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RESEARCH ARTICLE

MEANINGFUL HEALTHCARE SECURITY: DOES MEANINGFUL-USE ATTESTATION IMPROVE INFORMATION SECURITY PERFORMANCE?

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Appendix A

Theories in Certifications

Authors	Certification	Theory	Dependent Variable	Findings
Foster and Gutierrez 2013	Mexican Clean Industry Program	Signaling theory	Capital markets' response	Voluntary certifications can play an important role in the revelation of information about firm costs of compliance that can increase the efficacy of command and control regulation.
Oezpolat et al. 2013	Third-Party Assurance Seals	Signaling theory	Purchase conversion and purchase	The presence of the assurance seal increases the likelihood of purchase conversion.
Yeung et al. 2011	ISO 9000 Quality Management System	Institutional theory	CEO cash compensation rate and stock options	The CEOs' total cash compensation was positively adjusted when their firms received ISO 9000 certification, and they received higher-value stock options when their firms embarked on ISO 9000 certification.
Levine and Toffel 2010	ISO 9000 Quality Management System	Organizational learning theory	Annual earning, injury rates, sales, payroll, and average annual earnings.	ISO 9001 adopters subsequently had far lower organizational injury rates and higher outcomes (i.e., annual earning, growth rates for sales, payroll, and average annual earnings).
Gao et al. 2010	Capability Maturity Model	Signaling theory	The number of IT service exports	A software service provider gains more from certification in terms of its software exports when its service offerings are diversified.
Arimura et al. 2008	ISO14001 Environmental Management	Voluntary organizational learning	Manufacturing facilities' environ-mental performance	ISO14001 reduces the three factors: natural resource use, solid waste generation, and wastewater effluent.
Graffin and Ward 2010	Third-Party Certifications	Signaling theory	Reputation and performance	Certifications can influence an actor's reputation by reducing performance standard uncertainty rather than just technical uncertainty.

Authors	Certification	Theory	Dependent Variable	Findings
Benner and Veloso 2008	ISO 9000 Quality Management System	Organizational learning and institutional theory	Financial performance	While performance advantages accrue for earlier adopters in an industry, they are competed away over time for later adopters.
Boiral 2007	ISO 14001 Environmental Management	Grounded theory	Standards integration and assimilation	Adopting the ISO 14001 system can have an ambiguous effect on environmental management practices and performances, because the documentation required by these standards seems to make an organization more rigid and bureaucratic.
Hwang et al. 2006	ISO 9001 Quality Certificates	Game theory	A supplier's quality	Certification regimes outperform appraisal regimes if inspection costs are low.
Toffel 2006	ISO 14001 Environmental Management	Signaling theory and organizational learning	Environmental performance (toxic emissions)	ISO 14001 has attracted companies with superior environmental performance, and that adoption leads to further performance improvement.
Corbett et al. 2005	ISO 9000 Quality Management System	Organizational learning theory	Financial performance	ISO 9000 certification was indeed followed by significant abnormal improvements in financial performance.
Naveh and Erez 2004	ISO 9002 Quality Assurance Standard	Organizational learning theory	Cost of non-quality (repair time ratio) and productivity (the standard time per product)	ISO 9000 positively affected attention to detail but negatively affected innovation.
Terziovski et al. 2003	ISO 9000 Quality Management System	Organizational learning theory	Warranty claims cost, on time delivery rate, errors, defects, and productivity	There is a significant and positive relationship between the manager's motives for adopting ISO 9000 certification and business performance.
Benner and Tushman 2002	ISO 9000 Quality Management System	A theory of quality management	Exploitative and exploratory innovation (the number of patents)	The extent of process management activities in a firm was associated with an increase in both exploitative innovations that built on existing firm knowledge and an increase in exploitation's share of total innovations.
Hendricks and Singhal 2001	Quality Management Programs	Organizational learning theory	Stock price	Effective implementation of TQM principles leads to significant wealth creation. Long-term positive abnormal returns are observed.
King and Lenox 2000	ISO 14001 Environmental Management	Organizational learning theory	Environmental performance (emission rate)	The adoption of ISO9001 is associated with ISO140001 adoption and pollution prevention.
Anderson et al. 1999	ISO 9000 Quality Management System	Organizational learning and signaling theory	The amount of exports	ISO 9000 works as a credible public signal of effective quality management practices rather than regulatory compliance.
Terziovski et al. 1996	ISO 9000 Quality Management System	Organizational learning theory	Growth in sales	Significantly positive effect on organizational performance in the presence of a TQM environment has been observed.
Hendricks and Singhal 1997	Quality Awards	Organizational learning theory	Operating income, sales, the ratio of capital expenditure	Firms that have won quality awards outperform a control sample on operating income-based measures.
Hendricks and Singhal 1996	Quality Awards	Cost-benefit analysis	Stock price	Producing higher conformance quality products is always less costly than producing low conformance quality product; the stock market reacts positively to winning quality award announcements.

Appendix B

Breach Description and Type [redacted]

Date Made Public:	January 17, 2013
Company:	Medical Center
Location:	Texas
Type of breach:	HACK
Records Breached:	2,988
Total Records:	2,988

External Breach

An employee's computer was found to contain malware. The malware infection began on May 21, 2012 and was discovered on November 15, 2012. Files stored on the computer contained billing information with patient names, Social Security numbers, account numbers, medical record numbers, dates of birth, gender, treatment dates, insurance provider names, and account balances.

Information Source: HHS via PHIPrivacy.net

Date Made Public:	July 17, 2012
Company:	Medical Center
Location:	California
Type of breach:	PORT
Records Breached:	3,900
Total Records:	3,900

Accidental Internal Breach

An unencrypted thumb drive was lost on May 7 and discovered missing on May 8. It contained the names, account numbers, diagnoses, dates of admission and discharge, physician's name, account numbers, and medical record numbers of patients. It is unclear if only one Medical Center in California was affected, and if so, which one. The incident was posted on the HHS website on June 8.

Information Source: HHS via PHIPrivacy.net

Date Made Public:	October 11, 2013
Company:	General Hospital
Location:	Virginia
Type of breach:	INSD
Records Breached:	3,700
Total Records:	3,700

Malicious Internal Breach

Two dishonest nurse aides gathered information from at least 12 patients in order to file fraudulent tax returns. The breach occurred between September of 2011 and April of 2013. Some of the patients were from Sentara Virginia Beach General Hospital. The nurses' aides were indicted on charges of conspiracy to defraud the government.

Information Source: HHS via PHIPrivacy.net

Appendix C

Correlations in the DID Sample for the Short-Term Effect

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	Tol	VIF
Breach Information														
(1) External	1.00												0.41	2.41
(2) Accidental Internal	**0.07**	1.00											0.44	2.28
(3) Malicious Internal	0.02	**0.24**	1.00										0.67	1.48
(4) lnBreachCost	**0.66**	**0.57**	**0.46**	1.00									0.23	4.38
Hospital Information														
(5) NofBeds	**0.14**	**0.11**	**0.17**	**0.23**	1.00								0.41	2.44
(6) lnOexp	0.02	**0.05**	0.01	**0.03**	**0.52**	1.00							0.65	1.53
(7) ISPlan	**0.04**	**0.04**	0.00	**0.04**	**0.13**	**0.19**	1.00						0.87	1.15
(8) Academic	**0.17**	**0.14**	**0.10**	**0.22**	**0.50**	**0.20**	**0.03**	1.00					0.72	1.39
(9) Metro	**0.11**	**0.10**	**0.10**	**0.16**	**0.48**	**0.35**	**0.18**	**0.20**	1.00					
Healthcare Systems														
(10) Security	**0.07**	**0.07**	0.00	**0.07**	**0.20**	**0.17**	**0.22**	**0.10**	**0.18**	1.00			0.78	1.28
(11) Strategic IT	**0.09**	**0.11**	**0.10**	**0.15**	**0.42**	**0.31**	**0.30**	**0.23**	**0.33**	**0.47**	1.00		0.33	3.04
(12) Hospital Admin	**0.06**	**0.08**	**0.08**	**0.11**	**0.40**	**0.27**	**0.28**	**0.19**	**0.32**	**0.47**	**0.73**	1.00	0.42	2.37
(13) Clinical Operation	**0.11**	**0.14**	**0.10**	**0.18**	**0.58**	**0.44**	**0.30**	**0.26**	**0.40**	**0.40**	**0.74**	**0.66**	0.32	3.17

Notes: 6,028 observations. Bold represents statistically significant correlation coefficients with $p < 0.05$.

Appendix D

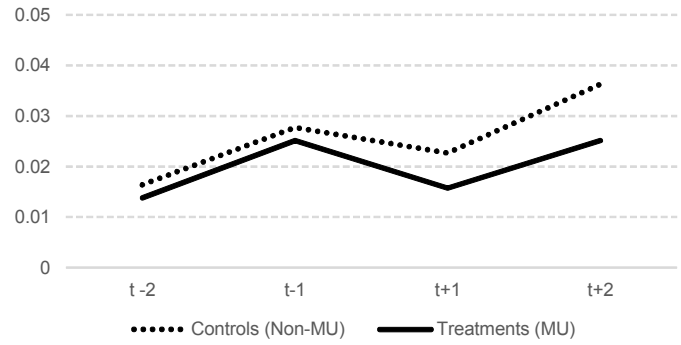
Correlations in the DID Sample for the Long-Term Effect

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	Tol	VIF
Breach Information														
(1) External	1.00												0.32	3.11
(2) Accidental Internal	**0.07**	1.00											0.45	2.21
(3) Malicious Internal	0.01	**0.25**	1.00										0.62	1.61
(4) lnBreachCost	**0.66**	**0.58**	**0.44**	1.00									0.19	5.39
Hospital Information														
(5) NofBeds	**0.15**	**0.10**	**0.16**	**0.21**	1.00								0.42	2.40
(6) lnOexp	0.00	**0.04**	0.00	0.01	**0.49**	1.00							0.70	1.42
(7) ISPlan	**0.05**	**0.04**	0.01	**0.04**	**0.15**	**0.20**	1.00						0.86	1.16
(8) Academic	**0.17**	**0.13**	**0.08**	**0.21**	**0.49**	**0.17**	**0.04**	1.00					0.73	1.38
(9) Metro	**0.12**	**0.10**	**0.10**	**0.16**	**0.49**	**0.32**	**0.20**	**0.21**	1.00				0.72	1.40
Healthcare Systems														
(10) Security	**0.08**	**0.07**	0.01	**0.08**	**0.21**	**0.15**	**0.24**	**0.08**	**0.18**	1.00			0.73	1.38
(11) Strategic IT	**0.10**	**0.10**	**0.10**	**0.15**	**0.41**	**0.27**	**0.31**	**0.24**	**0.34**	**0.48**	1.00		0.34	2.93
(12) Hospital Admin	**0.06**	**0.08**	**0.07**	**0.11**	**0.40**	**0.25**	**0.29**	**0.18**	**0.32**	**0.47**	**0.72**	1.00	0.43	2.35
(13) Clinical Operation	**0.13**	**0.14**	**0.11**	**0.19**	**0.59**	**0.40**	**0.32**	**0.27**	**0.41**	**0.41**	**0.74**	**0.65**	0.33	3.07

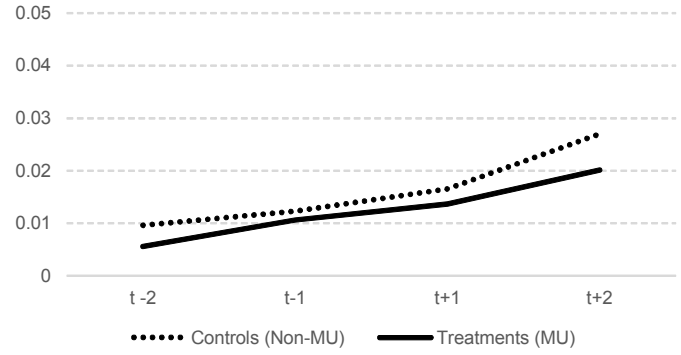
Notes: 4,424 observations. Bold represents statistically significant correlation coefficients with $p < 0.05$.

Appendix E

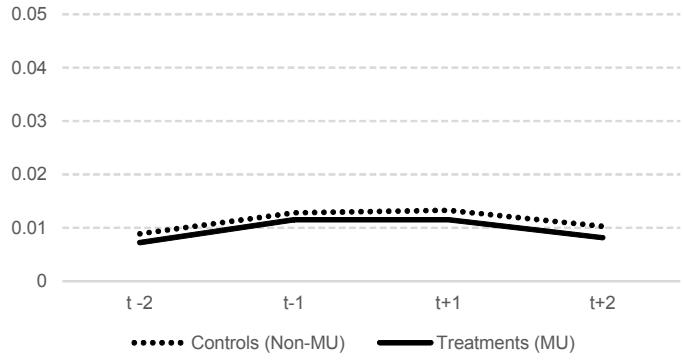
The Pre-Trends of Data Breaches in the Matched Sample



(a) The Pre-Trend of External Breaches



(b) The Pre-Trend of Accidental Internal Breaches



(c) The Pre-Trend of Malicious Internal Breaches

Appendix F

The Short-Term Effect in the DID Sample (Attestation Date: 2011–2012)

	External			Accidental Internal		
	Model (1)	**Model (2)**	**Model (3)**	**Model (1)**	**Model (2)**	**Model (3)**
DID Factors						
Treat			0.428 (0.356)			-0.829** (0.316)
AfterMU	0.013 (0.01)	0.018* (0.01)	0.658 (0.565)	-0.012 (0.008)	-0.015* (0.008)	-1.586*** (0.468)
Treat × AfterMU	**-0.022***** **(0.008)**	**-0.019**** **(0.008)**	**-1.493***** **(0.481)**	**0.017*** **(0.009)**	**0.019**** **(0.009)**	**1.148**** **(0.410)**
Breach Information						
External		-0.113*** (0.030)	0.053 (0.888)		-0.015 (0.025)	1.133 (0.601)
Accidental Internal		0.097*** (0.026)	-0.087 (0.788)		-0.313*** (0.021)	0.743 (0.443)
Malicious Internal		0.013 (0.021)	-15.603 (677.900)		-0.132*** (0.020)	-1.423 (1.059)
lnBreachCost		-0.003 (0.002)	0.091 (0.064)		0.004*** (0.002)	-0.030 (0.036)
Hospital Information						
NofBeds	-0.124 (0.108)	-0.100 (0.106)	0.878 (0.659)	-0.164*** (0.039)	-0.152*** (0.037)	-0.784 (0.581)
lnOexp	-0.011*** (0.003)	-0.013*** (0.003)	-0.009 (0.047)	0.009*** (0.002)	0.007*** (0.002)	-0.005 (0.029)
ISPlan	0.080** (0.031)	0.072** (0.031)	1.324*** (0.366)	-0.023 (0.030)	-0.025 (0.029)	-0.180 (0.447)
Academic			-0.030 (0.384)			0.882** (0.264)
Metro			1.123*** (0.411)			1.133** (0.330)
Security	0.004* (0.003)	0.004* (0.002)	-0.138** (0.055)	0.007*** (0.002)	0.003* (0.002)	0.032 (0.042)
Strategic IT	0.001 (0.002)	0.001 (0.002)	0.062 (0.066)	-0.009*** (0.002)	-0.009*** (0.002)	-0.021 (0.055)
HospitalAdmin	0.000 (0.001)	0.000 (0.001)	0.048 (0.039)	0.001 (0.001)	0.004*** (0.001)	-0.041 (0.030)
ClinicalOperation	0.001 (0.000)	0.001 (0.000)	0.042* (0.025)	0.002* (0.001)	0.001 (0.001)	0.093** (0.021)
Meaningful-Use Attestation Year						
MU2012			-0.044 (0.329)			-1.200** (0.230)
Other Information						
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Fixed effects	Yes	Yes	No	Yes	Yes	No
Clustered standard errors	Yes	Yes	No	Yes	Yes	No
Observations	4,424	4,424	4,424	4,424	4,424	4,424
R^2	0.365	0.383	0.025	0.409	0.465	0.043
Max-rescaled R^2			0.148			0.179
-2Log L			690.590			1037.070

Notes. Standard errors are in parentheses. *Significant at $p < 0.1$, **Significant at $p < 0.05$, ***Significant at $p < 0.01$.

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