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Modeling the Biomedical Engineering Technicians' Contribution to Hospital Quality with Donabedian's Triad

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Abstract

Purpose: To determine the relationships among Donabedian's Triad from a health support services perspective using the biomedical engineering technician (BMET), an underrepresented occupation in healthcare research, as the unit of analysis.

Method: The Biomedical Engineering Interdepartmental (BEI) Survey (Cronbach Alpha = .905) created under Dillman's Tailored Design Methods, gathered national data on 317 respondents. A multivariate correlation analysis method— structural equation modeling (SEM), assessed the hypothesized relationships of structural and intervening process predictors and the study variable—Level of Quality.

Findings: Leading observable scales of Structural Complexity (Uniform Standards, Coordination Evidence, and Inter-Professional Training) and Process Adequacy (Regular Meetings, Formal Equipment Training, Formal Department Information) represent key methods to addressing hospital quality through Clinical Engineering.

Conclusion: Understanding the role of the BMET is valuable due to the systemic impact of their medical device maintenance duties. Multiple predictive factors of Structural Complexity (Organizational Culture, Level of Coordination, Interdepartmental Medical Device Management) and Process Adequacy (Interdepartmental Communication, Interdepartmental Teamwork, Interdepartmental Collaboration, Knowledge Management), on the Level of Quality can markedly improve Clinical Engineering Effectiveness (a key indicator of quality) by increasing job satisfaction, department contribution to organization objectives, and integrating services with other professions such as purchasing.

1. Introduction

Limited empirical information on the biomedical engineering technician (BMET) function in Clinical Engineering is inconsistent with findings that their medical equipment duties influence nursing performance and consequently, patient outcomes as reported by Gurses and Caryon (2007), Needleman et al., (2007), and Mark et al., (2003). Determination of the BMET role in quality considers the structural characteristics, processes, and inter-professional healthcare relationships that support patient needs by providing equipment maintenance services to practitioners in the clinical environment of care. The proposition is premised on the knowledge that 1) the BMET duties are associated with medical equipment status, and 2) the availability of properly functioning, clean, and timely access to medical equipment that is central to healthcare.

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Industry guidelines and reports of increased satisfaction with hand sanitation campaigns have not led to a sufficient decrease in the incidence of hospital acquired infections and other adverse events associated with medical devices according to studies performed by Fukuda et al., (2009), Francis (2008), and Burke (2003). Multiple sectors of the United States healthcare system such as the Office of the Inspector General (2010, p. 19) and research efforts by McFee (2009, p. 423), Stock et al., (2007, p. 368), and Burke (2007, p. 651) continue to report activity related to these systemic problems that lead to $27 billion in additional cost burdens resulting from preventable temporary patient morbidity (estimated 180,000 - 2 million annually) and patient mortality (estimated 90,000 – 134,000 annually).

Given the sparse information regarding the BMET function in Clinical Engineering, the association of adverse events related to medical equipment, and interdependent professional dynamic to nursing performance, this study proposed to determine whether the BMET can improve quality by mitigating systemic adverse events and compliance issues related to medical devices. Organizational Performance Theory provides the basis for hypothesized relationships.

2. Theoretical Premise

Derivatives of Donabedian's (1966, 1988, 1989) Triadic linear constructs of Organizational Performance Theory— structure, process, and outcome were modified to hypothesize causal relationships. In addition to the direct relationship of structure to the study variable, this study recognizes the indirect relationship of structure on processes to quality measures. The unconditioned model without control variables is shown in Figure 1.

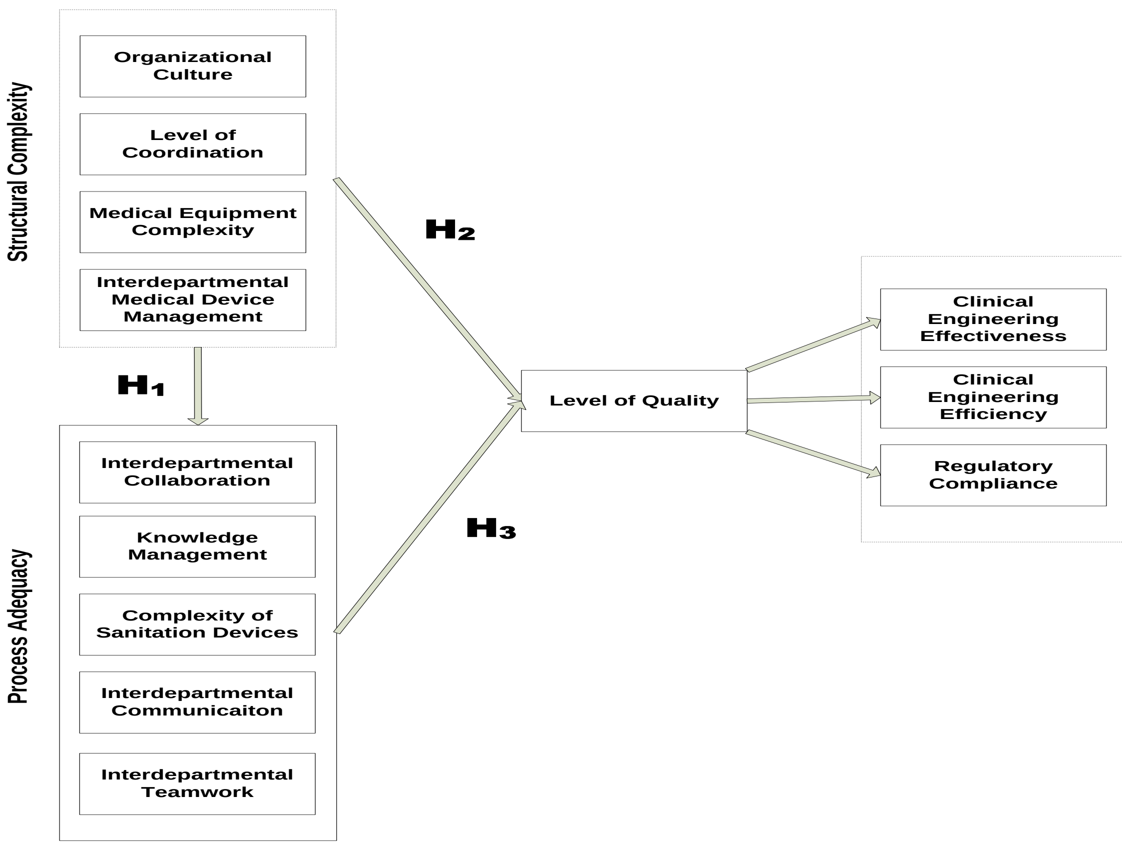

Figure 1: Unconditioned Analytical Model with Three Latent Variables Indicating Hypothesized Relationships Between Predictor Variables and the Level of Quality in Clinical Engineering as Measured by the Contributions of the Biomedical Engineering Technician

Identifying current structure and intervening processes that impact hospital quality were required to determine practices that may facilitate the implementation of regulatory recommendations and professional collaborations that can reduce the impact of HAIs. The Joint Commission (TJC, previously JCAHO—Joint Commission on Accreditation of Healthcare Organizations) recommends the establishment of an Infection Control Department under Infection Control IC.8.10 (Baran, 2004), organizational surveillance directed by Environment of Care EC.4.1, and mechanisms that report surveillance results to established multidisciplinary teams comprised of personnel accountable for corrective action under EC.4.3 (JCAHO, 2001, p.3). However, Edmond (2009), Hagtvedt et al. (2009), Patel et al., (2008) Anderson et al., (2006), Hota (2004), and McFadden et al. (2004) report the lack of expected integration of key health service support personnel in their recent studies.

Multiple predictive factors of Donabedian's constructs have been established in literature but analysis is often conducted on a small number of variables. Hence, little is known about the complex interactive nature of structural characteristics in conjunction with processes where professional interdependencies are required. Consequently, this study identifies and examines the contribution of factors and observed measurement variables in the latent exogenous constructs of Structural Complexity, intervening endogenous construct of Process Adequacy, and the endogenous study variable of Level of Quality.

The Institute of Medicine (2001) formally established healthcare quality outcome metrics of effectiveness, efficiency, and equity. These metrics are related to the equitable delivery of professional healthcare services through the economical application of the best known clinical practices and technology intended to achieve optimum patient health status (Mayberry et al., 2008; Lohr, 1990; Donabedian, 1988).

Seventeen significant and observable scales (Table 1) of the study constructs remained from the original 39 unique ordinal questions on the Biomedical Engineering Interdepartmental (BEI) Survey. Responses are analyzed on the basis of a 5-point Likert scale (1-strongly agree, 2-agree, 3-neither agree nor disagree, 4-disagree, 5-strongly disagree).Four factors of Structural Complexity were developed and measured by proxy questions in the BEI Survey with three factors demonstrating statistical significance—Organizational Culture, concurring with prior study results (Waterson, 2009; Minvielle, et al., 2008, 2005; Stock et al., 2007; McFadden et al., 2004; Scott et al., 2003); Level of Coordination, agreeing with prior research (Fewster-Thuente and Velsor-Friedrich, 2008; Flood et al., 2006; D'Amour et al., 2005; Alaszewski and Harrison, 1988; Corser, 1998); and Interdepartmental Medical Device Management, also consistent with prior research (Ridgway et al., 2009; Agnew et al., 2006). The fourth factor of Medical Equipment Complexity (Wakefield, 2008; Hwang and Herndon, 2007) did not demonstrate statistical significance for the biomedical population but may have a contribution in other professions such as nursing.

Five factors of Process Adequacy were developed and measured by proxy in the BEI Survey but only four were statistically significant—Interdepartmental Communication (Minvielle et al., 2008, 2005; Ballard and Siebold, 2006; Provonost et al., 2003), Interdepartmental Teamwork (Molleman et al., 2008; Xychris and Lowton. 2008; D'Amour et al., 2008; Schmalenberg et al., 2005); and Interdepartmental Collaboration (Fewster-Thuente and Velsor-Friedrich, 2008; Francis, 2008; Lindeke and Sieckert, 2005; D'Amour et al., 2005; Larson, 1999). The fifth factor, Complexity of Sanitation Methods, significant in other research (Halcomb et al., 2008; Lewis et al., 2008; Anderson et al., 2006; Schabrun and Chipchase, 2006; Rutala and Weber, 2004; Dubois, 2001) was not significant for the BMET population but may demonstrate statistical value in the evaluation of other clinical professions.

All three factors that measure the Level of Quality—Clinical Engineering Effectiveness, appearing in prior research (Ebben et al., 2008; Flood et al., 2006; Baker, 2003); Clinical Engineering Efficiency (Hwang and Herndon, 2007; Dey et al., 2006; Wang et al., 1999); and Regulatory Compliance (Waterson, 2009; Miller et al., 2005; Subhan, 2005) were developed and remained in the final analysis of the study model.

Table 1: Statistically Significant Scales of the Biomedical Engineering Interdepartmental Survey

Endogenous Latent Construct: Level of Quality		
Indicator	***Equivalent***	***Scales***
Clinical Engineering Effectiveness		
Acquisition Integration	CEEft1	Biomedical engineers are integrated in the medical equipment purchasing process.
Department Contribution to Organization Objectives	CEEft3	Biomedical engineers set and achieve department goals based on organizational objectives.
Job Reporting Satisfaction	CEEft4	Biomedical engineers are satisfied with reporting authorities.
Clinical Engineering Efficiency		
Implemented Cost Assessment	CEEfc3	Biomedical engineering measures cost using generally accepted metrics (e.g., labor cost/hour; labor cost/repair; total cost/repair; cost/bed supported; number of medical devices/bed supported; or cost of support as a percentage of the Acquisition Value of Capital Inventory.
Regulatory Compliance		
Regulatory Application	RC2	Biomedical engineering is able to apply medical equipment regulatory policy.
Regulatory Reporting	RC4	All departments have access to hospital acquired infection data.
Exogenous Latent: Construct Structural Complexity		
Organizational Culture		
Inter-professional Training	OC1	The organization values contributions to other staff members' professional development.
Appropriate Professional Job Training	OC2	I have been provided clear training to perform my job function.
Uniform Standards	OC3	Standards are applied equally across all departments
Level of Coordination		
Interdepartmental Work	LCR1	I receive and/or provide inter-departmental input in order to successfully complete work.
Coordination Evidence	LCR3	Inter-departmental coordination has resulted in visible positive benefits.
Interdepartmental Medical Device Management		
Device Failure Recognition	IMDM3	I receive and/or provide training to recognize medical device failure.
Intervening Variable (Latent Construct): Process Adequacy		
Interdepartmental Collaboration		
Equipment Purchasing Involvement	ICB1	I receive and/or provide advice on new equipment purchases.
Knowledge Management		
Formal Department Information	KM2	I have access to formal knowledge within the department.
Interdepartmental Communication		
Formal Equipment Training	ICOM2	I receive and/or provide training on the proper way to operate equipment.
Available Operational Equipment	ICOM3	I receive and/or provide clean, operational equipment in a timely fashion.
Interdepartmental Teamwork		
Regular Meetings	ITM3	Nursing and biomedical engineering conduct regularly scheduled meetings on equipment issues.

The study hypotheses are as follows:

Hypothesis$_1$: Structural complexity positively affects process adequacy in the hospital environment of care.

Hypothesis$_2$: Structural complexity positively affects level of quality in the hospital environment of care.

Hypothesis$_3$: Process adequacy positively affects level of quality in the hospital environment of care.

3. Methods

Data

The University of Central Florida's Institutional Review Board approved the Biomedical Engineering Interdepartmental (BEI) instrument and participants were duly notified of informed consent. The cross-sectional survey was provided online January 15-31, 2011 to 950 BMETs from 736 hospitals; adjusted response rate for cleansed data was 33.3%, N=317.

Measures

Four indicators of the predictive latent constructs of Structural Complexity and five from Process Adequacy each contained three scales in the form of survey questions. Three indicators, each with four questions, were used to identify the dependent study variable—the Level of Quality (Clinical Engineering Effectiveness, Clinical Engineering Efficiency, and Regulatory Compliance). The BEI Survey contained 47 questions developed a priori, including eight control variables used in respondent and facility identification. Hospital size and regional data were derived from reported data (number of beds, state). Analysis of control variables indicated low impact correlation but lacked statistical significance indicating that quality predictors in relationship to allied health personnel were not impacted by size, location or other control factors that may typically influence outcomes. Therefore, results can be generalized.

Sample Size

Final sample size (N=317) exceeded minimum requirements of N=282. Calculations considered the necessity to reach a minimum sample size of 200 required by the statistical software and probable non-response rate. The acceptable variance was narrow (±.1) on the 5-point Likert Scale, allowing boundaries to be identified at [2.90, 3.10]. Therefore, the margin of error is .0025. The unknown nature of the group made it practical to set the population variance σ^2=1.

Study Population

Respondents reported 5+ years of experience (97.2%) and a two year college degree (57.7%) followed by a four-year education (24.6%) and advanced graduate education (13.6%). They identified their place of employment as large hospitals with more than 150 beds (80.8%), medium with 26-150 beds (12.6%) and small with 25 beds or less (1.9%). The mean number of operational beds was 447.20. Hospital ownership was categorized as non-profit (68.8%), public (13.6%), university affiliated (8.5%), or private (7.6%). Though most reported Joint Commission accreditation (85.5%), others specified some other form of accreditation (8.2%), or indicated none (4.7%). Most were situated in urban locations (67.8%) across five regions. See Table 2 for a summary.

The largest regional concentration was the Midwest (26.8%) followed by Southern (19.6%), Northeast (18.3%), Southeast (17.7%) and Western (15.5%). Wyoming was not in the original sample and respondents from Hawaii, Nevada, and New Mexico did not participate and/or did not self-identify. States contributing the highest number of participants were California (25); Florida, Ohio, Texas (21); Tennessee (16); Indiana (15); New York (14); Pennsylvania, Virginia (13); and North Carolina (12).

Regional designations were as follows: Midwest—Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; Southern—Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, and Texas; Northeast—Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Washington, DC; Southeast—Florida, Georgia, North Carolina, South Carolina, Virginia, and West Virginia; and Western— Alaska, Idaho, Montana, Oregon, Washington, Wyoming, Arizona, California, Colorado, Hawaii, Nevada, New Mexico, and Utah.

Study Design

The unit of analysis in this study is the biomedical engineering technician in a hospital support services role for patient safety and quality assurance. A cross-sectional and correlation-based design was formulated. Multivariate analysis was performed to show the relationship between the multiple predictor variables (Xn) and the endogenous variable (Y). A residual term or error (ε) depicts the difference in the actual results from the predicted values. The following linear equation represents the generic form of multiple linear regressions calculated through statistical software:

$$Yi = \beta 0 + \beta 1X1 + \beta 2X2\ldots + \beta nXn + \varepsilon i$$

where*Y* = the endogenous (dependent) variable;

β = the regression coefficient;

X = the exogenous (independent) variable; and

ε = a random error or residual term.

This formal equation is translated into this study by examining the structural relationships among the three latent variables as follows:

Structural complexity positively affects process adequacy.

Process Adequacy = β0 + β1Structural Complexity + εi

The level of quality is influenced directly by structural complexity and process adequacy:

Level of Quality = β0 + β1Structural Complexity + β2 Process Adequacy + εi

4. Statistical Analysis

Two major data analysis processes were performed in this study. First, reliability analysis results from Statistical Package for the Social Sciences (SPSS) v. 15; PASW, Inc. v. 18 confirmed instrument reliability and internal consistency of respondent ratings to study constructs based on Cronbach Alpha (α) > 0.7 as defined by DeVellis (2003); Raza and Hanif (2013) and Ali and Raza (2015). Results of the reliability analysis showed Level of Quality, Endogenous latent construct—Cronbach α = 0.825; Structural Complexity, Exogenous latent construct—Cronbach α =0.826, and Process Adequacy, Intervening latent construct—Cronbach α =0.833. Second, the structural equation model was generated using Analysis of Moment Structures (AMOS) Graphics v. 18.0.0.

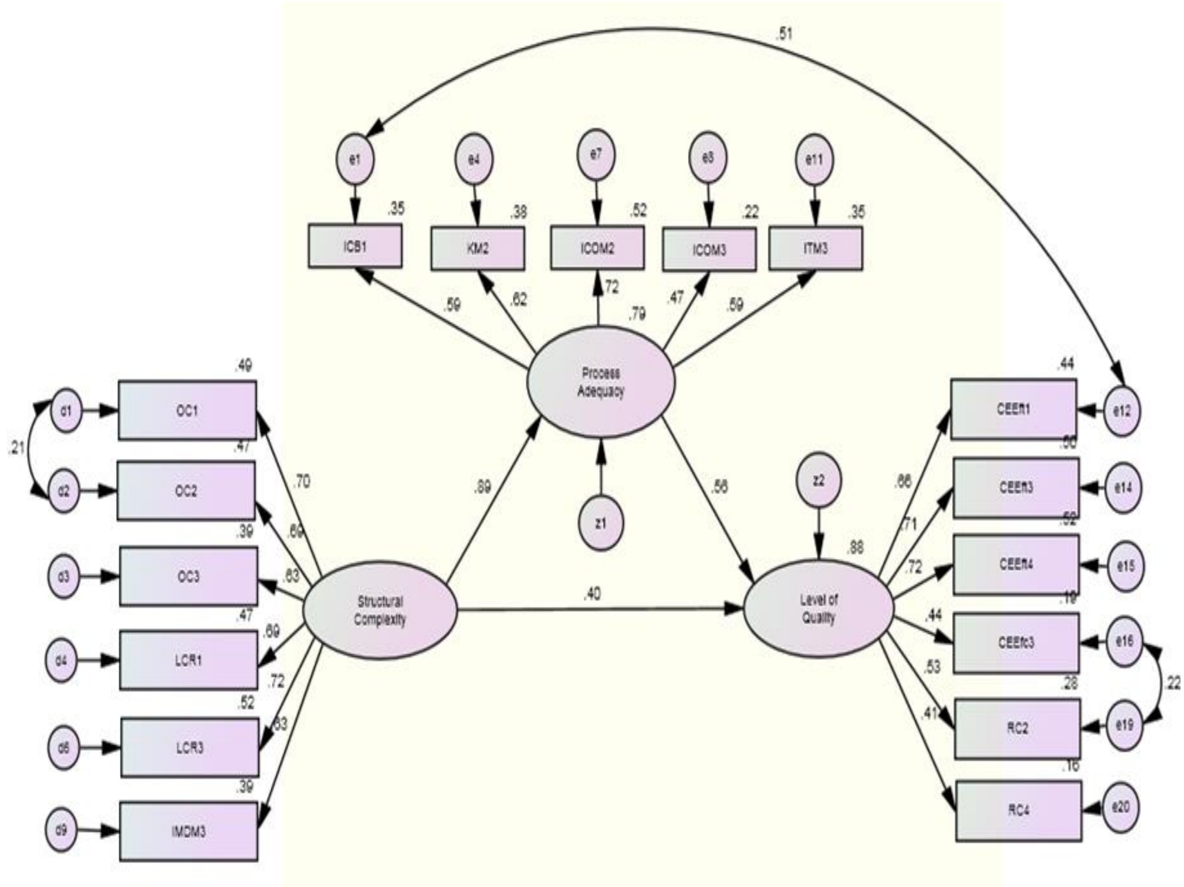

Figure 2: Structural Equation Model of Determinants of the Level of Quality in the Hospital Environment of Care for the Biomedical Engineering Technician Function in Clinical Engineering (Fiedler, 2011)

The final SEM containing 17 scales (Figure 2) was then regressed determining normal distribution, correlation, and statistical significance at t>1.96, p<.001 (2-tailed). Established metrics of goodness of model fit to data is reasonable and supported by Root Mean Square Error of Approximation (RMSEA) = .058 with good precision for the study population indicated by a lower/upper boundary of .048/.069 of a two-sided 90% confidence interval. Other evidence includes Chi-Square ($\chi 2$) = 234.683; degrees of freedom (df) = 113; $\chi 2$/df = 2.076; and Goodness of Fit Index (GFI) = .918 utilizing guidelines reported by Byrne (2001, p. 79-88), Table 2.

Measurement model analysis indicates that factor loading >0.50 by guidelines reported by Sahin et al., (2007) has been achieved in the relationship between underlying latent constructs and the observed variables. These relationships show that the model fits the data in the study population. For the purpose of overall analysis, some measures were retained in the model (ICOM3, 0.47; CEEfc3, 0.44; RC4, 0.41).

Further analysis results indicate that Structural Complexity contains several statistically significant positive predictors. The leading predictor in the latent construct was Coordination Evidence (LCR3) with 52% explanatory variance. LCR3 measured whether "Inter-departmental coordination has resulted in visible positive benefits". Other leading predictors include Inter-professional Training (OC1 at 49%), Inter-Departmental Work (LCR1 at 47%), and Appropriate Professional Job Training (OC2 at 47%).

Formal Equipment Training (ICOM2) contributed the largest variance in Process Adequacy at 52%. The largest variance in the dependent variable of Level of Quality in the SEM can be attributed to Job Reporting Satisfaction (CEEft4 at 52%) followed closely by Department Contribution to Organization Objectives

(CEEft3 at 50%). The least contribution to variance in the dependent variable in the SEM is RC4 (Regulatory Reporting) at 16%.

Table 2.Final Goodness of Fit Statistics: BEI Survey without Control Variables, Lambda Factor Loading Applied to First Factor of Each Latent Construct

Index	Criterion	Initial	Final
Chi-square (χ2)	Low	429.427	234.683
Degrees Of Freedom (df)	≥.0	166	113
Likelihood Ratio (χ2 /df)	<4	2.586	2.076
Probability	>0.05	0.000	0.000
Goodness of Fit Index (GFI)	>.90 x <1.0	.878	.918
Adjusted GFI (AGFI)	>.90 x <1.0	.846	.888
Normative Fit Index (NFI)	>.90	.818	.891
Tucker Lewis Index (TLI)	>.90	.861	.928
Comparative Fit Index (CFI)	>.90	.879	.940
Root Mean Square Error of Approximation (RMSEA)	≤.05 optimum or .05< value <.08 acceptable	.071	.058

Statistical Results

Unstandardized regressed estimates in Table 3 reveals that all exogenous factors $X_{1\text{-}6}$ and endogenous variables ($Y_{1\text{-}11}$) exhibit statistical significance at t>1.96, p<0.001. Uniform Standards had the greatest influence in Structural Complexity at 1:1.414 while Regular Meetings exerted the largest contribution to variance at 1:1.850 for determinants that effect quality. The cumulative impact of the predictors can positively double hospital Level of Quality as measured by the recorded estimates in the following scales: Acquisition Integration (1:2.166) which measured to what degree "Biomedical engineers are integrated in the medical equipment purchasing process" and Job Reporting Satisfaction (1:2.026) which measured to what extent "Biomedical engineers are satisfied with reporting authorities". Department Contribution to Organizational Objectives also has significant influence (1:1.737).

Table 3: Statistical Findings on Structural and Intervening Process Predictors of the Level of Quality in the Biomedical Engineering Interdepartmental Survey

	Unstandardized Regressed Weight Estimate	Standardized Regressed Weight Revised	Standard Error
Structural Complexity $X_{1\text{-}6}$			
Interdepartmental Work← Structural Complexity[1]	1.000	.687	
Uniform Standards ← Structural Complexity[2]	1.414	.627	.141
Inter-Professional Training ← Structural Complexity[3]	1.171	.701	.106
Coordination Evidence ← Structural Complexity[4]	1.161	.723	.101
Appropriate Professional Job Training ← Structural Complexity[5]	1.134	.685	.105
Device Failure Recognition ← Structural Complexity[6]	.992	.627	.099

	Unstandardized Regressed Weight Estimate	Standardized Regressed Weight Revised	Standard Error
Process Adequacy Y_{1-5}			
Available Operational Equipment ← Process Adequacy[7]	1.000	.469	
Regular Meetings ← Process Adequacy[8]	1.850	.590	.264
Equipment Purchasing Involvement ← Process Adequacy[9]	1.670	.593	.237
Formal Equipment Training ← Process Adequacy[10]	1.576	.719	.205
Formal Department Information ← Process Adequacy[11]	1.225	.618	.171
Level of Quality Y_{6-11}			
Regulatory Application ← Level of Quality[12]	1.000	.531	
Acquisition Integration ←Level of Quality[13]	2.166	.660	.259
Job Reporting Satisfaction ← Level of Quality[14]	2.026	.722	.231
Department Contribution to Organizational Objectives ← Level of Quality[15]	1.737	.709	.200
Implemented Cost Assessment ← Level of Quality[16]	1.294	.441	.179
Regulatory Reporting ← Level of Quality[17]	1.139	.406	.191

Notes on Scale[1-17]: 1) I receive and/or provide interdepartmental input in order to successfully complete work, 2) Standards are applied equally across all departments, 3) The organization values contributions to other staff members' professional development, 4) Interdepartmental coordination has resulted in visible positive benefits, 5) I have been provided clear training to perform my job function, 6) I receive and/or provide advice on new equipment purchases, 7) I receive and/or provide clean, operational equipment in a timely fashion, 8) Nursing and biomedical engineering conduct regularly scheduled meetings on equipment issues, 9) I receive and/or provide advice on new equipment purchases, 10) I receive and/or provide training on the proper way to operate equipment,11) I have access to formal knowledge within the department, 12) Biomedical engineering is able to apply medical equipment regulatory policy, 13) Biomedical engineers are integrated in the medical equipment purchasing process, 14) Biomedical engineers are satisfied with reporting authorities, 15) Biomedical engineers set and achieve department goals based on organizational objectives, 16) Biomedical engineering measures cost using generally accepted metrics, and17) All departments have access to hospital acquired infection data.

Table 4. Regression Analysis for Major Theoretical Constructs of the Biomedical Engineering Interdepartmental Survey

Predictors	Unstandardized Regressed Weight Estimate	Standardized Regressed Weight Revised	Unstandardized Regressed Weight Estimate	t	P
Process Adequacy ← Structural Complexity	.647	.889	.089	7.248	***
Level of Quality ← Process Adequacy	.504	.563	.161	3.136	.002
Level of Quality ← Structural Complexity	.262	.402	.106	2.469	.014

***<0.001 (2-tailed) significance level

Statistical evidence among study constructs (Table 4) infers validity of the research design. Standardized regression weight provided the Beta (β) coefficients for the final linear equation that illustrates the combined effect of the relationship between structure and processes on quality outcomes.

Level of Quality = .889 Structural Complexity + .563 Process Adequacy

5. Conclusions

The familiar assessment measures of Donabedian's Triad have been successfully modified and applied to the biomedical engineering technician function in Clinical Engineering. The impact of multiple interdependent predictive relationships inherent in structural characteristics of organizational culture and coordination coupled with inter-professional processes (interdepartmental teamwork, collaboration and communication) in the hospital environment of care is strong, positive, normally distributed and statistically significant in relation to the study variable. This combination of predictive scales infers that inter-professional development of the biomedical engineering technician function in Clinical Engineering can increase organizational quality by fostering relationships related to specific functions that affect patient care. Administrators can suggest regular meetings between nursing and BMETs, utilize the BMET medical device knowledge prior to purchasing decisions, and BMETs can assume more visible training functions (including sanitation methods) to reduce adverse events related to medical equipment. Consequently, the implementation of these processes may be supportive to current structural conditions or facilitate a positive change in organizational culture and coordination that promotes increased outcomes.

References

Agnew, J., Komaromy, N., and Smith, R. (2006), "Healthcare Institution Risk Assessments: Concentration on 'Process' or 'Outcome?" Journal of Risk Research, 9, 503-523.

Alaszewski, A. and Harrison, L. (1988), "Literature Review: Collaboration and Co-ordination Between Welfare Agencies." British Journal of Social Work, 18, 635-647.

Ali, M., & Raza, S. A. (2015). Measurement of Service Quality Perception and Customer Satisfaction in Islamic Banks of Pakistan: Evidence from Modified SERVQUAL Model. MPRA Paper No. 64039, University Library of Munich, Germany.

Anderson, B.M., Rasch, M., Hochlin, K., Jensen, F.-H., Wismar, P., Fredrickson, J.-E.(2006), Decontamination of Rooms, Medical Equipment and Ambulances Using an Aerosol of Hydrogen Peroxide Disinfectant.Journal of Hospital Infection, 62, 149-155.

Baker, T. (2003), "Journal of Clinical Engineering Roundtable: Debating the Medical Device. Preventive Maintenance Dilemma and What is the Safest and Most Cost-Effective Remedy," Journal of Clinical Engineering, 28, 183-190.

Ballard, D.I. and Seibold, D.R. (2006), "The Experience of Time at Work: Relationship to

Communication Load, Job Satisfaction, and Interdepartmental Communication," Communication Studies, 57,317-340.

Burke, J.P. (2003), "Infection Control—A Problem for Patient Safety in New England," The Journal of Medicine, 348, 651-659.

Byrne, B. M. (2001), Structural Equation Modeling with AMOS: Basic Concepts, Applications, and Programming. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Committee on Quality of Health Care in America, I.o.M.: Crossing the quality chasm: A new health system for the 21st century. Washington, D.C.: National Academy Press, 2001, Author.

Corser, W.D. (1998), "A Conceptual Model of Collaborative Nurse-Physician Interactions: The Management of Traditional Influences and Personal Tendencies," Research and Theory for Nursing Practice, 12, 325-341.

D'Amour, D., Ferrada-Videla, M., Rodriquez, L.S.M., and Beaulieu, M.D. (2005), "The Conceptual Basis for Interprofessional Collaboration: Core Concepts and Theoretical Frameworks," Journal of Interprofessional Care, 19(S1), 116-131.

DeVellis, R.F. (2003), Scale Development: Theory and Applications (Second Edition). Thousand Oaks, California: Sage.

Dey, P., Hariharan, S., and Clegg, B.T. (2006), "Measuring the Operational Performance of Intensive Care Units Using the Analytic Hierarchy Process Approach," International Journal of Operations & Production Management, 26, 849-865.

Dillman, D.A., J.D. Smyth, and L.M. Christian (2009), Internet, Mail and Mixed-Mode Surveys. The Tailored Design Method (Third Edition). Hoboken, NJ: John Wiley & Sons, Inc.

Donabedian, A. (1966), "Evaluating the Quality of Medical Care," Milbank Memorial Fund Quarterly, 44, 166-206.

Donabedian A. (1988), "The Quality of Care. How Can It Be Assessed?" Journal of the American Medical Association, 260, 1743-1748.

Donabedian, A. (1989), "Institutional and Professional Responsibilities in Quality Assurance," Quality Assurance in Health Care, 1,3-11.

Dubois, V. (2001), "Sterilization Techniques for Medical Equipment at a Health Care Facility," LeVide, 56, 29-33.

Ebben, S.F., Gieras, I.A., and Gosbee, L.L. (2008), "Harnessing Hospital Purchase Power to Design Safe Care Delivery," Biomedical Instrumentation & Technology, 48, 326-331.

Edmond, M.B. (2009), "Getting to Zero: Is It Safe?" Infection Control and Hospital Epidemiology, 30, 74-76.

Fewster-Thuente L., and Velsor-Friedrich B. (2008), "Interdisciplinary Collaboration for Healthcare Professionals," Nursing Administration Quarterly, 32, 40-8.

Fiedler, B.A. (2011), Effects of Hospital Structural Complexity and Process Adequacy on the Prevalence of Systemic Adverse Events and Compliance Issues: A Biomedical Engineering Technician Perspective".Doctoral dissertation, University of Central Florida.

Flood, A.B., Zinn, J.S. and Scott, W.R. (2006), "Organizational Performance: Managing for Efficiency and Effectiveness," in Stephen M. Shortell & Arnold D. Kaluzny (Eds.), Health Care Management, Organizational Design and Behavior, pp.415-454. Clifton Park, NY: Thomson Delmar Learning.

Francis, D. (2008), Iatrogenesis: The Nurse's Role in Preventing Patient harm. Evidence-Based Geriatric Nursing Protocols for Best Practice (Third Edition), New York: Springer Publishing Co.

Fukuda, H., Imanaka, Y., Hirose, M., and Hayashida, K. (2009), "Factors Associated with System-Level Activities for Patient Safety and Infection Control," Health Policy, 89, 26-36.

—(2009). Corrigendum to "Factors Associated with System-Level Activities for Patient Safety and Infection Control," [Health Policy 89 (2009) 26-36]. Health Policy, 92, 105.

Gurses, A., and Carayon, P. (2007), "Performance Obstacles of Intensive Care Nurses," Nursing Research, 56, 185-194.

Hagtvedt, R., Griffin, P., Keskinocak, P., and Roberts, R. (2009), "A Simulation Model to Compare Strategies for the Reduction of Health-Care Associated Infections," Interfaces, 39, 256-269.

Halcomb, E.J, Griffiths, R., and Fernandez, R. (2008), "Role of MRSA Reservoirs in the Acute Care Setting," International Journal of Evidence-Based Healthcare, 6, 50-77.

Hota, B. (2004), "Contamination, Disinfection, and Cross-Colonization: Are Hospital Surfaces Reservoirs for Nosocomial Infection?" Clinical Infectious Diseases, 39, 1182-1189.

Hwang, R.W., and Herndon, J.H. (2007), "The Business Case for Patient Safety," Clinical Orthopedics and Related Research, 457, 21-34.

Larson, E. (1999), "The Impact of Physician-Nurse Interaction on Patient Care," Holistic Nursing Practice, 13, 38-46.

Lewis, T., Griffith, C., Gallo, M., and Weinbren M. (2008), "A Modified ATP Benchmark for Evaluating the Cleaning of Some Hospital Environmental Surfaces," Journal of Hospital Infection, 69, 156-163.

Lindeke, L.L. and Sieckert, A.M. (2005), "Nurse-Physician Workplace Collaboration," Online Journal Issues of Nursing [online], 10.Available at www.nursingworld.org.

Lohr, K.N., and Schroeder, S.A. (1990), "A Strategy for Quality Assurance in Medicine," New England Journal of Medicine, 322, 707-712.

Mark, B.A., Salyer, J., and Wan, T.T.H. (2003), "Professional Nursing Practice: Impact on Organizational and Patient Outcomes," Journal of Nursing Administration, 33, 224-234.

Mayberry, R.M., Nicewander, D.A., Qin, H., and Ballard, D.J. (2008), "Improving Quality and Reducing Inequalities: A Challenge in Achieving Best Care," World Hospitals and Health Services, 44, 16-31.

McFadden, K.L., Towell, E.R., and Stock, G.N. (2004), "Critical Success Factors for Controlling and Managing Hospital Errors," The Quality Management Journal, 11, 61-74.

McFee, R.B. (2009), "Nosocomial or Hospital-Acquired Infections: An Overview," DM Disease –A-Month, 55, 422-438.

Miller, M.R., Provonost, P., Donithan, M., Zeger, S., Zhan, C., Morlock, L., and Meyer, G.S. (2005), "Relationship Between Performance Measurement and Accreditation: Implications for Quality of Care and Patient Safety," American Journal of Medical Quality, 20, 239-252. DOI: 10.1177/1062860605277076.

Minvielle, E., Aaegerter, P., Dervaux, B., Boumendil, A., Retbi, A., Jars-Guincestre, M.C., and

Guidet, B. (2008), "Assessing Organizational Performance in Intensive Care Units: A French Experience," Journal of Critical Care, 23,236-244.

Minvielle, E., Dervaus, B., Retbi, A., Aaegerter, P., Boumendil, A., Jars-Guincestre, M.C. et al., (2005), "Culture, Organization, and Management in Intensive Care: Construction and Validation of a Multidimensional Questionnaire," Journal of Critical Care, 20, 126-138.

Molleman, E., Broekhuis, M., Stoffels, R., and Jaspers, F. (2008), "How Health Care Complexity Leads to Cooperation and Effects the Autonomy of Health Care Professionals," Health Care Analysis, 16, 329–341.

Needleman, J., Kurtzman, E., and Kizer, K. (2007), "Performance Measurement of Nursing Care: State of the Science and the Current Consensus," Medical Care Research and Review, 64,10S-43S. doi: 10.1177/1077558707299260.

Patel, P.R., Srinivasan, A., and Perz, J.F. (2008), "Developing a Broader Approach to Management of Infection Control Breaches in Health Care Settings," American Journal of Infection Control, 36, 685-690.

Provonost, P., Berenholtz, S., Dorman, T., Lipsett, PA.Simmonds, T., and Haraden, C. (2003), "Improving Communication in the ICU Using Daily Goals," Journal of Critical Care, 18, 71-75.

Raza, S. A., & Hanif, N. (2013). Factors affecting internet banking adoption among internal and external customers: a case of Pakistan. International Journal of Electronic Finance, 7(1), 82-96.

Ridgway, M., Atles, L.R., and Subhan, A. (2009), "Reducing Equipment Downtime: A New Line of Attack," Journal of Clinical Engineering, 34, 200-204.

Rutala, W.A. and Weber, D.J. (2004), "Disinfection and Sterilization in Health Care Facilities: What Clinicians Need to Know," Clinical Infectious Diseases, 39, 702 -709.

Sahin, B., Yilmaz, F., and Lee, K-H. (2007), "Factors Affecting Inpatient Satisfaction: Structural Equation Modeling," Journal of Medical Systems, 31,9-16. DOI: 10.1007/s10916-006-9038-8.

Schabrun, S., and Chipchase L. (2006), "Healthcare Equipment as a Source of Nosocomial Infection: A Systematic Review," Journal of Hospital Infection, 63, 239-245.

Schmalenberg, C., Kramer, M., King, C., and Krugman, M. (2005),

—"Excellence Through Evidence: Securing Collegial/Collaborative Nurse-Physician Relationships, Part 1," Journal of Nursing Administration, 35, 450-458.

—"Excellence Through Evidence: Securing Collegial/Collaborative Nurse-Physician Relationships, Part 2," Journal of Nursing Administration, 35, 507-514.

Scott, T., Mannion, R., Davies, H.T.O., and Marshall, M. (2003a), "Implementing Culture Change in Health Care: Theory and Practice," International Journal for Quality Management, 15, 111-118.

Stock, G.N., McFadden, K.L., and Gowen III, C.R. (2007), "Organizational Culture, Critical Success Factors, and the Reduction of Hospital Errors," International Journal of Production Economics, 106, 368-392.

U.S. Department of Health and Human Services, Office of the Inspector General (OIG) (2010, November). Adverse Events in Hospitals: National Incidence Among Medicare Beneficiaries. OEI-06-09-00090, Author.

Wakefield, M. (2008), "Patient Safety and Medical Errors: Implications for Rural Health Care," Journal of Legal Medicine, 23, 43-56.

Wang, B.B., Ozcan, Y.A, Wan, T.T.H., and Harrison, J. (1999), "Trends in Hospital Efficiency Among Metropolitan Markets," Journal of Medical Systems, 23,83-97.

Waterson, P.E. (2009), "Systems Analysis for Infection Control in Acute Hospitals." in P.D. Bust (Editor) Contemporary Ergonomics 2009,pp. 165-173. London: Taylor & Francis.

Xyrichis A., and Lowton K. (2008), "What Fosters or Prevents InterprofessionalTeamworking in Primary and Community Care? A Literature Review."International Journal of Nursing Studies, 45, 140-153.