmacy services were associated with lower hospital mortality rates in our multiple regression model: drug information services, clinical research, CPR team participation, and drug admission histories. These services likely reflect better quality of care. Hospitals that had the services had up to 40,478 fewer deaths/year than those without them. The results suggest that clinical pharmacy services do save a significant number of lives in the country's hospitals. Given their significant benefits and low costs, it is our hope that clinical pharmacists and directors of pharmacy will develop and expand their clinical pharmacy services.

References

1. **American College of Clinical Pharmacy.** Vision statement. ACCP Rep 1997;16(10):S1–8.
2. **Black BL.** Resource book on progressive pharmaceutical services. Bethesda, MD: American Society of Hospital Pharmacists, 1986.
3. **Hatoum HT, Catizone C, Hutchinson RA, et al.** An eleven-year review of the pharmacy literature: documentation of the value and acceptance of clinical pharmacy. Drug Intell Clin Pharm 1986;20:33–48.
4. **Comptroller General of the United States.** Study of health facilities construction costs. Washington, DC: U.S. Government Printing Office, 1972:68–72, 363–79.
5. **Barker KN, Pearson RE.** Medication distribution systems. In: Brown TR, Smith MC, eds. Handbook of institutional pharmacy practice. Baltimore: Williams & Wilkins, 1986:325–51.
6. **Elenbaas RM, Payne VW, Bauman JL.** Influence of clinical pharmacists consultations on the use of blood level test. Am J Hosp Pharm 1980;37:61–4.
7. **Bollish SJ, Kelly WN, Miller DE, et al.** Establishing an aminoglycoside pharmacokinetic monitoring service in a community hospital. Am J Hosp Pharm 1981;38:73–6.
8. **Abramowitz PA, Nold EC, Hatfield SM.** Use of clinical pharmacists to reduce cefamandole, cefoxitin, and ticarcillin costs. Am J Hosp Pharm 1982;39:1176– 80.
9. **Mutchie KD, Smith KA, MacKay MW, et al.** Pharmacists' monitoring of parenteral nutrition: clinical and cost effectiveness. Am J Hosp Pharm 1979;36:785–7.
10. **Covinsky JO, Hamburger SC, Kelly KL, et al.** Impact of docent clinical pharmacists on treatment of streptococcal pneumonia. Drug Intell Clin Pharm 1982;16:587–91.
11. **Bond CA, Salinger RJ.** Fluphenazine out-patient clinics: a pharmacist's role. J Clin Psychiatry 1979;40:501–3.
12. **Herfindal ET, Bernstein LR, Kishi DT.** Effect of clinical pharmacy services on prescribing on an orthopedic unit. Am J Hosp Pharm 1983;40:1945–51.
13. **Avorn J, Soumerai SB.** Improving drug-therapy decisions through educational outreach: a randomized controlled trial of academically based "detailing." N Engl J Med 1983;308:1457–63.
14. **Knapp DE, Knapp DA, Speedie MK, et al.** Relationship of inappropriate drug prescribing to increased length of hospital stay. Am J Hosp Pharm 1979;36:1334–7.
15. **Knapp DE, Speedie MK, Yaeger DM, et al.** Drug prescribing and its relationship to length of hospital stay. Inquiry 1980;17:254–9.
16. **McKenney JM, Wasserman AH.** Effect of advanced pharmaceutical services on the incidence of adverse drug reactions. Am J Hosp Pharm 1979;36:1691– 7.
17. **Clapham CE, Hepler CE, Reinders TP, et al.** Economic consequences of two drug-use control systems in a teaching hospital. Am J Hosp Pharm 1988;45:2329–40.
18. **Bjornson DC, Hiner WO, Potyk RP, et al.** Effect of pharmacist on health care outcomes in hospitalized patients. Am J Hosp Pharm 1993;50:1875–84.
19. **Jenkins MH, Bond CA,** The impact of clinical pharmacists on

Appendix. Definitions of Terms

Central Clinical Pharmacy Services

Drug use evaluation: Check if, at minimum, drug use patterns are analyzed and results are reported to hospital committee.

In-service education: Pharmacist presents continuing education to fellow employees (M.D., R.N., R.Ph., etc) on a scheduled basis at least 4 times a year.

Drug information: Provided only if a formal drug information service with specifically assigned pharmacist(s) is available for questions. Does not require a physical location called drug information center.

Poison information: Provided only if a pharmacist is available to answer questions regarding toxicity or overdose on a routine basis with appropriate resources.

Clinical research: Is performed by pharmacists either as a principal investigator or coinvestigator. Pharmacist is likely to be (co-)author of a published paper. Do not check if activity is limited to investigational drug distribution or record keeping.

Patient-Specific Clinical Pharmacy Services

Adverse drug reaction management: Pharmacist evaluates potential adverse drug reaction while the patient is hospitalized and appropriately follows through with physicians.

Pharmacokinetic consultation: Provided if, only at a minimum, the drug regimen, serum level, and patient's medical record are reviewed, and verbal or written follow-up is provided when necessary.

Drug therapy monitoring: Provided only if a patient's medical record is reviewed and verbal or written follow-up is provided when necessary. Monitoring is continuing and repeated, often on daily basis. Do not check if only drug orders are reviewed. Does not include pharmacokinetic consults, total parenteral nutrition team, rounds, adverse drug reaction management, or drug therapy protocol management.

Drug protocol management: Pharmacist, under the order of a prescriber, requests laboratory tests as necessary and initiates or adjusts drug dosage to obtain the desired therapeutic outcome (e.g., aminoglycoside or heparin dosing/pharmacy).

Total parenteral team participation: Pharmacist, at a minimum, reviews patients' medical records with or without written or verbal follow-up as necessary.

Drug counseling: Pharmacist provides counseling either during hospitalizations or at time of discharge. Do not check if counseling involves only review of label directions.

CPR team participation: Pharmacist is an active member of the team, attending most arrests when present in the hospital.

Medical rounds participation: Pharmacist attends rounds with medical team at least 3 days/week, actively providing specific input.

Admission drug histories: Pharmacist provides admission histories.

psychiatric patients. Pharmacotherapy 1996;16(4):708–14.

20. **Monson RA, Bond CA, Schuna A.** Role of the clinical pharmacist in improving outpatient drug therapy. Arch Intern Med 1981;141:1441–4.
21. **Bond CA, Monson R.** Sustained improvement in drug documentation, compliance, and disease control—a four year ambulatory care model. Arch Intern Med 1984;144:1159–62.
22. **Tang I, Vrahnos D, Hatoum H, et al.** Effectiveness of clinical pharmacist interventions in a hemodialysis unit. Clin Ther 1993;15:459–64.
23. **Brown WJ.** Pharmacist participation on a multidisciplinary rehabilitation team. Am J Hosp Pharm 1994;51:91–2.
24. **Garber AM, Fuchs VR, Silverman JF.** Case mix, costs, and outcomes: between faculty and community services in a university hospital. N Engl J Med 1984;310:1231–7.
25. **Pauly MV, Wilson P.** Hospital output forecasts and the cost of empty hospital beds. Health Serv Res 1986;21:413–28.
26. **Rich EC, Gifford G, Luxenberg M, et al.** The relationship of hospital staff experiences to the cost and quality of inpatient care. JAMA 1990;263:953–7.
27. **Watts CA, Klastorin TD.** The impact of case-mix on hospital costs: a comparative analysis. Inquiry 1990;17:357–67.
28. **Boyko WL, Yurkowski PJ, Ivey M, et al.** Pharmacist influence on economic and morbidity outcomes in a tertiary care teaching hospital. Am J Health-Syst Pharm 1997;54:1591–5.
29. **Pitterle ME, Bond CA, Raehl CL, Franke T.** Hospital and pharmacy characteristics associated with mortality rates in United States hospitals. Pharmacotherapy. 1994;14(5):620–30.
30. **Bond CA, Raehl CL, Pitterle ME, Franke T.** Health care professional staffing, hospital characteristics, and hospital mortality rates. Pharmacotherapy 1999;19(2):130–8.
31. **Carter JH, Mills AC, Homan SM, et al.** Correlating the quality of care with nursing resources and patient parameters: a longitudinal study. NLN Publ 20-2191,1987:331–45.
32. **Kelly JV, Hellinger FJ.** Physician and hospital factors associated with mortality of surgical patients. Med Care 1986;24:785–800.
33. **Rhee SO.** Factors determining the quality of physician performance in patient care. Med Care 1976;14:733–50.
34. **Shortell SM, Hughes EFX.** The effects of regulation, competition, and ownership on mortality rates among hospital inpatients. N Engl J Med 1988;318:1100–7.
35. **Dubois RW, Brooks RH, Rodgers WH.** Adjusted hospital death rates; a potential screen quality of medical care. Am J Public Health 1987;77:1162–7.
36. **Krakauer H, Bailey RC, Skellan KJ, Stewart JD, Hartz AJ.** Evaluation of the HCFA model for the analysis of mortality following hospitalization. Health Serv Res 1992;27(3):317–35.
37. **Hartz AJ, Gottlieb M, Kuhn ER, Rimm A.** National validation study of Medicare mortality studies (project 1247-M). Technical report to the Health Standards and Quality Review Bureau. Washington, DC, 1989.
38. **Hartz AJ, Krakauer H, Kuhn EM, et al.** Hospital characteristics and mortality rates. N Engl J Med 1989;321:1720–5.
39. **Keeler EB, Rubenstein LV, Kahn KL, et al.** Hospital characteristics and quality of care. JAMA 1992;268:1709–14.
40. **Green J, Wintfield N, Sharkey P, Passman LJ.** The importance of severity of illness measures in assessing hospital mortality. JAMA 1990;262:241–6.
41. **Green J, Passman LJ, Wintfield N.** Analyzing hospital mortality—the consequences of diversity in patient mix. JAMA 1991;265:1849–53.
42. **Bond CA, Raehl CL, Pitterle ME.** 1992 National Clinical Pharmacy Services study. Pharmacotherapy 1994;14(3):282–304.
43. **Health Care Financing Administration.** Medicare hospital mortality information on data tape. Washington, DC: U.S. Government Printing Office, 1992.
44. **Health Care Financing Administration.** Medicare hospital mortality information, 1991. Washington, DC: U.S. Government Printing Office, 1992.

45. Raehl CL, Bond CA, Pitterle ME, Hospital pharmacy services in the Great Lakes region. Am J Hosp Pharm 1990;47: 1283–1303.
46. Raehl CL, Bond CA, Pitterle ME. Pharmaceutical services in U.S. hospitals in 1989. Am J Hosp Pharm 1992;49:323–46.
47. American Hospital Association. American Hospital Association abridged guide to the health care field data tape. Chicago: Author, 1992.
48. SAS Institute Inc. SAS, version 6.11. Cary, NC: Author, 1996.
49. Wampole BE, Freund RD. Use of multiple regression in counseling psychology research: a flexible data analytic strategy. J Counsel Psychol 1987;34:372–82.
50. Pedhazur EJ. Multiple regression in behavioral research: explanation and prediction, 2nd ed. New York: Harcourt Brace Jovanonich, 1982.
51. Greenfield S, Aronow HU, Elashoff RM, Watanaabe D. Flaws in mortality data: hazards of ignoring comorbid disease. JAMA 1988;260:2253–5.
52. Kenlel P. Hospitals balk at mortality report results. Modern Healthcare January 1, 1988:5–6.
53. American Hospital Association. Hospital statistics, 1992. Chicago: Author, 1993.
54. Rosenthal GE, Harper DL, Quinn LM, Cooper GS. Severity-adjusted mortality and length of stay in teaching hospitals and nonteaching hospitals: results of a regional study. JAMA 1997;278:485–90.
55. Pitterle ME, Bond CA, Raehl CL. Pharmaceutical care index measuring comprehensive pharmaceutical care. Am J Hosp Pharm 1992;46:2226–9.
56. Bond CA, Raehl CL, Pitterle ME. Cost of pharmaceutical services in U.S. hospitals in 1992. Am J Hosp Pharm 1995;52:603–13.
57. Leape LL, Bates DW, Cullen DJ, et al. System analysis of adverse drug events. JAMA 1995;274:35–43.
58. Johnson JA, Bootman JL. Drug related morbidity and mortality. Arch Intern Med 1995;155:1949–56.
59. Bates DW, Cullen DJ, Laird N, et al. Incidence of adverse drug events and potential adverse drug events JAMA 1995; 274:29–34.
60. Daley J, Jencks S, Draper D, et al. Predicting hospital-associated mortality for Medicare patients. JAMA 1988; 260:3617–24.