Published in final edited form as:

J Nurs Meas. 2015 ; 23(3): 379–392. doi:10.1891/1061-3749.23.3.379.

Confirmation of the Validity of the Relational Coordination Survey as a Measure of the Work Environment in a National Sample of Infection Preventionists

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Abstract

Healthcare-associated infections (HAIs) are leading causes of morbidity and mortality. Prevention of HAIs requires multifaceted approaches that consider the work environment in which interventions are implemented. This study assessed the construct validity of the Relational Coordination Survey (RCS) as a measure of the work environment in infection prevention departments.

Data were obtained from 614 Infection Preventionists (IPs). Factor analysis and structural equation modeling tested the hypothesized model.

Cronbach's alpha for the 28-item RCS was .91. Factor analyses confirmed a 4-factor solution that explained 58.17% of the variance. The fit indices for the model indicated an adequate fit (χ^2 (346) = 699.38, $p < .00$; CFI = .94; RMSEA = .06).

The RCS may be a useful tool for measuring aspects of the work environment for IPs.

Introduction

Healthcare-associated infections (HAIs) are a leading cause of morbidity and mortality in the U.S. (Klevens et al., 2002), due to an annual incidence estimated at two million cases (Scott, 2009), with up to 99,000 patients dying each year (Klevens et al., 2002). The prevention of HAIs requires a multifaceted, theoretically-based approach that considers the organizational context in which HAI prevention interventions are being implemented (Dixon-Woods, Bosk, Aveling, Goeschel, & Pronovost, 2011; Pronovost et al., 2010; Pronovost et al., 2006; Shekelle et al., 2010). The Quality Health Outcomes Model (QHOM) is a theoretical framework that proposes relationships between the variables of organizational context, which includes the construct of the work environment, HAI prevention interventions, client characteristics, and HAI outcomes (Mitchell, Ferketich, Jennings, & Care, 1998). To test these relationships, instruments that measure the concepts of interest are needed.

The work environment includes the concepts of teamwork, collaboration, and communication (Aiken & Patrician, 2000; Estabrooks et al., 2002; Lake, 2002). An instrument that has been used to measure these concepts within infection prevention programs is the Relational Coordination Survey (RCS). This paper will address the assessment of the measurement properties and construct validity of the items of the RCS as a measure of the work environment for infection prevention departments. This was part of a larger project that studied the work environment as a sub-concept of organizational context, and HAI prevention interventions, and outcomes, using structural equation modeling (Gilmartin, 2014).

BACKGROUND AND CONCEPTUAL FRAMEWORK

The RCS is based on the concept of relational coordination, which is an emerging theory for understanding the relational dynamics of coordinating work (Gittell, 2012). According to the theory, coordination that occurs through frequent, high quality communication supported by relationships of shared goals, shared knowledge, and mutual respect enables organizations to better achieve their desired outcomes (Gittell, 2012).

The concept of relational coordination is made up of four communication dimensions including frequent, timely, accurate and problem-solving communication, and three relationship dimensions based on shared goals, shared knowledge, and mutual respect. These dimensions are seen as mutually reinforcing and appear to have a significant impact on the quality and efficiency of patient care (Gittell, 2012). The theory of relational coordination was initially developed to study task coordination to improve airline safety and has now been extended to the healthcare setting.

The RCS was selected to examine the communication, coordination, and relationship patterns between Infection Preventionists (IPs), bedside clinicians, and other hospital staff for a large, national survey of infection prevention departments (Stone et al., 2014). A strength of the RCS is the focus on the relationships between roles rather than on relationships between unique individuals (Gittell, 2012). This has a practical advantage for it allows for an assessment of the interchangeability of employees, an important consideration

for organizations that strive to sustain prevention programs even during staff turnover (Gittell, 2012). The instrument has investigated relational coordination on inpatient units (Gittell et al., 2000; Gittell, Seidner, & Wimbush, 2010) and in nursing homes (Gittell, Weinberg, Pfefferle, & Bishop, 2008), but has not been used with infection prevention programs.

Infection prevention departments are unique in the hospital setting for their staff traditionally do not provide direct clinical services, but work directly with clinicians and administrators to implement, organize, and evaluate the effectiveness of prevention activities, conduct surveillance, investigate adverse outcomes, and record and analyze large amounts of data for use in performance improvement programs (Murphy et al., 2012). The use of the RCS in a new population, plus the need to study the RCS as a construct of the work environment, made an assessment of the psychometric properties of the instrument necessary.

Procedures for Instrument Development

Building on the use of the theory of relational coordination in the airline industry, Gittell and colleagues (2000) developed the RCS for healthcare to measure the degree of relational coordination between different categories of caregivers. The RCS was created as a seven-item survey that addresses each of the relational coordination dimensions. The questions are posed to selected caregiver categories (i.e. bedside nurses, physicians, therapists) that interact with each other. The seven items are repeated for each group to measure coordination between different caregiver categories. Ideally, the RCS is distributed to multiple caregiver groups to capture aspects of relational coordination from the varied perspectives of healthcare professionals, but this is oftentimes not feasible due to study design or financial restraints. To date, relational coordination from the perspective of the bedside nurse is the most frequently studied population (Gittell, 2012).

Since its inception, the RCS has been used to examine the relationships between relational coordination and patient outcomes. In a study of total joint arthroplasty patients, the authors reported that high levels of relational coordination was associated with improved quality of care, reduced postoperative pain, and decreased lengths of hospital stay (Gittell et al., 2000). In a subsequent study on inpatient medical units, the authors reported that high levels of nurse/physician relational coordination significantly predicted lengths of stay, total costs per stay and readmissions (Gittell, Weinberg, Bennett, & Miller, 2008). Finally, in a national sample of medical-surgical units, the authors reported that relational coordination did not influence patient satisfaction (Bacon & Mark, 2009).

To date, only one study has used the RCS to examine the impact of relational coordination on HAIs. In a study of five acute care community hospitals in rural Pennsylvania, bedside nurses were asked to report their perceptions of relational coordination with five other caregivers: nurses on their units, nurses working on other units, physicians, support staff on their unit, and therapists. The quality of patient care was measured through the respondents perception of the overall quality of care, the frequency of medication errors, patient or family complaints, frequency of patient falls, and frequency of HAIs (Havens, Vasey, Gittel, & Lin, 2010). The authors reported that as relational coordination increased between

caregivers, nurses reported less frequent patient and family complaints ($p < 0.01$), less frequent medication errors ($p < 0.01$), fewer HAIs ($p < 0.01$), and fewer patient falls ($p < 0.05$) (Havens et al., 2010).

A psychometric assessment of the seven dimensions of relational coordination found in the RCS was conducted by Gittell and colleagues (2010), using a convenience sample of nine hospitals that provided surgical care for joint replacement patients. The RCS was distributed to physicians, nurses, physical therapists, case managers, and social workers. The authors reported a Cronbach's alpha of 0.86. An exploratory factor analysis suggested that the seven dimensions of relational coordination were best represented as a single factor. The eigenvalue for the single factor was reported as 3.41.

METHODS

Sample

The data for this analysis was drawn from an existing dataset collected in the conduct of the Prevention of Nosocomial Infection and Cost-effectiveness-Refined (P-NICER) study (National Institutes of Health, RO1NR010107: Stone, P.). A sample of 614 hospitals were selected for testing of the RCS. Data from 307 of the hospitals (307 EFA dataset) were randomly selected for exploration of the RCS factor structure, while the remaining 307 hospitals (307 CFA dataset) were used for confirmation of the structure. The split samples were equally representative of the P-NICER study population (Table 1. Demographic Characteristics of Samples).

The P-NICER study was a three-year, mixed method study that employed qualitative and quantitative methods to survey eligible National Health Safety Network hospitals. An electronic survey was sent to participating hospital infection control departments with a request for a single IP to respond and provide data on the structure, resources, measures of organizational climate, and their perception of relational coordination of the infection control department in their hospital (Stone et al., 2014). IPs were the targeted population for the P-NICER study due to their primary role as nurse leaders in organizational programs to decrease HAIs. The P-NICER study was approved by the Columbia University Medical Center, New York University Medical Center, and RAND Corporation. The Colorado Multiple Institutional Review Board approved the secondary data analysis study.

Description and Scoring of the RCS Instrument

The RCS used in the P-NICER study was a 28-item questionnaire adapted from the original instrument by Gittell et al. (2000). The survey questions were modified to query relational coordination between IPs and physicians (MDs), bedside nurses (RNs), environmental services (EVS), and hospital administration (HA) (Figure 1. Model of Relational Coordination for Infection Preventionists).

The P-NICER study asked responding IPs to rate the *frequency, timeliness, accuracy, and problem-solving nature of communication with each professional group* on a one to five scale (one indicating never and five indicating always). The next section asked *when problems arise regarding infection control, does the professional group tend to blame others*

or work with infection control to solve the problem (one indicating always blame and five indicating always solve). The final questions assessed *how much the professional group knows about the role of infection control, how much they respect the role, and how much they share the departments goals* (one indicating nothing and five indicating everything).

A strength of this method was that the respondents were asked to report behaviors of others as opposed to being asked to report their own behaviors. In theory, this lessens the problem of socially desirable responses (Rosenthal & Rosnow, 1991). In addition, the respondents were asked to report typical patterns rather than specific incidents. This reduces the problem of retrospective response error (Freeman, Romney, & Freeman, 1987). It should be noted that the RCS, in this sample of IPs, queried relational coordination from a single caregiver perspective.

The scoring of the RCS was based on the criteria from the instrument developers, which indicated that each of the 28-items could be averaged for each respondent (Gittell, 2012). The data could then be aggregated to the group level, based on the seven dimensions described in the theory of relational coordination (i.e. frequency, timeliness, accuracy, etc.), though this was not performed in this study due to the exploratory nature of the analysis.

Procedure and Approaches to Reliability and Validity

An adequate sample size is an important consideration when attempting factor analysis. Due to this, an a priori power calculation, run with power parameters set at 0.8, an alpha of 0.05 (power = .95), a null hypothesis root mean square of approximation (RMSEA) at 0.05, and an alternative hypothesis at 0.45, was conducted (MacCallum, Browne, & Cai, 2006). The calculation recommended a minimum sample size of 312 for the EFA and CFA analyses. The sample of 614 hospitals that were available in the P-NICER dataset were deemed adequate to allow splitting of the dataset and detection of differences between the proposed models (MacCallum et al., 2006).

An exploratory factor analysis (EFA) was initially conducted for it is a useful statistical method for understanding latent constructs, refining measures, and evaluating construct validity (Conway & Huffcutt, 2003). This was followed by a CFA, within a SEM framework, to confirm the relationships between the measured items of the RCS and the proposed latent constructs. Since the aim of this project was to assess the measurement properties and construct validity of the RCS, CFA was an appropriate approach for the investigation.

Analyses were conducted using SPSS™, version 22 for the EFA and Mplus™, version 22 for the CFA. The first step was to evaluate the descriptive properties of the full, and split datasets (Table 2. Descriptive Statistics of the Samples). The scaling structures were evaluated to determine if there was adequate variability to perform statistical analysis and to test the distributions for the assumption of normality. The distribution of the individual responses of the RCS resulted in a non-normal distribution (Shapiro-Wilk (592df) = .76 – .86, $p < 0.00$) (Field, 2009). The data were negatively skewed, with scores clustered at the higher end of the scale. Due to a lack of variance noted in the 1–5 scale responses (Table 2), the items were collapsed to dichotomous results to improve variability. The never/rarely/

occasionally (1–3) responses were recoded to a score of one, the often/always (4–5) responses to a score of two, which improved the variability in responses. Due to these findings, the analyses were conducted using the dichotomous scored RCS items.

The EFA was conducted using a principal component analysis (PCA) factor extraction method and a varimax rotation. The selection of factors was guided by Kaiser's rule of selecting eigenvalues greater than one, and a similar convergence point on a scree plot (Conway & Huffcutt, 2003). The items with the largest loadings on a particular factor were assessed for similarity to a latent variable (i.e. loadings greater than .65) and were assigned a theoretically guided label (DeVellis, 2003).

The CFA was conducted using a robust weighted least mean square estimation estimate (WLSMV) for it is an appropriate method for non-normal, categorical data if the sample size is 200 or better (Ullman, 2007). The model from the EFA was initially tested, followed by a correlated model. The final step was the testing of the validity of the RCS as a measure of the work environment through the creation of a second-order measurement model.

The fit of the models were evaluated by assessing various statistics that assess the closeness of the model fit of the estimated population covariance matrix to the sample covariance matrix (Ullman, 2007). The chi-square (χ^2) statistic was initially used to assess the magnitude of the discrepancy between the sample and the fitted covariance matrices. One of the challenges with the χ^2 statistic is that it is sensitive to large sample sizes; a small discrepancy may lead to rejection of the model, even though the model may fit the data well. (Ullman, 2007). Due to this, additional goodness of fit indices were used to assess the model fit, such as the comparative fit index (CFI) and RMSEA (Table 3. Goodness of Fit Indices).

Results

The EFA, run on the 307 EFA database, resulted in a Kaiser-Meyer-Olkin (KMO) measure of .87, verifying the sampling adequacy for the analysis (Field, 2009). The Bartlett's test of sphericity was significant, (χ^2 (378) = 4,896.30, $p < 0.00$) indicating that the correlations between items were sufficiently large for PCA (Field, 2009). The factor analysis resulted in four components with eigenvalues over Kaiser's criterion of one that, in combination, explained 58.17% of the variance. The scree plot showed inflexion at the fourth component number, justifying the retention of four factors (Field, 2009).

Each measured item loaded only on a single factor that matched the professional groupings of the instrument, indicating the model was identified (McDonald & Ringo Ho, 2002). The seven items that clustered on component one were labeled HA relational coordination (.73–.81), the seven items that clustered on component two were labeled EVS relational coordination (.55–.81), the seven items that clustered on component three were labeled MD relational coordination (.54–.81), and the final seven items that clustered on component four were labeled RN relational coordination (.48–.80). The Cronbach's alpha for each subscale (HA = .92; EVS = .87; MD = .84; RN = .83) and the entire scale (.91) indicated support for the internal reliability of the measured items in a four factor structure (Tabachnick & Fidell, 2007).

The four-factor measurement model, with latent variables labeled as HA, EVS, MD, and RN relational coordination (Figure 2. Exploratory Factor Analysis: RCS Measurement Model) was then tested as a correlated model in the 307 CFA database using CFA techniques within a SEM framework. Due to the large sample size, the chi-square statistic for the model was significant, however, the other indicators of fit suggested that the model provided an adequate description of the pattern of relationships in the data ($\chi^2 (344) = 723.08, p < 0.00$; CFI = .94; RMSEA = .06). Post-hoc model modifications did not offer new paths to improve the fit (Figure 3. Confirmatory Factor Analysis: RCS Correlational Model).

The structural model presented in Figure 3 resulted in positive correlations between the latent constructs (.39 – .64) and moderately strong factor loadings between the constructs and each measured variable (.58 – .95). These results suggested the possibility of a single factor, second-order model, which might capture the concept of the work environment. In addition, the results suggested that each item adequately measured its respective, underlying construct (Raykov & Marcoulides, 2006).

The final step in the analysis was to create the second-order measurement model to test the RCS as an instrument that captures the concept of the work environment. The correlations between the constructs were removed and a standardized model was run (Figure 4. Work Environment: Second-order Measurement Model). The second-order work environment model was adequately supported ($\chi^2 (346) = 699.38, p < 0.00$; CFI = .94; RMSEA = .06). No post-hoc modifications were made. The structural model presented in Figure 4 revealed moderately strong factor loadings (.54 – .81) between the work environment concept and the latent variables represented by the HA, EVS, MD, and RN relational coordination constructs and the individual measured items. Based on the fit statistics and the strength of the explained variances, it can be suggested that the model fit the data and provides an adequate depiction of the patterns within the data.

Discussion

The work environment, as represented by the concept of relational coordination, has been suggested to influence the prevention and control of HAIs (Havens et al., 2010). Instruments that are validated and tested in multiple settings are an important contribution to the study of the work environment and HAI prevention. This analysis provided support for the construct validity of the RCS as a measure of the work environment in infection prevention departments. Future use of the RCS, from the perspectives of those who work to prevent infections, will aid in the study of how and why HAI prevention programs succeed or fail.

An additional finding of this study was that the RCS factor structure was grouped along professional categories. This was a new finding, and one that can be explained through the exploratory approach of this study. Previous testing of the RCS (Gittell et al., 2010) explored the theoretical dimensions of the instrument. The data were aggregated to the group level, based on the seven dimensions described in the theory of relational coordination, prior to exploring the factor structure. This resulted in a single factor structure which included all seven of the dimensions of relational coordination (Gittell et al., 2010). This study aimed to empirically explore the data with no a priori structure. The individual

responses for each of the 28-items were aggregated, and then explored for a factor structure. This allowed for an inductive investigation into the dimensions of the RCS, and allowed us to determine whether the items of the RCS formed a single construct or multiple constructs, and if the items represented the concept of the work environment, as a second order measurement model.

Further investigations are needed, using similar statistical methodologies, to expand on these findings. Future use of the RCS as a measure of the work environment in healthcare should include statistical tests, such as EFA and CFA, to provide additional evidence to support the construct validity. The use of a two-step exploratory and confirmatory, SEM approach allowed us to empirically test the conceptual structure of the instrument. It also demonstrated the strength of each of the measured items in relation to its respective latent constructs and the validity of the RCS as a measure of the work environment in infection prevention departments.

Acknowledgments

The authors would like to thank Dr. Jodi Gittell for use of the Relational Coordination Survey, Dr. Pat Stone for use of the P-NICER data for secondary analysis, and the Infection Preventionists who responded to the survey.

Funding: Funding for the P-NICER study was provided by the National Institute of Nursing Research (R01NR010107).

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Figure 1.
Model of Relational Coordination for Infection Preventionists

Figure 2.
Exploratory Factor Analysis: RCS Measurement Model

Figure 3.
Confirmatory Factor Analysis: RCS Correlational Model

Figure 4.
Work Environment: Second Order Measurement Model

Table 1

Demographic Characteristics of Samples

Characteristics	EFA (n=307)		307 CFA (n=307)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Patient Days (hospital)	56,348	61,463	61,356	60,585
# ICU beds	30	37	39	48
# IPs/100 beds	1.12	1.2	1.03	.88
	Frequency	Percentage	Frequency	Percentage
Setting				
Urban	67	22%	96	31%
Suburban	106	35%	104	34%
Rural	131	43%	106	35%
Location				
Northeast	61	20%	65	21%
South	102	33%	102	33%
Midwest	96	31%	82	27%
West	45	15%	54	18%
Other (AK, PR, HI)	3	1%	4	1%
Bedsizes				
<200 beds	158	52%	142	48%
201–500 beds	106	35%	111	37%
501–1,000 beds	32	10%	41	14%
>1,001 beds	1	1%	4	1%
ICU Type				
Medical/Surgical	238	78%	218	71%
Medical	37	12%	41	13%
Other	32	10%	48	16%

Table 2

Descriptive Statistics of the Samples

	Mean		Mean	Mean
	N=614 1 to 5 scale	614 collapsed scale	307 EFA dichotomous scale	307 CFA dichotomous scale
Communication with MDs				
Frequently	3.10	1.31	1.33	1.30
Timely	3.13	1.35	1.36	1.33
Accurately	3.31	1.44	1.46	1.42
Blame or Solve Problem	3.28	1.44	1.46	1.41
Know	2.77	1.14	1.15	1.13
Respect	3.05	1.31	1.33	1.30
Share IP Goals	3.01	1.31	1.32	1.30
Communicate with Bedside RN				
Frequently	3.92	1.81	1.81	1.82
Timely	3.92	1.80	1.79	1.82
Accurately	3.76	1.72	1.72	1.72
Blame or Solve Problem	3.60	1.64	1.65	1.64
Know	3.20	1.38	1.37	1.38
Respect	3.47	1.56	1.56	1.55
Share IP Goals	3.42	1.50	1.51	1.50
Communicate with EVS				
Frequently	3.65	1.64	1.61	1.66
Timely	3.74	1.68	1.67	1.69
Accurately	3.60	1.61	1.62	1.61
Blame or Solve Problem	3.59	1.62	1.65	1.59
Know	3.08	1.30	1.30	1.31
Respect	3.78	1.73	1.70	1.76
Share IP Goals	3.64	1.60	1.57	1.63
Communicate with HA				
Frequently	3.47	1.52	1.54	1.50
Timely	3.60	1.60	1.61	1.58
Accurately	3.63	1.62	1.62	1.62
Blame or Solve Problem	3.79	1.71	1.70	1.72
Know	3.34	1.49	1.48	1.50
Respect	3.60	1.61	1.58	1.64
Share IP Goals	3.88	1.73	1.71	1.74
Frequently				
MD – Physician				
EVS – Environmental Services				
RN – Nurse				
HA – Healthcare Administration				

Table 3

Goodness of Fit Indices (Ullman, 2007)

Fit Index	Range for fit	Description
CFI	0 = poor fit to 1.00 = perfect fit < 0.90 = adequate fit	Uses the non-central χ^2 distribution with non-centrality parameters
RMSEA	0.05 or less = good fit 0.51 to .799 = adequate fit 0.80 to .10 = mediocre fit > 0.10 = poor fit	Measure of discrepancy between the observed and model implied covariance matrices adjusted for degrees of freedom