MIS Quarterly

RESEARCH ARTICLE

DISASTER EXPERIENCE AND HOSPITAL INFORMATION SYSTEMS: AN EXAMINATION OF PERCEIVED INFORMATION ASSURANCE, RISK, RESILIENCE, AND HIS USEFULNESS

Insu Park
College of Business and Information Systems, Dakota State University,
Madison, SD 57042 U.S.A. {insu.park@dsu.edu}

Raj Sharman and H. Raghav Rao
Management Science & Systems, School of Management, University of Buffalo,
Buffalo, NY 14260 U.S.A. {rsharman@buffalo.edu} {mgmtrao@buffalo.edu}

Appendix A

Retrospective Survey Method

It is important to understand both the usefulness and the inherent limitations of utilizing retrospective recall memory. Retrospective recall has several potential sources of bias. First, compared with concurrent evaluations that rely on short-term memory, recall that utilizes long-term memory may lead to biases such as selectivity of recall, rationality bias, and so forth (East and Uncles 2008; Glick et al. 1990). Second, respondents' post-event recall may potentially bias their recall of pre-event experiences, and vice versa, most likely producing consistency of recall between the two. In other words, relying on long-term memory may introduce some biases, resulting in potential differences between consumers' recalled and actual experiences.

Even though most researchers agree that consumers' actual information processing is different from their recall (Ericsson and Simon 1980; Nisbett and Wilson 1977), there are several reasons why memory data might still be quite useful and insightful. According to Lynch and Srull (1982), for the value of recall data, the "recall protocol is assumed to be representative of the underlying [memory] structure with respect to both content and organization" (p. 24). In turn, these structures provide insight into previous processing (see Biehal and Chakravarti 1986).

In addition, memory may be particularly predictive of future behaviors (Cox and Hassard 2007). The vast majority of consumer decisions are either totally memory-based or a "mixed" combination of available and memory information (Alba et al. 1991). Thus, employees typically assign ratings and make evaluations by accessing their memories of disaster experiences, regardless of the "accuracy" of this information.

Finally, memory data may be the basis for most consumer "word of mouth" communications, as people are more likely to relate memories of their experiences (what they think occurred) than the actual experience itself. In specifically considering the factors that require recalling the disaster experiences, to the extent that such biases occur, there should be consistency across employees' memories of the specific and concrete disaster. Thus, if anything, differences found in this study between the experience group, recall group, and IS effectiveness evaluations are likely to be understated.

In terms of internal validity, the retrospective method has strong statistical power (Shadish and Luellen 2005). Howard et al. (1979) found the retrospective method to yield higher statistical power and to be more highly correlated with external measures of constructs of interest than their respective initial tests (Bray et al. 1984). Researchers have also found that retrospective methods may provide a more sensitive and valid measure of effects (Skeff 1992).

References

Alba, J., Hutchinson, W., and Lynch, J. 1991. "Memory and Decision Making," in *Handbook of Consumer Theory and Research,* H. H. Kassarjain and T. S. Robertson (eds.), New York: Prentice Hall, pp. 1-49.

Biehal, G., and Chakravarti, D. 1986. "Consumers' Use of Memory and External Information in Choice: Macro and Micro Perspectives," *Journal of Consumer Research* (12:4), pp. 382-405.

Bray, J. H., Maxwell, S. E., and Howard, G. S. 1984. "Methods of Analysis with Response-Shift Bias," *Educational and Psychological Measurement* (44), pp. 781-804.

Cox, J. W., and Hassard, J. 2007. "Ties to the Past in Organization Research: A Comparative Analysis of Retrospective Methods," *Organization* (14:4), pp. 475-497.

East, R., and Uncles, M. 2008. "In Praise of Retrospective Surveys," *Journal of Marketing Management* (24:9), pp. 929-944.

Ericsson, K. A., and Simon, H. A. 1980. "Verbal Reports as Data," *Psychological Review* (87:3), pp. 215-251.

Glick, W. H., Huber, G. P., Miller, C. C., Doty, D. H., and Sutcliffe, K. M. 1990. "Studying Changes in Organizational Design and Effectiveness: Retrospective Event Histories and Periodic Assessments," *Organization Science* (1:3), pp. 293-312.

Howard, G. S., Ralph, K. M., Gulanick, N. A., Maxwell, S. E., Nance, D., and Gerber, S. 1979. "Internal Invalidity in Pretest-Posttest Self-Report Evaluation and a Re-Evaluation of Retrospective Pretests," *Applied Psychological Measurement* (3), pp. 1-23.

Lynch Jr., J. G., and Srull, T. K. 1982. "Memory and Attentional Factors in Consumer Choice: Concepts and Research Methods," *Journal of Consumer Research* (9:1), pp. 18-37.

Nisbett, R. E., and Wilson, T. D. 1977. "Telling More Than We Can Know: Verbal Reports on Mental Processes," *Psychological Review* (84:3), pp. 231-259.

Shadish, W. R., and Luellen, J. K. 2005. "Quasi-Experimental Designs," in *Encyclopedia of Statistics in Behavioral Science,* B. S. Everitt and D. Howell (eds.), Chichester, UK: John Wiley & Sons, Ltd.

Skeff, K. M. 1992. "Evaluation of a Medical Faculty Development Program: A Comparison of Traditional Pre/Post and Retrospective Pre/Post Self-Assessment Ratings," *Evaluation and the Health Professions* (15:3), pp. 350-366.

Appendix B

Nonindependence Test

To ensure that concepts were addressed by the same unit of analysis, two tests were performed. First, we calculated within-group agreement (inter-rater reliability; R_{wg}[1]) indexes[2] (James et al. 1984) for the systems resilience scale. The R_{wg} value has been employed to justify the appropriateness of aggregating data to higher levels of analysis. For this analysis, all employees of five hospitals (three disaster area and two no-disaster area) were included. Results showed that within-group variances were not homogenous (R_{wg} = 0.34), which indicates that the concept of resilience should not be aggregated to a higher level. Second, we used ANOVA for testing equality of variances (Levene 1960), which indicates homogeneity of group variance to compare organizations. Results of this test were consistent with the R_{wg} analysis, showing that organizations' variances were independent ($F = 5.100$, $p < 0.05$).

[1]$R_{wg}(J) = \{J[1 - (\text{mean of } S_x^2/\sigma_E^2)]\}/\{J[1 - (\text{mean of } S_x^2/\sigma_E^2)] + \text{mean of } S_x^2/\sigma_E^2\}$, where J is the number of items rated, mean of S_x^2 is the observed item-wise variance across individuals and averaged over items, and $\sigma_E^2$is the expected variance.

[2]An index of the observed variance divided by the expected variance due to random measurement errors, which indicates the extent of within-group agreement as opposed to reliability (Kozlowski and Hattrup 1992). It reflects the perceptual congruence of a group of individuals who are assessing the same behavioral characteristic with respect to the target manager.

Tale B1. Data Set Independence Test: Disaster Data Set (n =103)						
Constructs	**Hospitals**	**Mean**	**Standard Deviation**	**Mean Square**	***F*-Value***	**Sig**
Perceived systems risk	1 2 3	4.35 4.88 4.65	1.06 1.67 1.44	1.982	.999	.372
Information assurance	1 2 3	5.66 5.76 5.42	.88 1.06 1.23	1.158	.959	.387
Perceived resilience	1 2 3	5.38 4.78 5.17	.94 1.66 .78	2.484	2.026	.137
Perceived usefulness	1 2 3	5.30 4.74 4.75	1.26 1.51 1.39	3.051	1.578	.212

*Between-groups mean squares.

Table B2. Data Set Independence Test: Non - Disaster Data Set (n =179)						
Constructs	**Hospitals**	**Mean**	**Standard Deviation**	**Mean Square**	***F*-Value***	**Sig**
Perceived systems risk	1 2	3.76 3.76	1.94 2.21	0.001	.000	1.00
Information assurance	1 2	5.95 5.57	0.99 1.01	2.018	1.861	0.159
Perceived resilience	1 2	5.42 5.16	0.93 1.01	0.886	0.948	0.390
Perceived usefulness	1 2	5.75 5.31	1.14 1.29	4.398	2.490	0.086

*Between-groups mean squares.

References

James, L., Demaree, R., and Wolf, G. 1984. "Estimating Within-Group Interrater Reliability With and Without Response Bias," *Journal of Applied Psychology* (69:1), pp. 85-98.

Kozlowski, S. W. J., and Hattrup, K. 1992. "A Disagreement About Within-Group Agreement: Disentangling Issues of Consistency Versus Consensus," *Journal of Applied Psychology* (77), pp 161-167.

Levene, H. 1960. "Robust Tests for Equality of Variances," in *Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling*, I. Olkin, S. G. Ghurye, W. Hoeffding, W. G. Mado, and H. B Mann (eds.), Stanford, CA: Stanford University Press, pp. 278-292.

Appendix C

Common Method Bias

To address common method bias in our measures, we employed two statistical and procedural methodologies recommended by Podsakoff et al. (2003) using Harman's single-factor test. In Harman's test, common method bias is an issue if results from an exploratory factor analysis reveal that (1) a single factor emerges, or (2) the first factor accounts for the majority of the covariance among the variables. In our study, the results from Harman's test suggested that common method bias was not a serious issue among these variables, as more than one factor emerged from the unrotated solution. All indicators showed high factor loadings and low cross-loadings. The principal components explained almost an equal amount of the 74% total variance, ranging from 3.98% to 30.46%. The first factor accounted for 30.46% of the variance; the second for 14.16%. This indicates that our data do not suffer from common method bias.

However, because Harman's one-factor test is increasingly being contested in terms of its ability to detect common method bias (Podsakoff et al. 2003), we applied the Marker technique in confirmatory factor analysis (CFA) to verify the extent to which the inclusion of a method construct affects the correlations among latent variables (Richardson et al. 2009; Williams et al. 1989). Four models were estimated for each simulated independent–dependent construct pair: a baseline model, a Method-C model, a Method-U model, and a Method-R model.

The comparison of the Method-C model with the baseline model provides a test of the method variance associated with the marker variable. A comparison of the Method-C and Method-U models tests the key difference between the CMV and UMV models and the assumption of equal method effects. The comparison of the Method-C model with the Method-R model provides the statistical test of the biasing effects of our marker variable on substantive relations.

The model fit results of the analyses for each model are shown in Table C1, including the chi-square, degrees of freedom, and X^2/df values. The comparison of the baseline model and Method-C model yields a chi-square difference of 4.714 with one degree of freedom, which exceeds the 0.05 chi-square critical value. This result shows that the chi-square difference test comparing these two models supports rejecting the restriction to 0 of the 22 method factor loadings in the baseline model. A model comparison between the Method-U and Method-C models shows that the chi-square difference testing provides support for rejecting the restrictions in the Method-C model. The comparison yielded a chi-square difference of 13.84 with 17 degrees of freedom, which does not exceed the 0.05 critical value of 0.678. The Method-U and Method-R models reveal the chi-square difference test resulted in a nonsignificant difference of 15.419 at 10 degrees of freedom. The result of the Method-U and Method-R models indicates that the effects of the marker variable did not significantly bias factor correlation estimates. Thus, as a set, there was not a significant difference between the baseline model factor correlations and the Method-U factor correlations.

Table C1. Chi-Square, Goodness-of-Fit Values, And Model Comparison Tests

Model	χ^2	*df*	*CFI*
CFA	324.199	194	0.972
Baseline	352.262	202	0.968
Model-C	347.547	201	0.968
Model-U	333.703	184	0.968
Model-R	349.122	194	0.966
Chi-square model comparison tests			
ΔModels	**$\Delta\chi^2$**	**Δ*df***	**Critical Value**
Baseline vs. Model-C	4.714	1	0.030
Model-C vs. Model-U	13.845	17	0.678
Model-U vs. Model-R	15.419	10	0.118

Table C2. Baseline and Model Factor Correlations

Factor Correlations	Baseline Model	Method-C Model	Method-U Model	Method-R Model
Systems risk to PU	–0.236	–0.24	–0.234	–0.115
IA to RES	0.305	0.304	0.304	0.307
IA to PU	0.167	0.169	0.169	0.134
RES to PU	0.360	0.362	0.362	0.267

References

Podsakoff, P., MacKenzie, S., and Podsakoff, N. 2003. "Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies," *Journal of Applied Psychology* (88:5), pp. 978-903.

Richardson, H., Simmering, M., and Sturman, M. 2009. "A Tale of Three Perspectives: Examining Post Hoc Statistical Techniques for Detection and Correction of Common Method Variance," *Organizational Research Methods* (12), pp. 762-800.

Williams, L. J., Cote, J. A., and Buckley, M. R. 1989. "Lack of Method Variance in Self-Reported Affect and Perceptions at Work: Reality or Artifact?," *Journal of Applied Psychology* (74), pp. 462-468.

Appendix D

Post Hoc Analysis

We tested the impact of a possible explanatory factor for our findings—namely, usage by different groups based on different systems. This *post hoc* analysis relates to the differential effect of both business resilience and information assurance on perceived usefulness between main (clinical system) users and support (administrative system) users.

In our study, we analyzed the different effects on HIS based on two systems. HIS can be classified into two major systems: clinical systems and administrative systems; accordingly, main users who are consumers of the clinical information system, such as physicians and nurses, and support users who use administrative systems, such as hospital and IT support personnel. Members of the two groups have different goals when using the systems. As consumers, main users are deeply involved with systems applications (i.e., software applications, database software) that typically relate to EMR. In the no-experience group, support users focus more on the technical and system hardware and billing/scheduling systems.

Given these differing purposes, the type of the user can moderate the effect of two factors on the relationship between risk, resilience, and information assurance and the consequence. Notably, the reasons for using HIS differs between main users, who are involved in data and information relating to the provisioning of care for patients, and support users, who focus on keeping the systems constantly available. For example, comparably stressful perceptions (i.e., perceived risk) can have a more serious influence on main users, such as physicians and nurses, than on administrators, such as IT support personnel. Put simply, perceived risk has a stronger negative impact on users of clinical information systems (such as nurses and physicians) than on the users of administration systems. In addition, the effects of information assurance and perceived resilience are greater for clinical systems users than for administration systems users. Interestingly, the effect of computer self-efficacy on perceived usefulness is greater for administration systems users, while the effect of perceived resilience is greater for clinical systems users. The differences between two path coefficients for clinical systems and administration users are shown in Table D1.

Table D1. Differences Between User Type (Two Systems) Groups						
Path	Clinical System User (N = 168)		Administration System User (N = 114)		Comparison of Clinical and Administration Users	
Direct Effect	Path	S.D.	Path	S.D.	P.Diff.[$]	T-Value
SR ⇨ PU	-0.028	0.033	-0.136	0.031	0.108*	2.281
IA ⇨ PU	0.051	0.043	0.095	0.040	-0.044	-0.715
RES ⇨ PU	0.136	0.039	0.057	0.057	0.079	1.189
Tenure ⇨ PU	0.381	0.051	0.422	0.041	-0.041	-0.583
EOU ⇨ PU	0.088	0.047	0.115	0.050	-0.027	-0.385
CSE ⇨ PU	-0.147	0.052	0.072	0.051	-0.219**	-2.898

Notes: SR: perceived systems risk; PU: perceived usefulness; IA: information assurance; RES: perceived systems resilience; CSE: computer self-efficacy; EOU: ease of use.
[$]P.Diff.: differences of path coefficients among the groups.
*p < 0.05; **p < 0.01; ***p < 0.001

Table D2. Sobel's Test Significance of Indirect Effects of Mediators			
Path[a]	Mediated Paths	Indirect Effect	Z Statistic[b]
IA → RES → PU	*No experience situation*	0.067*	2.39
	Experience situation	0.011	1.13
	Recall situation	0.034*	2.33

Note: PU: perceived usefulness; IA: information assurance; RES: perceived systems resilience.
[a]Standardized path coefficients without direct paths (Indirect path).
[b]The standard errors are approximated as Sqrt($\sigma_a^2\beta^2 + \sigma_b^2 a^2 + \sigma_a^2\sigma_b^2$) for a single mediated path, where, σ_j^2 is variance with j denoting α_i and β_i path coefficients, α_i and β_i are path coefficients with i denoting first and second mediators, and $\sigma_{\beta1\beta2}$ is covariance between β_1 and β_2, which is adapted from MacKinnon et al. (2002).
***p < 0.001, **p < 0.01, *p < 0.05

Reference

McKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G., and Sheets, V. 2002. "A Comparison of Methods to Test Mediation and Other Intervening Variable Effects," *Psychological Methods* (7:1), pp. 83-104.

Appendix E

Mixed Model Results

Table E1. Results of Mixed-Model Analyses Predicting Perceived Usefulness

Path to Perceived Usefulness	(*N* = 103)				No-Experience (*N* = 179)	
	Experience		*Recall*			
Direct Effect	**Base Model**	**Fixed-Effect Model**	**Base Model**	**Fixed-Effect Model**	**Base Model**	**Fixed-Effect Model**
SR	-0.310***	-0.240*	-0.174*	-0.160*	-0.129*	-0.120*
IA	0.006	0.013	0.037	0.080	0.037	-0.013
RES	0.097	0.034	0.104	0.123*	0.122*	0.127*
Ease of Use	0.506***	0.541***	0.641***	0.592	0.295***	0.300***
CSE	0.094	0.185*	0.044	0.030	0.228**	0.259***
Tenure	-0.093	0.025	0.010	-0.033	-0.081	-0.070
Hospital 1	0	0.278**	0	0.033	0	0.138*
Hospital 2	0	-0.095	0	-0.020	0	0.229*
Hospital 3	0	-1.014	0	-0.140	0	0.034
Hospital 4	0	-0.159*	0	-0.127	0	0.163*
R2	39.1%	46.5%	44.5%	47.6%	30.1%	33.8%
#*f*2 value (*Pseudo F*)	0.119 (12.068)		0.059 (5.97)		0.056 (9.89)	

Notes: SR: perceived systems risk; PU: perceived usefulness; IA: information assurance; RES: perceived systems resilience; CSE: computer self-efficacy.

Hospital1~Hospital 4: dummy variables for fixed effects.

#f^2 value is calculated as (R^2 full–R^2 excluded)/(1– R^2 full). The *pseudo f* statistic is calculated as $f^2 \cdot$ (n–k–1), with l, (n–k) degree of freedom when n = sample size, k = the number of constructs in the model (Subramani 2003).

*p < 0.05; **p < 0.01; ***p < 0.001

Appendix F

Survey Questions

Latent Variables	Items	Scale
Perceived usefulness (PU)	The hospital information system … 1. increases my productivity (requires less effort than would have been required without it). 2. saves my time (i.e., allows me to accomplish more work than what would have been possible without it). 3. helps me meet patient needs effectively.	7-point adapted and modified from Rai et al. (2002)
Perceived Resilience (RES)	1. Our information systems can handle many critical incidents at a time. 2. People in the organization are well prepared to respond during critical incidents. 3. Our organization has business continuity plans to handle unfamiliar situations. 4. Our information systems recover quickly after critical incidents.	7-point scale developed
Perceived System Risk (SR)	1. When network facilities (e.g., network/cable plant) are disrupted, the hospital information systems are affected. 2. When the internal telecommunications system is disrupted, the hospital information systems are affected.	7-point adapted and modified from Carreras et al. (2007)
Information Assurance (IA)	1. Hospital information systems are accessible only to those authorized to have access. 2. Information is securely shared in our hospital. 3. Legitimate users are never denied access to the hospital information whenever it is required. 4. Our primary database system (i.e., medical records) is stable and safe against tampering. 5. Our information systems protect the privacy of the patients (i.e., sensitive patient data are not shared or released without permission).	7-point adapted from Kim et al.(2004)
Computer self-efficacy	I could complete my job using the hospital information system (even) if ... 1. I had seen someone else using it before trying it myself. 2. I had only the software manuals for reference 3. I had used similar systems like this one before.	
Ease of Use	How would you rate the… 1. degree to which the information systems easy to use 2. reliability of the hospital information systems (i.e., does the system perform its functions in routine as well as unexpected circumstances)? 3. ability of the hospital information system to transmit data between systems servicing different functional areas (i.e., can the system pull out data from the systems in other functional areas efficiently)	Rai et al (2002)

References

Carreras, B. A., Newman, D. E., Gradney, P., Lynch, V. E., and Dobson, I. 2007. "Interdependent Risk in Interacting Infrastructure Systems," in *Proceedings of the 40th Annual Hawii International Conference on System Sciences*, Los Alamitos, CA: IEEE Computer Society Press.

Kim, D. J., Sivasailam, N., and Rao, H. R. 2004. "Information Assurance in B2C Websites for Information Goods/Services," *Electronic Market* (14:4), pp. 344-359.

Rai, A., Lang, S. S., and Welker, R. B. 2002. "Assessing the Validity of IS Success Models: An Empirical Test and Theoretical Analysis," *Information Systems Research* (13:1), pp. 50-69.

Appendix G

Cross-Loadings

Table G. PLS Component-Based Analysis: Cross-Loadings

		Experience Group								No-Experience Group			
		Experience Group				Recall Group							
Constructs	Items	Cross-Loadings*	C.R.	C.A.	AVE	Cross-Loadings	C.R.	C.A.	AVE	Cross-Loadings	C.R.	C.A.	AVE
Perceived Systems Risk	IR1	0.870				0.904				0.964			
	IR2	0.866	0.859	0.812	0.718	0.912	0.903	0.787	0.824	0.967	0.971	0.855	0.917
Perceived Resilience	RES1	0.864				0.912				0.869			
	RES2	0.869				0.622				0.894			
	RES3	0.802				0.780				0.913			
	RES4	0.739	0.891	0.851	0.673	0.750	0.854	0.769	0.597	0.910	0.943	0.919	0.804
Information Assurance	IA1	0.902				0.887				0.857			
	IA2	0.894				0.887				0.849			
	IA3	0.873				0.870				0.776			
	IA4	0.878				0.806				0.813			
	IA5	0.883	0.948	0.932	0.785	0.862	0.936	0.915	0.745	0.855	0.917	0.888	0.690
Perceived Usefulness	PU 1	0.971				0.975				0.921			
	PU 2	0.973				0.965				0.919			
	PU 3	0.952	0.976	0.963	0.931	0.943	0.973	0.958	0.923	0.820	0.919	0.865	0.792
Computer Self-efficacy	CSE1	0.790				0.791				0.928			
	CSE2	0.765				0.765				0.869			
	CSE3	0.644	0.778	0.791	0.562	0.641	0.863	0.789	0.615	0.918	0.941	0.919	0.799
Ease of Use	EOU1	0.817				0.865				0.938			
	EOU2	0.883	0.864	0.763	0.680	0.852	0.856	0.747	0.667	0.947		0.920	0.863
	EOU3	0.771				0.726				0.901	0.950		

Notes: To calculate cross-loadings, a factor score for each construct was calculated based on the weighted sum, provided by PLS Graph, of that factor's standardized and normalized indicators. Factor scores were correlated with individual items to calculate cross-loadings.
*We included two items for organization impact and perceived resilience, even though such items showed slightly lower factor loading scores than the recommended cut-off of .70 in further analyses. As Barclay et al. (1995) mention, some of the scales do not show the same psychometric properties when used in different theoretical and research contexts from those in which they were first developed. Thus it is important to retain as many items as possible from the original scale to preserve the integrity of the original research design, as well as the comparability of the results with other studies that used the same scales, even though some of the factor loadings are slightly less than .70.

Reference

Barclay, D. C., Higgins, C., and Thompson, R. 1995. "The Partial Least Squares Approach to Causal Modeling: Personal Computer Adoption and Use as an Illustration," *Technology Studies* (2:2), pp. 285-308.