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Impact of Relational Coordination on Quality of Care, Postoperative Pain and Functioning, and Length of Stay

A Nine-Hospital Study of Surgical Patients

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BACKGROUND. **Health care organizations face pressures from patients to improve the quality of care and clinical outcomes, as well as pressures from managed care to do so more efficiently. Coordination, the management of task interdependencies, is one way that health care organizations have attempted to meet these conflicting demands.**

OBJECTIVES. **The objectives of this study were to introduce the concept of relational coordination and to determine its impact on the quality of care, postoperative pain and functioning, and the length of stay for patients undergoing an elective surgical procedure. Relational coordination comprises frequent, timely, accurate communication, as well as problem-solving, shared goals, shared knowledge, and mutual respect among health care providers.**

RESEARCH DESIGN. **Relational coordination was measured by a cross-sectional questionnaire of health care providers. Quality of care was measured by a cross-sectional postoperative questionnaire of total hip and knee arthroplasty patients. On the same questionnaire, postoperative pain and functioning were measured by the WOMAC osteoarthritis instrument. Length of stay was measured from individual patient hospital records.**

SUBJECTS. **The subjects for this study were 338 care providers and 878 patients who completed questionnaires from 9 hospitals in Boston, MA, New York, NY, and Dallas, TX, between July and December 1997.**

MEASURES. **Quality of care, postoperative pain and functioning, and length of acute hospital stay.**

RESULTS. **Relational coordination varied significantly between sites, ranging from 3.86 to 4.22 ($P < 0.001$). Quality of care was significantly improved by relational coordination ($P < 0.001$) and each of its dimensions. Postoperative pain was significantly reduced by relational coordination ($P = 0.041$), whereas postoperative functioning was significantly improved by several dimensions of relational coordination, including the frequency of communication ($P = 0.044$), the strength of shared goals ($P = 0.035$), and the degree of mutual**

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respect ($P = 0.030$) among care providers. Length of stay was significantly shortened (53.77%, $P < 0.001$) by relational coordination and each of its dimensions.

CONCLUSIONS. **Relational coordination across health care providers is associated with improved quality of care, reduced postoperative pain, and decreased lengths of hospital stay for patients undergoing total joint arthroplasty. These findings support the design of formal practices to strengthen communication and relationships among key caregivers on surgical units.**

Key words: coordination; quality of care; length of stay; clinical outcomes; arthroplasty. (Med Care 2000;38:807–819)

Healthcare organizations face multiple, apparently conflicting demands. They face pressures from patients to improve the quality of care and clinical outcomes, as well as pressures from managed care to do so more efficiently. Coordination is one way that health care organizations have attempted to meet these demands. According to one administrator interviewed for this study:

> We've moved from patients experiencing individuals as caregivers to patients experiencing systems as caregivers. There's less time to build individual relationships with the patient. It's not just individual brilliance that matters anymore. It's a coordinated effort.

Coordination has been shown to generate improvements in both quality and efficiency performance in nonmedical settings.[1–4] Coordination has also been shown to improve some dimensions of performance in health care settings, particularly emergency and intensive care.[5] In addition, patient focus groups in one landmark study identified the coordination of care as 1 of 7 factors that influence their perceptions of quality.[6]

There is little agreement among practitioners about how to improve the coordination of care, however. Hospitals with limited resources consider clinical pathways, information systems, primary nursing, case management, and interdisciplinary rounds as potential tools to improve the exchange of critical information among care providers. Much of coordination research has focused on the design of formal structures through which coordination occurs.[7–13]

But to design formal practices that facilitate the coordination of care, we argue it is important to better understand what constitutes effective coordination in a given setting. In particular, what are the interactions among care providers that constitute effective coordination? These issues have received far less attention in coordination research. We believe that by better understanding the nature of effective coordination processes in the care of surgical patients, we will be in a better position to design the organizational structures that support those processes. In this report, we measure dimensions of communication and relationships among health care providers, known as "relational coordination," and test their impact on performance.

In particular, the present study investigates whether relational coordination can improve performance simultaneously along both quality and efficiency dimensions, ie, whether improvements can be made in both the quality of care experienced by the patient and clinical outcomes while reducing lengths of stay. We focus on total joint arthroplasty because it is a common surgical procedure that accounts for substantial health care expenditures and has been used to benchmark hospital performance.[14]

On the basis of previous research[15] and existing theory, relational coordination is expected to improve performance in settings characterized by high levels of uncertainty,[16] interdependence,[17] and time constraints.[18] In the health care setting, uncertainty surrounds a given patient's reaction to interventions and the speed of his or her recovery. Interdependencies among health care providers are not the simple sequential hand-offs found on production lines, but rather are iterative, requiring feedback among providers as new information emerges regarding a given patient. Time constraints are imposed by clinical requirements to assess the patient for possible negative reactions and to mobilize the patient in a timely fashion and are further intensified by payor pressures for timely patient discharge. Relational coordination improves quality and efficiency performance in this setting by improving the exchange of information relevant to the care of a given patient.

Methods

Setting and Data Sources

To measure relational coordination and assess its effects on patient outcomes, we conducted a multisite cross-sectional study from July through December 1997 in a convenience sample of 9 hospitals with orthopedic departments that perform total joint arthroplasty. Participants included 4 Boston, MA, hospitals (Massachusetts General Hospital, Brigham and Women's Hospital, Beth Israel Deaconess Medical Center, and New England Baptist Hospital); 3 New York City hospitals (Beth Israel Hospital, Hospital for Joint Diseases, and Hospital for Special Surgery); and 2 Dallas, TX, area hospitals (Baylor University Medical Center and Presbyterian Plano Hospital). One additional New York City hospital was invited to participate and declined. The chief of each orthopedics department agreed to participate, and either he or a colleague served as the coinvestigator and copetitioner to the hospital's institutional review board. The participating orthopedics departments had performed between 353 and 920 total hip or knee arthroplasty procedures in the 6 months preceding the study period. The median volume of total hip and knee arthroplasty is estimated at 256 procedures per year for US hospitals (J.N. Katz, MD, Brigham and Women's Hospital, personal communication), so departments participating in this study were relatively high volume.

Data from the participating hospitals included a patient questionnaire, participants' hospitalization records, and a care-provider questionnaire. The patient questionnaire (154 items) was adapted from a validated instrument that is widely used to assess service quality in health care settings. The questionnaire was designed to assess satisfaction with provider-patient communication, provider's respect for patient's preferences, attentiveness to patient's physical care needs, education of patient regarding medication and tests, quality of relationship between patient and physician in charge, and education of and communication with patient's family regarding care, pain management, and hospital discharge planning.[19] Patients were selected at random from among those admitted to 1 of the 9 hospitals for primary, elective unilateral total joint arthroplasty during the study period with a diagnosis of osteoarthritis. We excluded patients with rheumatoid arthritis and those undergoing revised or bilateral arthroplasty to enhance sample homogeneity. Questionnaires were mailed to all patients between 6 and 10 weeks after discharge. Nonrespondents were sent up to 3 questionnaires.

We sent questionnaires to all eligible care providers in the 5 core disciplines who had clinical or administrative responsibilities for total joint arthroplasty patients during the study period: physicians, nurses, physical therapists, social workers, and case managers (known in some departments as care coordinators). A key departmental administrator (designated by the department chief) identified all eligible care providers at each institution. The administrator was supplied written guidelines as to who should be included (all providers listed above who were directly or indirectly involved with patient care). Questionnaires were mailed to all eligible care providers initially during the second month of the study period, with 1 repeat mailing during the study period for nonrespondents. Providers were asked to comment on ongoing, day-to-day coordination occurring in their units. We were unable to match providers with the patients for whom they provided care. The majority of the orthopedics patients were hospitalized on a single nursing unit in each hospital.

Outcome Variables

Quality of care, postoperative pain and functioning, and length of stay were the outcome measures for this study. We developed a quality-of-care index from the 25 questionnaire items pertaining to the patient's acute-care experience. We excluded 10 items with the potential response "not applicable" because of a large number of missing values. Those items were of the nature, "Did you get answers you could understand from the physician?" with the response option, "Did not have any questions for the physician." The inclusion of those items resulted in a biased subsample of respondents with more questions and problems than the typical respondent.

The 15 questionnaire items that remained were the patients' reported confidence and trust in their physicians, nurses, physical therapists or case managers; knowledge of the identity of the physician, nurse, physical therapist, or case manager in charge of their care; belief that providers were aware of their medical history; belief that providers were aware of their condition and needs; belief that their providers supplied consistent information; belief that their providers worked well to-

gether; belief that they were treated with respect and dignity; satisfaction with their overall care; and finally, intent to recommend the hospital to others. An equally weighted index with potential values from 1 to 5 was created from these 15 items.

Length of stay was calculated from hospital records for each patient as the number of whole days between the date of admission and the date of discharge. Postoperative pain and functional status were assessed from the patient questionnaire with the 5 items relating to pain and 17 items relating to physical functioning from the WOMAC (Western Ontario and McMaster University Osteoarthritis Index), a validated osteoarthritis instrument. The WOMAC is a self-administered instrument that was designed to assess 3 dimensions: pain, stiffness, and physical functioning associated with osteoarthritis of the hip and knee.[20] This instrument has proved useful to assess outcomes after hip or knee arthroplasty.[21] The pain items query patients about amount of pain or degree of difficulty with functioning (5 potential responses ranging from none to severe) experienced in the past 48 hours during common activities. We did not use the stiffness scale. To minimize missing values, we included responses of all patients who completed at least 80% of the items in each of the indices. We assigned the mean of the nonmissing values for each item to missing values for that item. The resulting indices of postoperative pain and functional status have potential values ranging from 1 to 100.

Provider Measures

Relational coordination encompasses 4 communication dimensions (frequent, timely, accurate, and problem-solving communication), as well as 3 relationship dimensions (shared goals, shared knowledge, and mutual respect). The concept of relational coordination was developed and validated in the context of commercial airline flight departures[15] and is expected to be relevant for achieving performance in settings that are highly uncertain, interdependent, and time constrained. The instrument was adapted to the health care setting by including the item "accuracy of communication" and deleting the item "helping across disciplines," given the critical importance of accuracy in this setting and the lesser potential for helping given task boundaries that are enforced by regulatory and professional organizations. On the basis of the original study, relational coordination and each of its individual dimensions were expected to have index reliability scores greater than 0.700.

The questionnaire given to care providers assessed the strength of communication and relationship ties between each respondent and each of the 5 core disciplines involved in the care of total joint arthroplasty patients, including physicians, nurses, physical therapists, social workers, and case managers (Fig. 1). Respondents were asked to assess their interactions with each of the 5 core disciplines along the 7 dimensions of relational coordination. Each dimension of relational coordination was constructed as a 5-item measure, reflecting the respondent's coordination with each of the 5 disciplines. The overall measure of relational coordination was a 7-item measure comprising each of the 7 dimensions of relational coordination.

Individual questionnaire responses were weighted to reflect the interdisciplinary composition of care providers responsible for hip and knee arthroplasty patients in each hospital and to correct for differences in response rates across disciplines. For example, if nurses constituted 60% of the care providers responsible for arthroplasty patients at a given hospital, nursing responses were given 60% of the sample weight. Questionnaire responses were averaged together within disciplines, then across disciplines to create hospital-level measures of relational coordination with potential values from 1 to 5.

Control Variables

All patients were admitted with a diagnosis of osteoarthritis for unilateral, primary hip, or knee arthroplasty. Control variables for this study included patient age, comorbidities, overall mental health, preoperative pain, preoperative functioning, surgical procedure (hip vs. knee arthroplasty), number of days between surgery and questionnaire completion, marital status, race, and sex. Patient age and sex were determined from hospital records. Comorbid conditions were assessed in the patient questionnaire with a series of questions asking patients whether they had heart disease, high blood pressure, diabetes, ulcer or stomach disease, kidney disease, anemia or other blood disease, cancer, depression, or back pain.[22] The resulting index of comorbidities was computed as the number of comorbid conditions reported by the respondent. The SF-36 is a brief,

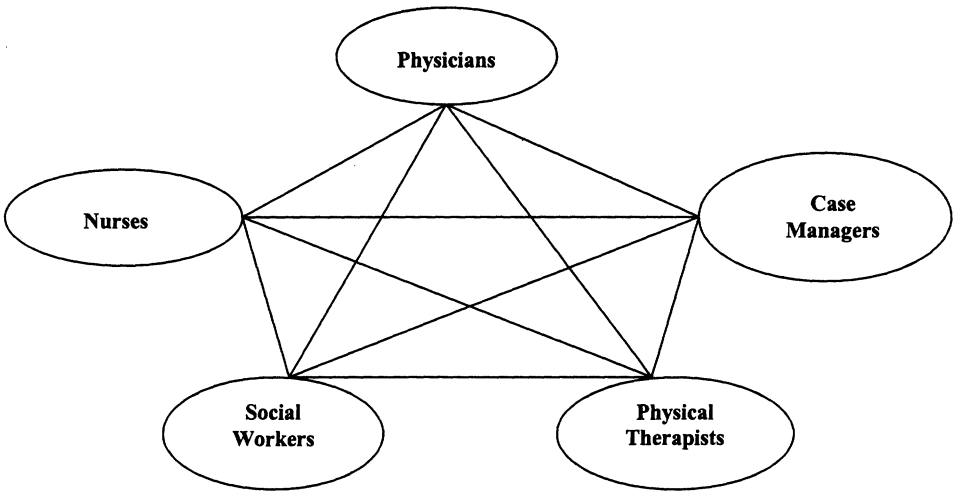

FIG. Patient care coordination. Each line in this diagram represents a tie that was measured by the relational coordination survey.

internally consistent, and valid health-related quality-of-life instrument.[23,24] It is organized into 8 dimensions: physical function, role function (physical), role function (emotional), bodily pain, social functioning, mental health, vitality, and general health perceptions. Overall mental health was assessed in our patient questionnaire using the mental health component, which has been shown to be sensitive to clinical change after hip arthroplasty.[25] The mental health items were averaged to construct a score of overall mental health, an approach that has been validated elsewhere.[26] Preoperative pain and functioning were measured in the same way as postoperative pain and functioning with the WOMAC instrument, with the same treatment of missing values. We asked patients to report the date on which they completed the questionnaire to determine the number of days between surgery and questionnaire completion. We also queried patients about race and marital status in the questionnaire.

In addition to patient characteristics, we collected measures of the volume of total joint arthroplasties conducted in each hospital in the 6-month period before the study period. Previous research has identified positive effects of the volume of procedures on clinical outcomes, whether due to the effects of learning or economies of scale.[27]

Statistical Analysis

Descriptive Analysis. We tested the indices of relational coordination and quality of care for reliability using Cronbach's alpha, a test of index reliability based on interitem correlation. Cronbach's alphas for the individual dimensions of relational coordination ranged from 0.717 to 0.840, exceeding the 0.700 recommended minimum level of index reliability.[28] Cronbach's alpha was 0.849 for the overall index of relational coordination and 0.844 for the quality-of-care index, both of which well exceeded the recommended minimum level of index reliability.

We assessed cross-site differences in relational coordination, patient characteristics, and unadjusted patient outcomes using 1-way analysis of variance. We examined correlations between hospital response rates and each measure of patient outcome, as well as correlations between hospital response rates and each measure of coordination.

Random-Effects Linear Regression. For each model presented in this article, random-effects modeling was used to adjust coefficients and standard errors for the multilevel (patient/hospital) nature of the data, with hospital as the random effect. Random-effects models, also known as mixed, hierarchical linear, or multilevel models, are an extension of fixed-effects models and are well known in the statistical literature.[29,30]

Models of Relational Coordination as a Predictor of Quality of Care. The impact of relational coordination on quality of care was assessed by random-effects linear regression with the quality-of-care index as the dependent variable (n = 518 patients for whom quality of care and

covariates were available). The variable of interest was the index of relational coordination, with the hospital (n = 9) as the unit of measurement. In addition, each of the 7 dimensions of relational coordination was entered individually into separate models (without the overall index) to assess the association of each individual dimension with quality of care.

We included in each model the covariates expected to affect quality of care and clinical outcomes, on the basis of previous literature on arthroplasty and quality of care[19] and on the basis of clinical appropriateness. These included age, comorbidities, overall mental health, surgical procedure (hip vs. knee), sex, race, marital status, and volume of procedures. We elected not to eliminate any covariates from the final model, both to minimize residual confounding and because no covariate was collinear with our variable of interest (relational coordination). We present regression coefficients, 95% confidence intervals, and exact *P* values.

Models of Relational Coordination as a Predictor of Length of Hospital Stay. The relationship between relational coordination and length of hospital stay was evaluated (n = 599 patients for whom length of stay and covariates were available) by random-effects linear regression with length of stay as the dependent variable. Length of stay was log transformed to correct its skewness. Base 10 logarithms were used to improve interpretability of results. The index of relational coordination was the variable of interest, with the hospital (n = 9) as the unit of measurement. In addition to the main model that used the relational coordination index, we entered each dimension of relational coordination individually into separate models (without the overall index) to assess its association with length of stay.

We included the same covariates as for the quality-of-care model described above, and we also adjusted for preoperative clinical status, calculated by combining the 6 items from the preoperative pain index with the 16 items from the preoperative functioning index. We present percent decrease in length of hospital stay, 95% confidence intervals, and exact *P* values.

Models of Relational Coordination as a Predictor of Clinical Outcomes. We evaluated the relationships between relational coordination and 2 clinical outcomes: postoperative pain and functional status. Both of these outcomes were derived from patient responses to the WOMAC osteoarthritis instrument included in the mailed postoperative questionnaire.[20] In linear regression models that used the relational coordination index to predict postoperative pain (n = 539 patients with complete data for analysis), we included age, comorbidities, overall mental health, surgical procedure (hip vs. knee), preoperative pain, sex, race, marital status, and number of days between surgery and questionnaire response. We also included volume of procedures to capture possible effects of learning or economies of scale. In separate random-effects regression models with postoperative functional status as the dependent variable, we had 531 patients with complete data for analysis. The postoperative functional status models included the same covariates as the postoperative pain models, except preoperative functioning was included instead of preoperative pain.

Results

Response Rates

We received responses to 878 of 1,367 questionnaires sent to patients in the target population, for a response rate of 64%. Patient response rates varied significantly between hospitals, ranging from 55% to 71%. These differential patient response rates suggest the potential for response bias. However, none of the 15 elements of quality of care was significantly associated with patient response rates by hospital. Similarly, length of stay was not significantly associated with patient response rates by hospital. However, postoperative pain ($P = 0.026$) and mobility ($P = 0.038$) were significantly associated with patient response rates by hospital. Hospitals with better overall pain and mobility scores tended to have higher patient response rates.

We received responses from 338 of 666 providers, for an overall provider response rate of 51%. Sixty-seven percent of physicians responded, as did 35% of nurses, 73% of physical therapists, 92% of social workers, and 94% of case managers. Overall provider response rates also varied between hospitals, ranging from 38% to 75%. As with our patient response rates, these differential provider response rates across hospitals raise concern for response bias. However, none of the correlations between provider response rates and each of our coordination measures approached statistical significance, which suggests response

bias is less likely to threaten the validity of our assumptions.

Patient Characteristics and Outcomes

Table 1 shows patient characteristics and unadjusted outcomes by site. The mean overall age of patients was 66.9 years; 58% were female, 6% were black, and 64% were married. Hip arthroplasty constituted 43% of hospital procedures, and the mean interval between surgery and questionnaire response was 80.6 days. Mean 6-month volume of arthroplasty procedures was 458, including patients with diagnoses other than osteoarthritis. Significant differences were detected across sites with regard to percent hip arthroplasty, interval since surgery, race, and marital status. Cross-site differences were statistically significant for quality of care, length of stay, and postoperative freedom from pain.

Relational Coordination

Table 2 shows the individual measures of relational coordination (possible values 1–5) by site. With the exception of mutual respect, significant cross-site differences were found for all measures of relational coordination.

Models of Relational Coordination as a Predictor of Quality of Care

Table 3 shows adjusted models of quality of care and length of stay. Improved quality of care was significantly associated with higher levels of relational coordination among care providers (linear regression coefficient 1.068, $P < 0.001$). This result suggests that a 1-point increase in relational coordination on a 5-point scale is associated with slightly more than a 1-point increase in patient-perceived quality of care on a 5-point scale. The model accounted for 74% of between-hospital variation in the quality of care, relative to just 20% if relational coordination was dropped from the model. All individual dimensions of relational coordination were significantly associated with improved quality of care (Table 3). Age, overall mental health, and marital status were also significantly associated with improved quality of care. No other covariates reached statistical significance in the quality-of-care models.

Models of Relational Coordination as a Predictor of Lengths of Stay

Lengths of stay were also significantly associated with relational coordination among care providers: a 1-point increase in relational coordination was associated with a 53.77% decrease in the length of stay (95% CI 44.41%–61.45%). The model accounted for 81% of between-hospital variation in length of stay, compared with only 26% if relational coordination was dropped from the model. All individual dimensions of relational coordination were also significantly associated with shorter lengths of stay (Table 3). Other significant correlates of decreased lengths of stay were fewer comorbidities and better overall mental health. In addition, the volume of procedures in a given hospital was associated with significantly longer patient lengths of stay.

Models of Relational Coordination as a Predictor of Postoperative Freedom From Pain

Table 4 shows models of relational coordination as a predictor of postoperative freedom from pain and functioning. Postoperative freedom from pain was associated with the overall index of relational coordination (linear regression coefficient 10.915, $P = 0.041$). The model accounted for 46% of the between-hospital variation in postoperative freedom from pain, compared with 37% if relational coordination was dropped from the model. Freedom from pain also was significantly associated with 4 dimensions of relational coordination: frequency of communication, shared goals, shared knowledge, and mutual respect. Other significant correlates of postoperative freedom from pain included greater preoperative freedom from pain, hip rather than knee replacement, and overall mental health.

Models of Relational Coordination as a Predictor of Postoperative Functioning

Finally, postoperative functioning was not significantly associated with the overall index of relational coordination (Table 4). The model accounted for 17% of the between-hospital variation in postoperative functioning, compared with 9% if relational coordination was dropped from the model. Postoperative functioning was associated with 3 dimensions of

TABLE 1. Mean Patient Characteristics, Hospital Volume, and Unadjusted Outcomes by Site

Variable	Hosp 1 (n = 109)	Hosp 2 (n = 93)	Hosp 3 (n = 125)	Hosp 4 (n = 135)	Hosp 5 (n = 65)	Hosp 6 (n = 67)	Hosp 7 (n = 97)	Hosp 8 (n = 70)	Hosp 9 (n = 48)	Mean (n = 809)	SD	*P*
Patient characteristics												
Age	66.3	67.2	67.2	67.3	67.6	65.9	66.4	67.2	66.6	66.9	11.1	0.9887
Comorbidities index	1.5	1.7	1.4	1.4	1.3	1.7	1.6	1.5	1.7	1.5	1.3	0.4988
Overall mental health	3.3	3.1	3.2	3.2	3.2	3.2	3.3	3.3	3.4	3.2	1.0	0.8282
Pre-op freedom from pain	43.3	38.9	44.8	45.1	43.9	42.4	41.9	46.6	43.5	43.5	19.6	0.3860
Pre-op functional status	48.6	40.6	46.8	48.6	48.9	48.5	44.5	49.2	48.5	47.0	21.2	0.1929
Days since surgery	78	85	83	80	75	80	84	78	76	81	17	0.0015
% Female	61	66	58	50	60	49	62	63	58	58	49	0.2753
% Black	13	11	5	2	0	6	6	9	0	6	24	0.0009
% Hips	24	45	59	43	43	48	40	47	40	43	50	0.0001
% Married	64	52	73	62	77	50	68	65	63	64	48	0.0079
Hospital characteristics												
Arthroplasty volume	458	362	920	527	400	363	501	353	400	476	177.9	
Outcomes												
Quality-of-care index	3.50	3.79	3.95	4.71	4.51	4.36	3.95	4.51	3.75	4.10	0.67	0.0000
Length of stay, d	5.6	5.8	5.9	4.4	4.2	4.4	5.6	4.3	5.0	5.1	2.1	0.0000
Post-op freedom from pain	72.3	71.1	78.7	77.6	74.8	79.6	73.8	77.3	76.5	75.8	20.8	0.0924
Post-op functional status	72.2	68.6	74.6	74.2	73.0	76.5	71.2	74.9	76.7	73.3	19.8	0.2864

Hosp indicates hospital; Pre-Op, preoperative; % Hips, percentage of hip (vs. knee) arthroplasties performed; and Post-Op, postoperative. n = number of patient respondents.

TABLE 2. Mean Relational Coordination by Site

Variable	Hosp 1 (n = 52)	Hosp 2 (n = 51)	Hosp 3 (n = 33)	Hosp 4 (n = 40)	Hosp 5 (n = 15)	Hosp 6 (n = 27)	Hosp 7 (n = 33)	Hosp 8 (n = 39)	Hosp 9 (n = 46)	Mean (n = 336)	SD	P
Relational coordination	3.90	3.86	3.94	4.17	4.10	4.22	4.08	4.06	4.04	4.02	0.45	0.0001
Frequent communication	3.65	3.70	3.89	4.08	3.87	4.05	3.82	4.05	3.64	3.84	0.73	0.0000
Timely communication	3.98	3.83	3.86	4.22	4.41	4.35	4.11	4.17	4.08	4.07	0.62	0.0000
Accurate communication	4.18	3.92	4.00	4.43	4.34	4.36	4.28	4.35	4.25	4.22	0.61	0.0007
Problem-solving	3.94	3.84	3.86	4.24	4.08	4.21	4.01	4.14	4.14	4.04	0.46	0.0000
Shared goals	4.13	4.06	4.20	4.28	4.21	4.33	4.19	4.17	4.16	4.18	0.62	0.0125
Shared knowledge	3.68	3.82	3.88	3.98	3.95	4.21	4.01	3.75	3.80	3.87	0.58	0.0000
Mutual respect	3.68	3.75	3.93	3.97	3.78	4.05	3.97	3.72	3.73	3.83	0.62	0.1463

Hosp indicates hospital. n = number of care-provider respondents.

relational coordination, however: frequency of communication, shared goals, and mutual respect among care providers. Other significant correlates of postoperative functional status included higher levels of preoperative functioning, hip rather than knee replacement, and overall mental health.

TABLE 3. Impact of Relational Coordination on Quality of Care and Length of Stay

	Quality of Care*		Percent Decrease in Length of Stay†	
Variable	Adjusted Coeff. (P)	95% CI	Adjusted Coeff. (P)	95% CI
Relational coordination	1.068 (<0.001)	0.656, 1.480	53.77 (<0.001)	44.41, 61.45
Frequent communication	0.929 (<0.001)	0.593, 1.265	45.67 (<0.001)	37.05, 53.22
Timely communication	0.737 (<0.001)	0.406, 1.067	47.88 (<0.001)	39.61, 54.92
Accurate communication	0.738 (<0.001)	0.394, 1.082	44.41 (<0.001)	34.99, 52.36
Problem-solving	0.897 (<0.001)	0.499, 1.294	50.34 (<0.001)	40.72, 58.50
Shared goals	1.701 (<0.001)	0.930, 2.463	74.65 (<0.001)	64.68, 81.80
Shared knowledge	0.598 (<0.001)	0.349, 0.847	31.18 (<0.001)	21.84, 37.48
Mutual respect	0.942 (<0.001)	0.472, 1.411	41.92 (<0.001)	28.39, 52.79

Coeff. indicates coefficient.

*Quality-of-care models are adjusted for hospital arthroplasty volume, patient age, comorbidities index, surgical type (hip vs. knee), sex, race, marital status, and overall mental health. Number of patients = 518.

†Length-of-stay models are adjusted for hospital arthroplasty volume, patient age, comorbidities index, surgical type (hip vs. knee), sex, race, marital status, overall mental health, and preoperative pain and functioning. Number of patients = 599.

TABLE 4. Impact of Relational Coordination on Postoperative Pain and Functioning

Variable	Postoperative Freedom From Pain*		Postoperative Functioning†	
	Adjusted Coeff. (*P*)	95% CI	Adjusted Coeff. (*P*)	95% CI
Relational coordination	10.915 (0.041)	0.433, 21.598	7.762 (0.123)	−2.095, 17.620
Frequent communication	11.092 (0.011)	2.572, 19.611	8.238 (0.044)	0.204, 16.272
Timely communication	4.941 (0.254)	−3.543, 13.425	2.251 (0.584)	−5.811, 10.312
Accurate communication	3.100 (0.491)	−5.714, 11.913	0.928 (0.827)	−7.392, 9.247
Problem-solving	9.953 (0.054)	−0.178, 10.084	7.784 (0.107)	−1.679, 17.246
Shared goals	21.989 (0.022)	3.130, 40.848	19.326 (0.035)	1.410, 37.243
Shared knowledge	6.634 (0.040)	0.309, 12.958	4.497 (0.139)	−1.468, 10.461
Mutual respect	14.503 (0.013)	3.023, 25.994	12.212 (0.030)	1.205, 23.219

Coeff. indicates coefficient.

*Postoperative pain models are adjusted for hospital arthroplasty volume, patient age, comorbidities index, surgical type (hip vs. knee), sex, race, marital status, overall mental health, and preoperative pain. Number of patients = 539.

†Postoperative functioning models are adjusted for hospital arthroplasty volume, patient age, comorbidities index, surgical type (hip vs. knee), sex, race, marital status, overall mental health, and preoperative functioning. Number of patients = 531.

Random-Effects Linear Regression

All of the above models were estimated with random-effects linear regression to account for the multilevel (patient/hospital) structure of the data. After accounting for the factors in these models, however, the differences in patient outcomes across hospitals were no greater than would be expected from a random assignment of patients to hospitals. As a result, the coefficients and standard errors estimated through random effects did not differ from those estimated by ordinary least squares regression.

Discussion

We described the concept of relational coordination and tested its impact on outcomes for arthroplasty patients. Significant associations were observed between relational coordination and several important outcomes for surgical patients: patient-perceived quality of care, length of stay, and postoperative pain. In addition, several dimensions of relational coordination were associated with postoperative functioning. Recent interest among medical centers in improving patient-perceived quality of care makes these findings immediately applicable to clinical practice. In an era dedicated to cost savings, shorter lengths of stay have become a necessity. We note further that the decrease in length of stay was not achieved at the expense of either the quality of care perceived by patients or clinical outcomes.

Positive effects of coordination have been reported in other health care settings. Improved patient care coordination in hospital emergency units was reported to improve promptness and quality of care, although as perceived by providers rather than patients.[11] Studies in intensive care units (ICUs) have found lower mortality rates,[31] shorter lengths of stay,[32] and fewer deaths and readmissions[33] associated with increased caregiver interaction and interdisciplinary care coordination. A more recent study of ICUs showed a 3-fold increase in mortality associated with lack of daily rounds by an ICU physician.[34]

At least 1 previous study has addressed the impact of coordination in nonintensive care, non-

emergency settings. The National VA Surgical Risk Study showed an inverse association between coordination and surgical morbidity rates[35] and a positive association between coordination and provider-perceived quality of care.[36]

This study makes 4 new contributions to our understanding of patient care coordination. First, no previous study has demonstrated the impact of improved coordination on the quality of care as experienced by patients. This study therefore helps to address the need identified in a recent report[37] to find ways to improve the patient experience in health care settings. Second, decreased length of hospital stays as a result of improved coordination has not been demonstrated previously outside the intensive care setting. Third, no previous study has demonstrated the impact of improved coordination on postoperative pain. Finally, this study documents the performance impact of a new, broader concept of coordination. This study shows that important patient outcomes are influenced by the frequency, timeliness, and accuracy of communication among health care providers, and by the strength of problem-solving, shared goals, shared knowledge, and mutual respect among those providers.

This study has several limitations. We were unable to collect data on surgical complications and morbidity. Such data may have allowed us to test the impact of relational coordination on complications and morbidity in addition to postoperative pain and functioning. However, complications and morbidity are relatively rare in total joint arthroplasty and might be expected to be correlated with length of hospital stay.

Second, preoperative freedom from pain and functional status were measured based on patient recall and therefore may suffer from recall bias. Patients asked to recall preoperative pain and functioning several years after surgery were found to significantly misreport their condition.[38] However, our questionnaire was conducted within several months after surgery; this brief delay may be less likely to impair patient recall. Third, our study was conducted in only 9 medical centers because of funding constraints. This factor may limit the generalizability of the study beyond larger-volume centers. Further research should be performed to confirm that the principles of relational coordination apply in small-volume centers as well. Fourth, we were unable to match responses from specific providers and patients. However, we expect that the degree of coordination in a particular care unit would apply to the majority of the patients receiving care on that unit. Also, our patient and provider surveys were not simultaneous. However, the study took place over a relatively brief (6 month) period, and we are unaware of any major restructuring efforts during this period. Despite this, the potential measurement error introduced by lack of provider-patient matching and time differences would tend to bias our effect estimates toward the null.

Finally, although patient and provider response rates were reasonable for a mailed questionnaire (64% and 51%, respectively), both varied significantly by hospital site. Patient response rates by hospital were not correlated with the quality of care or length of stay, but they were correlated with postoperative pain and functioning, presumably because patients with better clinical outcomes were more likely to complete the survey. It is impossible to determine in which direction the overall results might be biased. The provider response rate, however, which was lower than the patient response rate and differed more significantly across hospitals, was not correlated with any measures of coordination among providers.

Despite these limitations, our study results have important implications for health care providers and administrators. Surgical care is increasingly managed via clinical pathways. Our data support the need for frequent, high-quality communication and strong relationships among health care providers to maximize the quality of care, improve the efficiency of care, and improve clinical outcomes. It is our opinion that clinical pathways cannot replace contacts between providers during patient care. Given the findings we have reported here, this question warrants further research.

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