SPECIAL ARTICLE

Clinical Pharmacy Services, Pharmacy Staffing, and Hospital Mortality Rates

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Objective: To determine if hospital-based clinical pharmacy services and pharmacy staffing continue to be associated with mortality rates.

Methods: A database was constructed from 1998 MedPAR, American Hospital Association's *Annual Survey of Hospitals*, and National Clinical Pharmacy Services databases, consisting of data from 2,836,991 patients in 885 hospitals. Data from hospitals that had 14 clinical pharmacy services were compared with data from hospitals that did not have these services; levels of hospital pharmacist staffing were also compared. A multiple regression analysis, controlling for severity of illness, was used.

Results: Seven clinical pharmacy services were associated with reduced mortality rates: pharmacist-provided drug use evaluation (4491 reduced deaths, p=0.016), pharmacist-provided in-service education (10,660 reduced deaths, p=0.037), pharmacist-provided adverse drug reaction management (14,518 reduced deaths, p=0.012), pharmacist-provided drug protocol management (18,401 reduced deaths, p=0.017), pharmacist participation on the cardiopulmonary resuscitation team (12,880 reduced deaths, p=0.009), pharmacist participation on medical rounds (11,093 reduced deaths, p=0.021), and pharmacist-provided admission drug histories (3988 reduced deaths, p=0.001). Two staffing variables, number of pharmacy administrators/100 occupied beds (p=0.037) and number of clinical pharmacists/100 occupied beds (p=0.023), were also associated with reduced mortality rates.

Conclusion: The number of clinical pharmacy services and staffing variables associated with reduced mortality rates increased from two in 1989 to nine in 1998. The impact of clinical pharmacy on mortality rates mandates consideration of a core set of clinical pharmacy services to be offered in United States hospitals. These results have important implications for health care in general, as well as for our profession and discipline.

Key Words: clinical pharmacy services, pharmacy staffing, mortality rates, reduced deaths.

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Six years ago, using data from 1992, we published a series of two articles that evaluated the association between hospital pharmacist staffing and clinical pharmacy services on severity-of-illness–adjusted mortality rates.[1, 2] These two studies demonstrated that increased levels of hospital pharmacist staffing and the presence of four clinical pharmacy services—clinical research, drug information, admission drug histories, and cardiopulmonary resuscitation (CPR) team participation—were associated with

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lower mortality rates. Subsequent to these publications, we reanalyzed the staffing data and determined that the major contributor from hospital pharmacy staffing on the lowering of mortality rates was increased clinical pharmacist staffing/100 occupied beds. Unfortunately, there have been no further studies to determine if hospital pharmacy staffing variables or the presence of clinical pharmacy services are still valid indicators of lower mortality rates. Thus, we have replicated this study, 6 years later, to determine if these pharmacy variables remain valid measures of improved health care outcomes. Mortality rate was chosen as the primary outcome measure for this study since it represents one of the clearest and most significant outcome measures for health care. In addition, an avoidable death represents an ultimate failure in health care that all health care professionals would strive to avoid. Finally, mortality rate is a quality measure that both those in the health care field and the lay public regard as significant.

In addition to the two previous studies on mortality rates and pharmacy variables,[1, 2] three other studies evaluated the impact of clinical pharmacy services on mortality rates for hospitalized patients.[4–6] Two of these studies evaluated the impact of a clinical pharmacist on mortality rates in a single hospital.[4, 5] Neither of these studies was able to demonstrate that a clinical pharmacist had a statistically significant effect on mortality rates. One study found that increased pharmacist staffing and the provision of drug information services were associated with reduced mortality rates in 718 hospitals.[6] Other hospital-based mortality rate studies have been limited to exploring the associations among demographics, teaching affiliation, ownership, staff education and training, disease, quality of care, staffing, and fiscal characteristics.[7–15] Although hospital mortality rate is not a specific measure of quality of care, it does have a close association with quality of care.[11–14, 16, 17] In the past decade, there has been a greater emphasis on specific disease states and in some cases individual drugs when evaluating mortality and quality of care.[15, 18, 19] However, the field of clinical pharmacy is relatively young and does not have universal acceptance of the types of services that should be provided. Thus, large studies like this one are still required to help our discipline develop a consistent core set of clinical pharmacy services that are most likely to benefit our patients.

Studies involving large numbers of patients from multiple sites are critical, since they are not subject to bias of patient populations, physical facilities, structure, and process that may confound studies conducted at single sites. Large-population studies also significantly reduce the intervener's bias that occurs when investigators evaluate the impact of pharmacists on patient care outcomes at single sites (the pharmacists know they are being evaluated and thus are more diligent). Large-population studies also provide objective data that are most likely to influence physicians, hospital administrators, health care policy experts, and government officials. These studies are more effective in objectively supporting provider status for pharmacists and are more useful in helping the profession gain reimbursement for clinical services.

Patient care outcome measures must adjust for patient characteristics that influence the outcome measure.[11, 13, 15, 20, 21] If outcome measures (e.g., hospital mortality rate) do not adjust for severity of illness, conclusions for hospitals that provide care for more severely ill patients would be inaccurate, leading to erroneous conclusions about the quality of health care provided by professionals in these institutions. We tested the association between severity-of-illness–adjusted mortality rates for Medicare patients in 885 hospitals in the United States with hospital pharmacy staffing and 14 clinical pharmacy services.

Methods

Data Sources

The National Medicare Provider and Review (MedPAR) data cartridges for 1998 were purchased from Health Care Financing Administration.[22] The MedPAR data set consists of records of 100% of Medicare beneficiaries who used hospital inpatient services. Discharge status data were used to calculate mortality rates for each of the 6238 hospitals listed in the MedPAR data set. Data for 14 clinical pharmacy services and pharmacy staffing levels were obtained from the 1998 National Clinical Pharmacy Services (NCPS) database, which is the largest hospital-based pharmacy database in the United States.[23] To populate the 1998 NCPS database, the NCPS survey was updated from previous surveys and pretested by 25 directors of pharmacy.[24–27] It was then mailed to the director of pharmacy in each of the 3950 U.S. acute care, general medical-surgical hospitals listed in the American Hospital Association's (AHA) *Annual Survey of Hospitals*

database.[28] Study methodology, variables, and demographic results of this study are available elsewhere and will not be repeated.[23] Data from these two databases were integrated into one database, and SPSS release 11.5 (SPSS Inc., Chicago, IL) was used for statistical analysis.

The MedPAR database provided 1998 Medicare mortality data for 6238 hospitals (general medical-surgical, pediatric, psychiatric, alcohol and drug rehabilitation, etc.) The AHA listed 3950 general medical-surgical hospitals in the United States.[28] The 3950 general medical-surgical hospitals in the AHA database constituted 100% of hospitals that could be included in the study population. 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 for care. From the 950 hospitals in the NCPS database, the 3950 hospitals in the AHA database, and the 6238 hospitals in the MedPAR database, data were matched for 885 hospitals based on the presence of Medicare mortality data, 14 clinical pharmacy services, and pharmacy staffing level data.[22, 23, 28] Patients in these 885 hospitals constituted the study population.

Variables and Analysis

Centrally delivered clinical pharmacy services used in the analysis were drug use evaluation, in-service education, drug information, poison information, and clinical research. Patient-specific clinical pharmacy services were pharmacist-provided adverse drug reaction (ADR) monitoring, pharmacokinetic consultations, drug therapy monitoring, drug protocol management, total parenteral nutrition team participation, drug therapy counseling, CPR team participation, medical rounds participation, and admission drug histories. Clinical pharmacy service definitions may be found in Appendix 1. Clinical services were defined specifically to indicate active participation by pharmacists in patient care. All hospital pharmacy staffing variables (hospital pharmacy administrators, dispensing pharmacists, clinical pharmacists, and pharmacy technicians) were mutually exclusive. Full-time equivalent (FTE) hospital pharmacy staff was defined as follows: hospital pharmacy administrators spent more than 50% of their time in administration, dispensing pharmacists more than 50% of their time in distribution, and clinical pharmacists more than 50% of their time in clinical activities. All pharmacist staffing included these three staffing components. Staffing was adjusted per 100 occupied beds to reflect actual workloads, not absolute numbers. This study is limited to exploring the impact of clinical pharmacy services and pharmacy staffing on mortality rates. As such, it does not analyze other factors that may affect mortality rates. Data were for inpatients only.

Correlation and multiple regression methods were used. Severity of illness was controlled by forcing two variables into the regression analysis model: annual number of emergency room visits divided by the average daily census, and percentage of Medicaid patients (calculated as number of Medicaid admissions divided by total number of admissions).[1, 2, 6, 13–15] These variables were previously validated as measures of severity of illness in similar studies.[1, 2, 6, 13–15] We chose these variables because they are the only ones that were available that are validated as adjusters for severity of illness using these national databases. 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 patient case mix, patient age, number of surgical patients, physician experience, length of shifts, patient workloads); these variables were not available through these national databases. 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 pharmacy staffing levels and observed mortality rates.[29, 30] 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 the expected mortality rate for each hospital. Parameter estimate 95% confidence intervals were calculated for the coefficients in the multiple regression model.

Hierarchical regression results were calculated in two steps. First, parameter estimates for severity-of-illness variables were calculated by entering the two variables into the model. Second, the remaining parameter estimates were calculated by entering them into the model 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.[31, 32] This analysis was used because the mortality rates derived from the MedPAR database do not include accurate measures of severity of illness. We did not include the all pharmacist staffing variables in the multiple regression model as we wished to include the component staffing variables to determine which type of staff was associated with mortality rates (e.g., clinical pharmacists). A Pearson r correlation analysis between the all pharmacist staffing variable and mortality rates is provided in the Results section.

The correlation matrix for the independent variables and the variance inflation factors 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 used with this study is published elsewhere.[1, 6] Multiple regression analysis allowed us to determine which clinical pharmacy services and pharmacy staffing levels explain mortality rates in U.S. hospitals. The intent was to build a multiple regression model to determine if these services and staffing levels were associated with hospital mortality rates. This study did not look at non-pharmacy variables in the context of mortality rate.

A comparison of clinical pharmacy services that were statistically significant in both the correlation analysis and 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 in both the correlation analysis and with multiple regression model were included in this analysis. Actual reduced deaths were calculated based on the difference in death rates for hospitals that had these clinical pharmacy services and those that did not. The reduced deaths reflect the reduced number of patients who died in hospitals that had pharmacists providing clinical pharmacy services, and as such, these deaths should be considered potentially avoidable. The reduced deaths reflect an actual lower number of deaths in those hospitals having clinical pharmacy services. Statistical tests include a Pearson r and multiple regression analysis. The a priori level of significance for all tests was set at 0.05.

Table 1. Clinical Pharmacy Services, Hospital Pharmacy Staffing Levels, and Severity of Illness in the 885 Hospitals

Variable	Value
	No. (%)
Clinical pharmacy services	
Central	
Drug use evaluation	836 (94.46)
In-service education	580 (65.54)
Drug information	227 (25.65)
Poison information	137 (15.48)
Clinical research	104 (11.75)
Patient specific	
ADR monitoring	623 (70.40)
Pharmacokinetic consultations	711 (80.34)
Drug therapy monitoring	473 (53.45)
Drug protocol management	616 (69.60)
TPN team participation	386 (43.62)
Drug therapy counseling	410 (46.33)
CPR team participation	281 (31.75)
Medical rounds participation	203 (22.94)
Admission drug histories	37 (4.18)
	Mean ± SD
Pharmacy FTE staff/100 occupied beds	
All pharmacists	9.77 ± 4.15
Pharmacy administrators	2.53 ± 5.33
Distribution pharmacists	4.82 ± 4.05
Clinical pharmacists	2.42 ± 1.81
Pharmacy technicians	8.16 ± 5.26
Severity of illness	
No. of emergency room visits/ADC	278.99 ± 213.95
Medicaid discharges/total admissions	0.14 ± 0.09

ADR = adverse drug reaction; TPN = total parenteral nutrition; CPR = cardiopulmonary resuscitation; FTE = full-time equivalent; ADC = average daily census.

Results

A total of 885 hospitals (93%) of the 950 general medical-surgical hospitals from the NCPS database were matched from the 3950 hospitals from the MedPAR and AHA databases (potential pool of study hospitals).[22, 23] These 885 of the 3950 (22.40%) hospitals constituted the study population. The mean ± SD number of admissions/year/hospital was 8918 ± 8292 in study hospitals, or 7,892,430 total admissions (22.98% of total U.S. admissions).[28] The mean ± SD number of Medicare patient admissions/year was 3318 ± 2931, or 2,836,991 total admissions (23.14% of total Medicare admissions). The mean ± SD number of deaths/year/study hospital was 47.38 ± 25.68 deaths/1000 admissions. There were 423 ± 292 deaths/hospital/year for all admissions (374,355 total deaths).[22] The number of deaths reflect Medicare deaths, which were 35.70% of total U.S. admissions.

Table 1 shows severity of illness, pharmacy

staffing levels, clinical pharmacy services, and extent that services were available to patients. The presence of clinical services varied between 4.18% of hospitals providing drug admission histories and 94.46% providing drug use evaluation.

Table 2 shows Pearson correlation coefficients from the weighted least squares regression analysis of mortality rates with pharmacy staffing levels and clinical pharmacy services. All adjusted correlations except for drug information were negative, suggesting that the provision of most of the clinical pharmacy services and increased hospital pharmacy staffing levels trended toward reductions in mortality rates. Eleven of 18 clinical pharmacy services and staffing variables correlated with reduced mortality rates in a statistically significant manner: drug use evaluation, in-service education, clinical research, ADR monitoring, drug protocol management, CPR team participation, medical rounds participation, admission drug histories, increased pharmacy administrator staffing, increased clinical pharmacist staffing, and increased pharmacy technician staffing. A significant association was noted between the all pharmacist

Table 2. Correlations of Clinical Pharmacy Services and Staffing with Mortality Rates

Variable	r Value[a]	p Value
Clinical pharmacy services		
Central		
Drug use evaluation	-0.118	0.006
In-service education	-0.107	0.012
Drug information	0.000	0.498
Poison information	-0.011	0.409
Clinical research	-0.080	0.046
Patient specific		
ADR monitoring	-0.138	0.001
Pharmacokinetic consultations	-0.029	0.269
Drug therapy monitoring	-0.022	0.318
Drug protocol management	-0.117	0.007
TPN team participation	-0.049	0.151
Drug therapy counseling	-0.053	0.132
CPR team participation	-0.155	0.001
Medical rounds participation	-0.071	0.047
Admission drug histories	-0.128	0.001
Pharmacy FTE staff/ 100 occupied beds		
Pharmacy administrators	-0.088	0.031
Distribution pharmacists	-0.007	0.438
Clinical pharmacists	-0.122	0.003
Pharmacy technicians	-0.088	0.031

ADR = adverse drug reaction; TPN = total parenteral nutrition; CPR = cardiopulmonary resuscitation; FTE = full-time equivalent.
[a]Pearson correlation coefficient.

Table 3. Multiple Regression Analysis for Clinical Pharmacy Services, Pharmacy Staffing, and Mortality Rates[a]

Variable	Slope	SE	Standardized β	p Value	95% CI
Severity of illness					
No. of emergency room visits/ADC	0.000004	0.0001	0.056	0.400	0.000 to 0.000
Medicaid discharges/total admissions	-0.0016	0.006	-0.013	0.796	-0.014 to 0.011
Clinical pharmacy services					
Central					
Drug use evaluation	-0.0096	0.004	-0.115	0.016	-0.017 to -0.002
In-service education	-0.0026	0.004	-0.100	0.037	-0.005 to -0.001
Drug information	0.0006	0.001	0.026	0.626	-0.001 to 0.003
Poison Information	0.000006	0.001	0.002	0.965	-0.003 to 0.003
Clinical research	-0.0017	0.001	-0.067	0.221	-0.004 to 0.001
Patient specific					
ADR monitoring	-0.0014	0.001	-0.129	0.012	-0.027 to -0.004
Pharmacokinetic consultations	0.0021	0.001	0.067	0.245	-0.001 to 0.006
Drug therapy monitoring	0.0004	0.001	0.020	0.710	0.001 to 0.003
Drug protocol management	-0.0018	0.001	-0.115	0.017	-0.08 to -0.003
TPN team participation	-0.0001	0.001	-0.006	0.902	-0.002 to 0.002
Drug therapy counseling	-0.0005	0.001	-0.025	0.632	-0.003 to 0.002
CPR team participation	-0.0031	0.001	-0.133	0.009	-0.006 to -0.001
Medical rounds participation	-0.0022	0.001	-0.109	0.021	-0.004 to -0.001
Admission drug histories	-0.0031	0.001	-0.195	0.001	-0.022 to -0.008
Pharmacy FTE staff/100 occupied beds					
Pharmacy administrators	-0.001	0.0004	-0.137	0.037	-0.004 to -0.001
Distribution pharmacists	0.0003	0.0002	0.108	0.717	-0.002 to 0.002
Clinical pharmacists	-0.014	0.0006	-0.178	0.023	-0.006 to -0.002
Pharmacy technicians	-0.0002	0.0002	-0.071	0.309	-0.001 to 0.001

SE = standard error; CI = confidence interval; ADC = average daily census; ADR = adverse drug reaction; TPN = total parenteral nutrition; CPR = cardiopulmonary resuscitation; FTE = full-time equivalent.
[a]R^2=20.81%, adjusted R^2=19.96%.

Table 4. Death Rates and Number of Reduced Deaths/1000 Admissions Associated with Lower Mortality Rates in Hospitals with and Those without Clinical Pharmacy Services

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)[a]	No. of Deaths/ Hospital without This Service (mean ± SD)[a]	No. of Reduced Deaths[b]	No. of Reduced Deaths/Hospital, mean ± SD (%)
Drug use evaluation	836	9105 ± 8279	47.30 ± 23.33	47.89 ± 18.77	4491	5.37 ± 4.29 (1.2)
In-service education	580	10,502 ± 9174	46.96 ± 15.57	48.70 ± 35.50	10,660	18.38 ± 13.96 (7.69)
ADR monitoring	623	9710 ± 8604	46.98 ± 21.60	49.38 ± 39.03	14,518	23.30 ± 19.38 (5.04)
Drug protocol management	616	9335 ± 8296	46.31 ± 14.34	49.51 ± 37.64	18,401	29.87 ± 22.41 (6.35)
CPR team participation	281	8798 ± 8153	43.75 ± 19.49	48.96 ± 24.56	12,880	45.84 ± 31.92 (10.59)
Medical rounds participation	203	10,951 ± 8922	44.12 ± 38.04	49.11 ± 41.87	11,093	54.65 ± 47.24 (10.49)
Admission drug histories	37	11,239 ± 4462	38.29 ± 19.67	47.88 ± 40.18	3988	107.78 ± 87.60 (20.15)

ADR = adverse drug reaction; CPR = cardiopulmonary resuscitation.
[a]Per 1000 admissions.
[b]Difference in death rates x no. of admissions/year x no. of hospitals.

staffing variable (all categories of pharmacists) and reduced mortality rates (Pearson r = -0.118, p<0.001).

Table 3 shows the multiple regression analysis for severity-of-illness variables, pharmacy staffing levels, clinical pharmacy services, and mortality rates. For each parameter estimate, slope (rate of change), standard error, standardized β, probability, and 95% confidence intervals are presented. Statistically significant associations with mortality rates were found with drug use evaluation, in-service education, ADR monitoring, drug protocol management, CPR team partici-pation, medical rounds participation, admission drug histories, increased staffing of hospital pharmacy administrators, and increased staffing of clinical pharmacists. These nine pharmacy variables provided the best regression equation (fit) for the 14 services and four staffing categories studied. The R^2 for this model was 20.81%, and the adjusted R^2 was 19.96%.

Table 4 shows the mean number of deaths/ hospital/1000 admissions for hospitals having the seven clinical pharmacy services that had a statistically significant association with reduced mortality (multiple regression analysis). The number of reduced deaths in hospitals providing these clinical pharmacy services ranged from 3988 for admission drug histories to 18,401 for drug protocol management. The number of reduced deaths/hospital in hospitals that provided these clinical pharmacy services ranged from 5.37 ± 4.29 for drug use evaluation to 107.78 ± 87.60 for admission drug histories. Based on the variance (R^2 = 20.81%), the maximum number of deaths that could be attributable

Table 5. Evolution of Favorable Associations of Clinical Pharmacy Services and Hospital Pharmacy Staffing with Mortality Rates from 1989–1998

Variable	1989[6]	1992[1, 2]	1998[a]
Clinical pharmacy services			
Central			
Drug use evaluation			X
In-service education			X
Drug information	X	X	
Poison information			
Clinical research		X	
Patient specific			
ADR monitoring			X
Pharmacokinetic consultations			
Drug therapy monitoring			
Drug protocol management			X
TPN team participation			
Drug therapy counseling			
CPR team participation		X	X
Medical rounds participation			X
Admission drug histories		X	X
Pharmacy FTE staff/ 100 occupied beds			
All pharmacists	X	X	X
Pharmacy administrators			X
Distribution pharmacists			
Clinical pharmacists		X	X
Pharmacy technicians			

X represents service or staffing with a statistically significant association with lower mortality rate.
ADR = adverse drug reaction; TPN = total parenteral nutrition; CPR = cardiopulmonary resuscitation; FTE = full-time equivalent.
[a]Current study.

to the pharmacy variables was 77,903 (0.2081 x 374,355 total deaths). Thus, the reduced deaths for each clinical pharmacy service listed in Table 4 should not be summed.

Table 5 shows the evolution of the favorable associations between clinical pharmacy services, hospital pharmacy staffing categories, and mortality rates between 1989 and 1998. Figures 1 and 2 show the graphic relationship between staffing levels for hospital pharmacy administrators and clinical pharmacists and deaths/1000 admissions.

Discussion

Although substantial literature documents the value of clinical pharmacy services on clinical and economic outcomes at single clinical sites[33–41] and multiple clinical sites in large populations of patients,[1–3, 42–48] very few studies have evaluated the impact of clinical pharmacy services over a period of time (> 1 yr).[49, 50] Studies that reevaluate associations over a period of time with use of similar methodologies are far more important than individual studies that only capture findings at a certain point in time. Longitudinal health care studies not only determine if relationships are sustained over a period of time, but more important, they explore how these relationships change. In addition, these studies often provide some evidence of strengthening or weakening of the relationships.

In our report published in 1994 (1989 data), we found that pharmacist staffing/100 occupied beds and the presence of one clinical pharmacy service (i.e., drug information) were associated with reduced mortality rates.[6] In two reports published in 1999 (1992 data), we again found that pharmacist staffing/100 occupied beds[1] and the presence of four clinical pharmacy services (i.e., drug information, clinical research, CPR team participation, and admission drug histories) were associated with reduced mortality rates.[2] Subsequent to these publications, we reanalyzed the staffing data and determined the major contributor from hospital pharmacy staffing on the lowering of mortality rates was increased clinical pharmacist staffing/100 occupied beds.[3]

This report provides evidence of an expansion of both pharmacy staffing variables (administrators and clinicians) and the number of clinical pharmacy services performed on reduced mortality rates. From a service perspective, there were seven clinical pharmacy services in 1998 (five patient-specific clinical pharmacy services) versus four clinical pharmacy services in 1992 (two patient-specific clinical pharmacy services)[2] that showed statistically significant associations with reduced mortality rates (Tables 2, 3, and 5). The reasons for these findings are unknown but probably reflect maturation of the discipline and continued improved patient care.

Although these data should not be construed as cause and effect, these four articles over a period of 9 years clearly document the benefits of increased pharmacist staffing (particularly clinical pharmacists) and the provision of certain clinical pharmacy services on one of the most important health care outcomes, mortality rate.

Clinical Pharmacy Services Associated with Reduced Mortality

Drug Use Evaluation

The specific reasons why 4491 fewer deaths occurred in hospitals that had pharmacist-provided drug use evaluation are not known. Increasingly, drug use evaluation is being used for auditing and improving the quality of drug therapy in hospitals, and not just for its ability to reduce

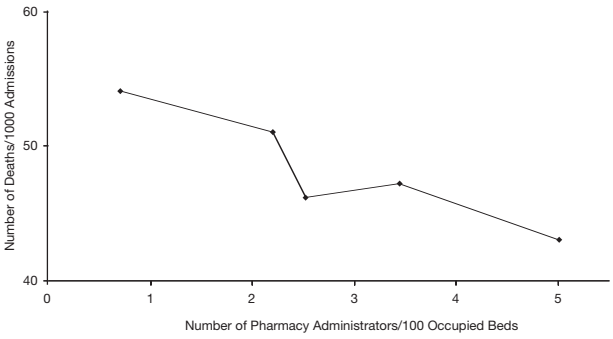

Figure 1. Relationship between pharmacy administrator staffing levels and deaths/1000 admissions.

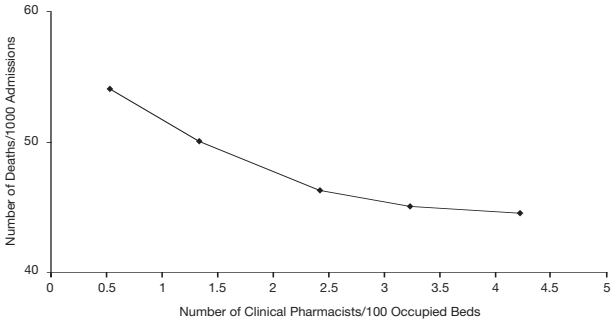

Figure 2. Relationship between clinical pharmacist staffing levels and deaths/1000 admissions.

drug costs. In addition, many hospitals have the results of drug use evaluation, ADR monitoring, drug protocol management, and CPR reported and monitored through the pharmacy and therapeutics committee. Thus, drug use evaluation may serve as an indicator of the pharmacy and therapeutics committee's involvement and oversight in improving drug therapy in the institution. Growth in drug use evaluation since 1989 has been almost negligible, increasing from 90% of hospitals in 1989 to 96% of hospitals in 1998.[23, 26] Extrapolating the 4491 fewer actual deaths in hospitals that had this clinical pharmacy service to the entire Medicare population of general medical-surgical hospitals would result in 20,168 fewer deaths. A total of 0.94 ± 0.68 FTE pharmacist was required to provide drug use evaluation in those hospitals that had this service.[23, 51]

Pharmacist-Provided In-Service Education

The specific reasons why 10,660 fewer actual deaths occurred in hospitals that had pharmacist-provided in-service education are not known. Perhaps the presence of pharmacist-provided in-service education is an indicator of a hospital's commitment to staff education. A better-educated staff probably equates to better care, with lower mortality rates. In addition, the presence of pharmacist-provided in-service education may also be an indicator of a teaching hospital, and teaching hospitals have been shown to have lower mortality rates.[1, 13, 14] The percentage of hospitals that have pharmacist-provided in-service education programs has remained virtually unchanged from 1989 (66%) to 1998 (67%) in U.S. hospitals.[23, 51] Extrapolating the 10,660 fewer actual deaths in hospitals that had this clinical pharmacy service to the entire Medicare population of general medical-surgical hospitals would result in 47,872 fewer deaths. A total of 0.54 ± 0.37 FTE pharmacist was required to provide in-service education in hospitals that had this service.[23, 51]

Adverse Drug Reaction Monitoring

A total of 2,216,000 hospitalized patients developed a serious ADR, and 106,000 patients/year die from an ADR.[52] Fatal ADRs appear to rank between the fourth and sixth leading causes of death. As sobering as these figures appear, ADRs are also one of the more frequent causes of hospitalization (range 3.7–6.5%).[53, 54] It is logical that hospitals that had pharmacist-provided ADR management had 14,518 fewer actual deaths. This service is specifically designed to detect and manage ADRs. Pharmacist-provided ADR management most likely indicates a significant commitment by the hospital to reduce ADRs (both by pharmacy and probably other services) and to improve drug safety. The percentage of hospitals that have pharmacist-provided ADR management increased significantly from 46% of hospitals in 1989 to 71% in 1998 (a 54% increase).[23, 51] Extrapolating the 14,518 fewer actual deaths in hospitals that had this clinical pharmacy service to the entire Medicare population of general medical-surgical hospitals would result in 65,186 fewer deaths. A total of 20.97 ± 13.99 minutes/patient were required for pharmacists to provide this service in hospitals that had this service.[23, 51]

Drug Protocol Management

It is logical that hospitals that had pharmacist-provided drug protocol management (collaborative drug therapy) had 18,401 fewer actual deaths. This service is specifically designed to improve drug therapy in selected populations of patients. A 2003 White Paper from the American College of Clinical Pharmacy on collaborative drug therapy management by pharmacists noted that 75% of the states had enacted changes in their laws or practice acts to increase the pharmacist's role in the management of patients' drug therapy.[55] Of the 154 single-site studies involving pharmacist collaborative drug therapy manage-ment, 85% of these studies showed beneficial results on patient care outcomes.[55] Previous large-scale studies on pharmacist-provided drug therapy management found that hospitals without this service had 4664 more deaths from heparin, 2786 more deaths from warfarin, 1048 more deaths from aminoglycosides or vancomycin, and 374 more deaths from antiepileptic drugs when compared with hospitals that have pharmacists who manage these drugs.[46, 47, 56] Drug management (any drug) by pharmacists is the fastest growing clinical pharmacy service in U.S. hospitals. This clinical pharmacy service was present in 25% of the hospitals in 1989[23] and 70% of hospitals in 1998 (a 180% increase).[23, 51] Extrapolating the 18,401 fewer actual deaths in hospitals that had this clinical pharmacy service to the entire Medicare population of general medical-surgical hospitals would result in 82,621 fewer deaths. Of interest, note that this clinical pharmacy service had the greatest reduction of deaths associated with it (18,401 actual deaths; Table 4).

A total of 27.76 ± 17.96 minutes/patient were required for pharmacists to provide this service in hospitals that had this service.[23, 51]

Participation on Cardiopulmonary Resuscitation Team

The reason why pharmacist participation on the CPR team was associated with 12,880 fewer actual deaths is unknown. Having a pharmacist on the CPR team probably 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. Given the number of deaths, the presence of this service is likely an indicator of other factors (e.g., decentralized pharmacists), as the number of reduced deaths is too large to be due to improved CPR outcomes alone. This clinical pharmacy service was present in 25% of the hospitals in 1989[23] and 32% of hospitals in 1998 (a 28% increase).[51] Extrapolating the 12,880 fewer actual deaths in hospitals that had this clinical pharmacy service to the entire Medicare population of general medical-surgical hospitals would result in 57,831 fewer deaths. A total of 36.58 ± 12.84 minutes/patient were required for pharmacists to provide this service in hospitals that had this service.[23, 51]

Participation on Medical Rounds

It is logical that hospitals that had pharmacist participation on medical rounds had 11,093 fewer actual deaths, since decisions about care and drug therapy are primarily made while the medical team does rounds. Having a pharmacist present on rounds undoubtedly increases the likelihood that drug therapy is more appropriate. Also, substantial documentation exists for reductions in adverse drug events (66–94%) when pharmacists are placed on rounds.[34, 37] This clinical pharmacy service was present in 13% of the hospitals in 1989[23] and 25% of hospitals in 1998 (a 92% increase).[51] Extrapolating the 11,093 fewer actual deaths in hospitals that had this clinical pharmacy service to the entire Medicare population of general medical-surgical hospitals would result in 49,808 fewer deaths. A total of 17.43 ± 20.12 minutes/patient were required for pharmacists to provide this service in hospitals that had this service.[23, 51] Whereas medical rounds used to be almost exclusive to teaching institutions, the rise of the hospitalist as well as other changes in inpatient care has led to more nonteaching institutions having rounds.

Admission Drug Histories

It is logical that hospitals that had pharmacist-provided drug histories had 3988 fewer actual deaths when one considers that 28% of all hospital admissions are attributable to drug-related morbidity.[57] In addition, a recent study found that 64% of physician prescribing errors occurred at the time of admission.[58] In a recent study on discrepancies in admission drug orders in geriatric patients, the authors found that 65% of newly admitted patients had discrepancies with the drugs they were taking before admission (not documented in the chart).[59] Not only may pharmacists detect ADRs, but also they could obtain an accurate history of ADRs and allergies, prescription drugs, herbal medicines, and over-the-counter drugs and then document these findings. This service is particularly important, when considering that the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) has implemented a program (January 2006) for documenting (history) a complete list of drugs at the time of admission and with each transfer throughout the hospital.[60] It was unfortunate that pharmacy organizations did not publicize the JCAHO standard in supporting the value of pharmacists in providing admission drug histories. This clinical pharmacy service was present in 2% of the hospitals in 1989[23] and 5% of hospitals in 1998 (a 150% increase).[51] Extrapolating the 3988 fewer actual deaths in hospitals that did not have this clinical pharmacy service to the entire Medicare population of general medical-surgical hospitals would result in 17,906 fewer deaths. A total of 16.71 ± 10.01 minutes/patient were required for pharmacists to provide this service in hospitals that had this service.[23, 51]

This is a very important clinical pharmacy service because it is associated with all of our previous health care outcomes in a positive manner.[2, 42–48] In addition, the number of reduced deaths/hospital (107.78 ± 87.60) is almost twice that of the closest other clinical service (Table 4). Although clearly inefficiencies occur when decentralized pharmacists are used to obtain drug histories, several hospitals have significantly reduced this problem by having pharmacists in the admissions area of the hospital to obtain histories on all patients. Drug histories obtained by pharmacists in the admissions area of the hospital allows efficient assessment of drug therapy, ADRs, disease control, costs, and so forth, in one central location.

Clinical Pharmacy Services Not Associated with Reduced Mortality

Drug Information

Two clinical pharmacy services not associated with reduced mortality rates in this study, but that were associated with reduced mortality rates in our 1992 data,[2] were the following: pharmacist-provided drug information and pharmacist-conducted clinical research. Although the reasons for this observation are unknown, the loss of drug information may reflect the changes in drug informatics that occurred in the 1990s. During the past 15 years, decentralized computer systems, personal digital assistants, and drug information software have changed drug information services from a centralized resource center to decentralized resources. This has allowed pharmacists in patient care areas to obtain drug information rather than rely on a centralized resource. Of interest, a number of well-known drug information centers have closed at least in part due to these changes in technology.[61]

Clinical Research

The reasons why pharmacist-conducted clinical research was not associated with reduced mortality rates in this study are unknown. In the late 1980s and early 1990s, major teaching hospitals were found to have lower mortality rates.[1, 13, 14] Pharmacist-provided clinical research was likely an indicator of a major teaching program. Although there was no documentation that mortality rates in teaching hospitals have changed, this is likely, since JCAHO's Agenda for Change (which was implemented in 1994) dramatically improved outcome measures and compliance for all U.S. hospitals.[62] This probably resulted in a narrowing of the differences between teaching and nonteaching hospitals.[62]

Staffing Variables Associated with Reduced Mortality

Figures 1 and 2 show the graphic relationships between clinical pharmacist and administrative pharmacy staffing and deaths/1000 admissions. Although the curves differ slightly, they both reflect the positive effects of increased staffing levels of clinical and administrative pharmacists. Explaining why increased clinical pharmacist staffing is associated with reduced deaths/1000 admissions is fairly easy, as clinical pharmacist staffing provides the manpower for the hospital to deliver their clinical pharmacy services. Less clear, however, is why the increased staffing level of administrative pharmacists was associated with reduced deaths/1000 admissions. Perhaps some of these differences may be attributable to the level of education of the pharmacy director. In 1992, 50% of the directors of pharmacy had only the bachelor of science (B.S.) in pharmacy degree and 15% had the doctor of pharmacy (Pharm.D.) degree.[27] By 1998, 44% of the directors of pharmacy had only the B.S. in pharmacy degree, and 21% had the Pharm.D. degree. In addition, there were substantially more Pharm.D. degree graduates in 1998 than in 1992 (2632 vs 1216 graduates).[63] Undoubtedly, more hospital pharmacy administrators possessed the Pharm.D. degree in 1998 than in 1992.

Legal Implications of Preventable Events

The 18,401 fewer actual deaths seen in hospitals that had pharmacist-provided drug protocol management represent preventable events (when compared with hospitals that did not have pharmacists providing this service) and have significant legal implications. Fatalities that resulted in legal judgments or settlements cost an additional $1.1 million/death.[64] Thirteen percent of cases in which the patient experienced an adverse drug event or died resulted in litigation with settlements paid to the patient or family.[65] If we applied the 13% figure to these preventable deaths, this would result in legal settlements associated with these preventable deaths of $2,392,130,000. The $2,392,130,000 in legal settlements that could be expected in these cases is significant, in that it does not appear in the Medicare billing costs, but clearly affects hospitals that incur these legal costs. Averting just one successful litigation would pay for all clinical pharmacy services in most hospitals for years.

Core Set of Clinical Pharmacy Services

In previous articles, we developed the concept of a core set of clinical pharmacy services that should be considered for all patients, based on favorable associations with the following seven health care outcomes: mortality rate, drug costs, total cost of care, length of stay, medication errors, medication errors that adversely affect patient outcomes, and ADRs.[1–3, 42–48] If we replaced the older mortality rate data with the data from this study, it would result in the following core set (at least two favorable

associations with the seven health care outcomes) of pharmacist-provided clinical pharmacy services: participation on CPR teams (two favorable associations), in-service education (three), ADR management (four), drug information (four), medical rounds participation (five), drug protocol management (seven), and admission drug histories (seven).[1–3, 42–48] These findings provide strong evidence to support our recommendation that these services suffice as a core set of clinical pharmacy services for all of our patients.

This report, building on our previous reports, provides compelling evidence for the value for clinical pharmacy services and clinical pharmacists. Considerable evidence exists that our discipline continues to make substantial contributions to the care of patients. These findings suggest that the impact of clinical pharmacy services on health care outcomes continues to grow (Table 5). Unmistakably, the findings of this study strongly support the continued development of clinical pharmacy services and the further implementation of these services. Clinical pharmacy, which began in the 1960s, is a relatively young discipline. Development of our discipline has been slow and somewhat plodding. After all, we still do not have any clinical pharmacy services that are universally provided for all patients. It is time that we reach a consensus on what constitutes core clinical pharmacy services and accelerate implementation of these services. Clearly, pharmacy practice organizations, JCAHO, and the American Association of Colleges of Pharmacy are key stakeholders in developing a set of core clinical pharmacy services available to all patients.

Limitations

As with any self-reported data, there can be no absolute assurance that the data are correct. Given the normal delays in obtaining the AHA and MedPAR databases, as well as the time it takes to convert the MedPAR database into a format that can be used for analysis, it is unrealistic to expect studies, like this one, to appear sooner than 5–9 years after the data are collected and the databases are purchased. Although the data in this study may appear to be old, they are the most current available. Study data are from 1998 and may not be representative of health care in 2007.

Information provided to us could possibly be inaccurate. We did not attempt to verify information by phone contact or through hospital visitation. Our study design allowed us to determine strength, association, and direct relationships between variables, but it did not allow us to determine causality. The hospitals in our study population possibly are not representative of all U.S. hospitals. This is doubtful, however, since the study hospitals represented 2,836,991 Medicare patient admissions (23.14% of total admissions). Although the variance (R^2 = 20.81%, adjusted R^2 = 19.96%) may appear low, we would like to remind readers that the variance in this study only explains reasons for deaths for pharmacy variables, not for those from other health care professionals, as well as structure and process variables for hospitals. Caution should be used in applying these findings to individual hospitals.

Conclusion

This study provides continuing evidence for the value of clinical pharmacy services and clinical pharmacists in our nation's hospitals. In addition, these findings strongly suggest that the impact of clinical pharmacists and the services they provide for patients are having a growing effect on health care outcomes. It appears that clinical pharmacy is truly a life-saving discipline.

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Appendix 1. Definitions of Clinical Pharmacy Services

Central Clinical Pharmacy Services

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

In-service education: pharmacist presents continuing education to fellow employees (physicians, nurses, pharmacists, etc.) on a scheduled basis at least 4 times/year.

Drug information: provided only if a formal drug information service with specifically assigned pharmacist 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 toxicity and overdose questions on a routine basis with appropriate resources.

Clinical research: performed by pharmacist either as a principal investigator or coinvestigator. Pharmacist is likely to be (co-) author on 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 (ADR) management: pharmacist evaluates potential ADR while the patient is hospitalized and appropriately follows through with physicians.

Pharmacokinetic consultation: provided only if, 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 needed. Monitoring is ongoing and repeated, often on a daily basis. Do not check if only drug orders are reviewed. Does not include pharmacokinetic consults, total parenteral nutrition (TPN) team, rounds, ADR management, or drug therapy protocol management.

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

TPN team participation: pharmacist, at a minimum, reviews patient's medical records and/or provides written or verbal follow-up if needed.

Drug therapy counseling: pharmacist provides counseling on drugs either during hospitalization or at time of discharge. Do not check if counseling involves solely review of label directions.

Cardiopulmonary resuscitation (CPR) team participation: pharmacist is an active member of the CPR team attending most cardiac arrests when the pharmacist is present in the hospital.

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

Admission drug histories: pharmacist provides admission histories.