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Integrating information quality dimensions into information security risk management (ISRM)

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ABSTRACT

Information security is becoming an important entity to most organizations due to current trends in information transfer through a borderless and vulnerable world. This gives more concerns and aware organization to apply information security risk management (ISRM) to develop effective and economically-viable control strategies. Even though there are numerous ISRM methods that are readily available, most of the ISRM methods prescribe a similar process that leads to establish a scope of the assessment, collecting information, producing intermediary information, and finally using the collected information to identify their security risks and provide a measured, analyzed security profile of critical information assets. Based on the "garbage in-garbage out" phenomenon, the success of ISRM planning tremendously depends on the quality of input information. However, with the amount, diversity and variety of information available, practitioners can easily deflects with grown information and becoming unmanageable. Therefore this paper contribute as a stepping stone to determine which IQ dimensions constitute the quality of the information throughout the process of gathering information during ISRM. Seems to accurately define the attributes of IQ dimensions, IQ needs to be assessed within the context of its generation. Thus, papers on IQ web were assessed and comparative analysis was conducted to identify the possible dimensions for ISRM. Then, online survey using likert structured questionnaire were distributed among a group of information security practitioners in Malaysia (N = 150). Partial least square (PLS) analysis revealed that dimension accuracy, amount of data, objective, completeness, reliability and verifiability are significantly influence the quality of information gathering for ISRM. These IQ dimensions can guide practitioners in the process of gathering quality and complete information in order to make a plan that leads to a clear direction, and ultimately help to make decisions that lead to success.

1. Introduction

Organizations are becoming progressively aware that information security is an important aspect of their businesses strategy. The concern aware organizations to apply information security risk management (ISRM) to identify the security risks in the organizations and provides a measured, analyzed security risk profile of the critical assets in order to build plans to treat the risks [30,50–52]. Nowadays, there are a number of different types of risk management methods, standards, guidelines and specifications that are available for assessing and managing risk management [13,42].

Most of the methods prescribe a similar process that leads to establishing a scope of the assessment, collecting information, producing intermediary information, and finally quantifying and sorting items such as assets, vulnerabilities, threats and risks, according to a set of parameters. All the ISRM methods only differ from each other in terms of the target community, details of the analytic process, as well as the information they prescribe [28].

Seems the goal of ISRM is basically the same, which is selecting effective preventive measures and combating information threat in an active fashion [11], organizations need to define appropriate controls for reducing or eliminating those risk by using the output

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of the risk assessment. Therefore, information security department needs to complete all the required planning before starting the actual risk assessment. This because the success of the risk assessment fully depends on the information gathered in order to make concise and accurate security planning decisions.

Practically, practitioners systematically gather more information than the use, yet continue to ask for more in order to fulfill the requirements to be met before risk assessment is conducted. According to Kenett and Shmueli [25], basically, there are many different collection tools are available to use to collect information such as surveys, laboratory tests, field and computer experiments, simulations, web searches, observational studies, social network and more. This situation will lead practitioners to easily deflects with grown information and become unmanageable. Much of the information is gathered in a surveillance mode rather than in a decision mode. Furthermore, with the development of information technology [61], organizations tend to collect enormous of information and more complex information resources [33].

Hence practitioners are required to evaluate the collected information resources based on the user's perspective in order to eliminate all the "garbage" information. This is due to the quality of the output is extremely depends on the quality of the input information, known as the "garbage-in-garbage-out" phenomenon [6,7]. Furthermore, information is a critical resource for organization merely because the quality of information is one of the key determinants of the quality of their decisions and actions [54].

Although there is a wide range of active research and practice in IQ in other application areas [16], there is a need for further research incorporating IQ in ISRM field in order to successfully measure the quality of the information to be gathered in process of gathering and planning risk assessment. In the area of risk management, the concept of what dimensions constitutes IQ in risk management has not been addressed.

Therefore, this study strives to serve as a fundamental and stepping stone for triggering the attention of researchers and practitioners on the needs of integrating IQ dimension in the ISRM field. This paper seeks to contribute by determining which IQ dimensions constitute the quality of the information throughout the process of gathering information during ISRM. The analysis was conducted using PLS-SEM analysis technique. The determined dimensions can guide information security practitioners to do their own quality evaluations for ensuring the information gathered for ISRM is considered quality and can lead information security practitioners to make evidence-based decisions.

This paper is organized into several sections. The immediate section describes the importance of having ISRM and needs to integrate IQ in ISRM. Section 2 explaining related work for this study. Section 3 explained on research approach used in identifying possible IQ for ISRM. Section 4 explains the research method used followed by the results of the analyses conducted. Last but not least, Section 6 concludes the paper.

2. Related work

Generally, information practitioners should understand where, how, and how much information are needed to impact an organization's ability to successfully deliver its objectives. Because most modern organizations tend to collect increasing amount of data and more complex information resources [33]. Based on the "garbage in-garbage out" phenomenon, the success of ISRM planning tremendously depends on the quality of input information because the quality of information is one of the key determinants of practitioners decisions and actions. Studies also have shown that poor IQ can have a negative impact on operational and strategic management, which can require information rework, make significant process inefficiencies, spoil valuable resources, and lead to poorer decision making and lost future.

Moreover, most of the influential IQ research originated from information system research and the IQ research is divided into two research communities: databases and management [17,34]. As well, Zhu et al. [62] also have proven IQ research mostly focused on developing techniques for querying multiple data sources and building large data warehouses. According to Ge [16], although researchers have applied IQ to various organizational context, none of the studies applied the IQ in the ISRM field.

It has been proven by author Ge [16] by summarizing representative publications for each application context in IQ theory within the period of 1996 until 2006. Researchers only have applied IQ theory on database, information manufacturing system, accounting, marketing, data warehouse, decision making in the database, healthcare, enterprise resource planning, customer relationship management, finance, e-business, World Wide Web and supply chain management. Therefore there is a need for further research to identify and classify IQ dimensions in ISRM field.

Therefore, by examining what the basic IQ dimensions constitute quality in risk management will be good stepping stone to ensure the collected information using the ISRM's information collection structure [43,44] would encourage in making a plan that leads to a clear direction, and ultimately help to make decisions that lead to success.

2.1. Overview on IQ

Organizations and researchers striving towards to achieve the objective of IQ which is to determine the characteristics of information items that are important, or suitable for information consumers [10,59]. Based on the Juran (1992) as cited in [59], the definition of IQ has been defined as "fitness for use" and this definition is widely adopted in the quality literature [7,10,17,22,32,33,47,53–55,60,62]. Since Wang and Strong [59] define IQ as the information that is fitness for use by information consumers, only information consumer are ultimately responsible for judging whether or not the gathered information is successfully serving the purposes of customers for intended use.

According to Shankaranarayanan and Cai [47], quality of data is dependent on the purpose of the task. Therefore, in order to assess the status of organization's information, organizations need to develop comprehensive measures of the quality of their information and to benchmark their effort against that of other organizations [29].

There is an agreement amongst researchers and practitioners that IQ is a multi-dimensional concept in which each dimension represent a single aspect or construct of information items and is described by a set of features [4,10,40,58,59]. As users have different perceptions of IQ, they have to propose a flexible model that enable them to create and weight their own IQ dimensions and features [10].

However, most of these frameworks are ad hoc, intuitive, and incomplete and may not produce robust and systematic measurement models [39,54,58]. There seems to be a lack of methodologies that are general enough to be applied to most data quality situations, regardless of the type of organization [5,57]. Generally, IQ framework consists with varying attributed characteristics depending on an author's philosophical viewpoint [27]. A literature review shows that there is no general agreement on IQ dimensions [5]. Since there is no agreement on the set of the dimensions characterizing IQ, many proposals have been made, but no one has emerged as a standard [31].

Although, each new research carried out on the IQ field is forming a new framework, researchers used to bank on previous researchers' classifications as a reference for developing their new

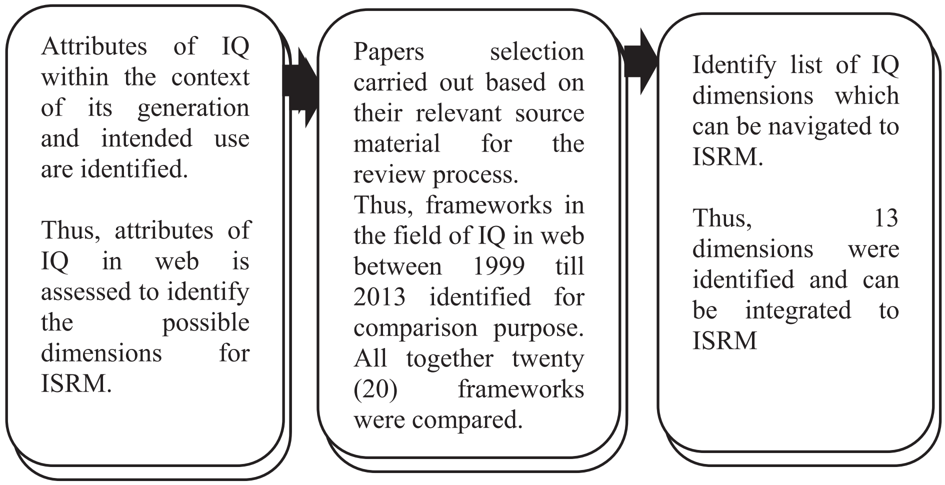

Fig. 1. Activities flow for identifying potential IQ dimensions for ISRM.

ones that match their needs. By analyzing those classifications, it is possible to define a basic set of data quality dimensions which represent the dimensions considered by the majority of the authors [37].

3. Research approach to identify IQ dimensions

This study is developed based on the activities flow presented in Fig. 1 in order to identify the IQ dimensions for ISRM.

Since there is numerous IQ framework currently available, there is a need for further research in this area to explore and examine what dimensions constitute quality in the process of collecting information throughout the risk management using the ISRM's information collection structure [43,44]. Thus, firstly, researchers identified attributes of IQ within the context of its generation and intended use which is in web field was identified. Search was done from the year 1999 till 2013. A total of 20 articles which related to web IQ dimensions were chosen by doing a comparison to see the most frequently used IQ dimensions by other researchers to make comparisons in their study.

3.1. Similarity situation between IQ dimensions in web and ISRM

In order to accurately define the attributes of IQ, IQ needs to be assessed within the context of its generation [49] and intended use [23]. This is because the attributes of IQ can vary depending on the context in which the data is to be used [45]. Therefore IQ in the web is assessed to identify the possible dimensions for ISRM.

Web applications normally based on user-generated content. Therefore it comes under criticism for containing low-quality information. The community of web authors is heterogeneous, including people with different levels of education, age, culture, language skills, and expertise. In contrast in printed articles, the contributions to web seldom reviewed by experts before publication. These factors make clear that the most important, but probably the most difficult challenge for web pertains to the quality of its articles. In addition, the impressive growth in the number of information sources available on the web also another problem in a web. The user of the information (web searcher) have to make judgments about the quality of the information they obtain from the vast information available on the web by themselves [41].

The same situation also happened in the process of collecting information in ISRM. During the process of design and implementation of ISRM, different levels of education, age, culture, language skills, and expertise of practitioners will involve gathering information. Practitioners possibly collect information from an unreliable source. The risk of poor data quality increases when more of the available content is obtained from sources with mixed, and sometimes dubious provenance [3]. In addition, with the development of information technology has enabled organizations to collect and store enormous amounts of information [61]. Practitioners also have to make a judgment about the information they obtain in order to make a quality decision which will lead them to successful ISRM.

3.2. Research model and hypothesis

Researchers in the field of web IQ have highlighted a number of dimensions that need to be considered to ensure the quality information. Therefore, in order to identify the attributes of IQ that are relevant to this study have identified. Altogether twenty major frameworks in the field of IQ in the web were identified for comparison purpose. Table 1 shows a summary of the most common dimensions and the frequency of which they have appeared in the twenty web related IQ frameworks. The analysis of the below IQ frameworks reveals common dimensions between them.

Based on comparative analysis done on twenty (20) types web-based framework, the analysis results reveal that there are totally thirteen (13) dimensions may influence in ensuring the quality of information gathered during ISRM. The IQ dimensions that are the most frequently ticked are accuracy, objectivity, believability, availability, relevance, timeliness, completeness, the amount of data, understandability, concise representation, consistent representation, reliability, and verifiability. The dimensions were chosen based on more than half of the ten authors used it in their frameworks.

Referring to Fig. 2, researchers posit this thirteen information quality dimensions of which these thirteen constructs are then posited to influence the quality of ISRM information. The proposed thirteen (13) hypotheses are as below. As such the structural framework highlighted the thirteen main hypotheses which are relevant to this study.

The hypotheses are:

H1: Accuracy is significantly influencing the quality of information gathering for ISRM.
H2: Amount of data is significantly influencing the quality of information gathering for ISRM.

Table 1
Summary and frequency of the IQ dimensions frameworks. The references cited in this table are [63–82]

Year	Authors	Accuracy	Objectivity	Believability	Reputation	Availability\Accessibility	Security	Relevancy	Value Added	Timeliness	Completeness	Amount of Data	Interpretability	Understandability	Concise Representation	Consistent Representation	Reliability	Verifiability\ Validity	Latency	Response Time	Customer Support	Documentation	Price	Authority	Efficiency	Navigation	Validity	Ease of Operation	Informativeness	Usability	Applicability	Duplicates	Novelty	Specialization	Traceability	Uniqueness	Others
1999	(Alexander & Tate, 1999)	X	X							X								X						X		X											Orientation
	(Katerattanakul & Siau, 1999)	X			X	X		X		X	X	X		X		X	X									X											Attractiveness
2000	(Naumann & Rolker, 2000)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X														
2002	(M. J. Eppler & Muenzenmayer, 2002)	X	X	X				X		X	X			X	X	X																					
	(Klein, 2002)	X						X		X	X	X																									
	(Katerattanakul & Siau, 2002)	X				X		X		X	X	X	X	X	X	X	X																				
2004	(Matheus, 2004)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																					
2005	(Knight & Burn, 2005)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X														
	(Molaughlin et al., 2005)	X				X		X		X	X		X				X	X						X			X										Generalizability, Sufficiency
2006	(Herrera-Viedma et al., 2006)			X				X		X	X			X	X																						Originality
	(Parker et al., 2006)	X	X	X	X	X	X	X	X	X	X	X		X	X	X																					Manipulation, Speed
	(Caro et al., 2006)	X		X		X		X		X		X		X		X	X	X									X										
2007	(Caro et al., 2007)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X					X	X			X	X	X	X	X		
2008	(Knight, 2008)	X	X	X		X	X	X		X	X			X	X	X	X								X					X						X	
	(Caro et al., 2008)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X					X	X			X	X	X	X	X		
2011	(Kandari et al., 2011)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						X	X	X		X									Advertising
	(Knight, 2011)	X	X	X		X	X	X		X	X			X	X	X	X								X					X						X	
	(Kargar, 2011)	X	X	X		X				X	X	X		X	X	X		X	X		X			X					X								Redundancy, Cohesiveness, Popularity, Representation, Maintainability
2012	(Šajna, 2012)		X							X				X				X																			Credibility
2013	(Mohammadi & Abrizah, 2013)	X	X							X	X							X											X								Reusability
Total		18	14	14	8	14	9	16	7	20	17	12	8	16	13	12	11	11	3	2	5	4	2	4	3	3	4	3	2	2	2	2	2	2	2	2	

H3: Availability is significantly influencing the quality of information gathering for ISRM.
H4: Believability is significantly influencing the quality of information gathering for ISRM.
H5: Completeness is significantly influencing the quality of information gathering for ISRM.
H6: Concise representation is significantly influencing the quality of information gathering for ISRM.
H7: Consistent representation is significantly influencing the quality of information gathering for ISRM.
H8: Objective is significantly influencing the quality of information gathering for ISRM.
H9: Relevancy is significantly influencing the quality of information gathering for ISRM.
H10: Reliability is significantly influencing the quality of information gathering for ISRM.
H11: Timeless is significantly influencing the quality of information gathering for ISRM.
H12: Understandability is significantly influencing the quality of information gathering for ISRM.
H13: Verifiability is significantly influencing the quality of information gathering for ISRM.

4. Method

4.1. Sample and data collection

As this study concerns information quality dimensions in ISRM, the sample consists of practitioners from organizations which received an accreditation certificate for complying with ISO/IEC 27,001:2007 international standards. To decide on the sample size of the respondents for this study, first used the G-power software to calculate the minimum sample size required. Since the structural information quality framework had a maximum of 13 predictors, researchers set the effect size as small (0.15) and power needed as 0.8. The sample size required was 131. Hence researchers set out to collect data larger than the required number.

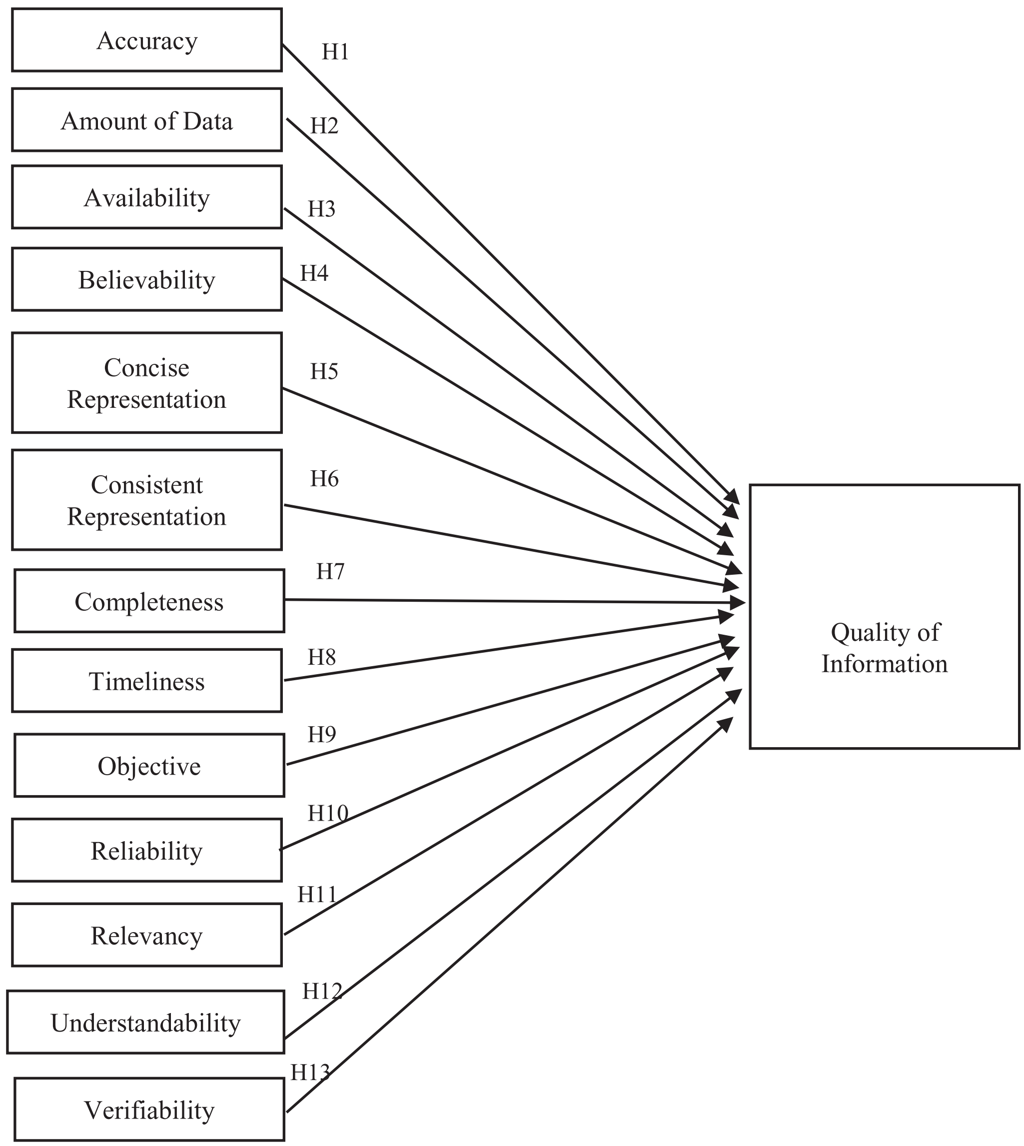

Fig. 2. The hypothesized research framework.

Using online survey "Survey Monkey" method, two hundred and one (201) questionnaire were distributed and hundred and fifty (150) valid responses were collected.

4.2. Measures

Respondents were given the link of online survey "Survey Monkey" which consists of a structured questionnaire. They were asked to answer questions on their demographics, information quality dimensions and quality of information in ISRM. The items or measures for these independents and dependents variables were adapted from [29,56] anchored on a 5-points Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree.

4.3. Respondents' profile

Table 2 portrays the demographic profile of the respondents by types of industry, job position, and year of experience as IS officer.

As depicted in Table 2, the participants work in various industries in both the public and private sectors. The professionals also have a variety of roles in the organization. It was found that 20.67% of professionals are management executives. Professionals who have titles of the security officer and security staffs resulted in 22.67 and 16%, respectively. It indicates that more than half of professionals (59.34%) have crucial information security management responsibilities.

5. Results

This study employed the Partial Least Square (PLS) analysis technique using Smart PLS 3.0 software. There are two-stage analytical procedures in PLS-SEM to conduct in order to determine the information quality dimensions. The first examination is known as measurement model to test validity and reliability of the measures followed by an examination of the structural model to determine which information quality dimensions constitute quality in ISRM [2]. In order to test the significance of the path coefficients and the loadings, a bootstrapping method was used [20].

5.1. Measurement model evaluation

The aim of conducting the measurement model is to measure how the observed variables depend on the unobserved variables

Table 2
Sample characteristics of respondents.

Profile	Frequency (N)	Percentage (%)
Types of industry		
Financial and insurance service	12	8
Electricity, gas, water and waste services	26	17.33
Agriculture, forestry and technical services	4	2.67
Consultancy	3	2
Information Technology	35	23.33
Manufacturing	–	–
Government-federal, military	47	31.33
Medical/Healthcare-public or private	2	1.33
Consumer Products/Retail/Wholesale	–	–
Professional service- legal, marketing	3	2
Education/Research	6	4
Travel/Hospitality	1	0.67
Telecommunications	7	4.67
Mining	–	–
Administrative and support services	–	–
Culture & recreational services	–	–
Property & business services	1	0.67
Others	3	2
Job position		
Executive management	31	20.67
Security officer	34	22.67
Security staff	24	16
IT staff	41	27.33
Technical management	9	6
Consultant/Contractor	–	–
System administrator	11	7.33
Others	–	–

([19]). To assess the measurement model, two types of validity were examined, the first will be convergent validity and the second will be discriminant validity. Convergent validity of the measurement model is ascertained by examining the loadings, average variance extracted (AVE), and also the composite variables [18]. The loadings were all higher than 0.7, the composite reliability were all higher than 0.7 and the AVE values were also higher than 0.5 as suggested by [20]. Table 3 shows the results for convergent validity.

The discriminant validity of the measures was examined by following the [15] criterion of comparing the correlations between constructs and the square root of the AVE for that constructs. In order to evaluate the discriminant validity, the AVE for each construct should be greater than the squares of the correlations between the construct and all other constructs. Furthermore, the correlations between the constructs should be lower than the square root of the average variance extracted. Refereeing to Table 4, the square root of the AVEs as represented by the bolded values on the diagonals were greater than the corresponding row and column value indicating the measures were discriminant.

Table 3
Convergent validity of measurement model.

Constructs	Items	Loadings	AVE	CR
Accuracy	ACC1	0.886	0.747	0.936
	ACC2	0.908		
	ACC3	0.925		
	ACC4	0.787		
	ACC5	0.805		
Amount of data	AMD1	0.895	0.708	0.878
	AMD2	0.909		
	AMD3	0.705		
Availability	AVA1	0.897	0.800	0.941
	AVA2	0.920		
	AVA3	0.939		
	AVA4	0.817		
Believability	BEL1	0.909	0.808	0.954
	BEL2	0.850		
	BEL3	0.916		
	BEL4	0.924		
	BEL5	0.892		
Completeness	COP1	0.850	0.776	0.912
	COP2	0.920		
	COP3	0.870		
Concise representation	CNR1	0.921	0.886	0.939
	CNR2	0.961		
Consistent Representation	CRP1	0.869	0.748	0.922
	CRP2	0.900		
	CRP3	0.807		
	CRP4	0.881		
Objective	OBJ1	0.827	0.669	0.890
	OBJ2	0.852		
	OBJ3	0.781		
	OBJ4	0.810		
Relevancy	REL1	0.943	0.874	0.933
	REL2	0.927		
Reliability	RLB1	0.871	0.771	0.910
	RLB2	0.909		
	RLB3	0.854		
Timeliness	TIM1	0.921	0.851	0.945
	TIM2	0.922		
	TIM3	0.925		
Understandability	UND1	0.898	0.790	0.938
	UND2	0.911		
	UND3	0.865		
	UND4	0.881		
Verifiability	VRP1	0.966	0.930	0.964
	VRP2	0.963		
Quality of Information	QofInfo1	0.750	0.681	0.955
	QofInfo2	0.799		
	QofInfo3	0.840		
	QofInfo4	0.860		
	QofInfo5	0.823		
	QofInfo6	0.894		
	QofInfo7	0.751		
	QofInfo8	0.907		
	QofInfo9	0.827		
	QofInfo10	0.785		

5.2. Structural model evaluation

After examining the Measurement Model, a structural model was conducted by analyzing the inner model. In order to do this, the researchers first examined the path loadings between constructs to identify significance using computed T-statistics. Furthermore, during the structural model assessment involves evaluating R^2 and beta [20].

In this study, the significant of the path is tested with the bootstrap running with sub-sample size of 150 and 5000 repetitions. In other words, in order to obtain the t-values, a bootstrapping procedure with 5000 resamples was applied. One tail *t*-test, 95% significance level or $p < 0.1$ requires t-value > 1.28.

The structural model of PLS was then examined to see whether the hypotheses were supported by the data or not. The results are presented in Table 5 presents the significant path coefficients.

As shown in Table 5, there is thirteen main hypothesis involved (H1, H2, H3, H4, H5, H6, H7, H8, H9, H10, H11, H12, and H13). All the constructs were positively related to the quality of information (dependent construct) explaining 62.9% (R^2) of the variance in quality if information. The R^2 values which are above the 0.35 value as suggested by Cohen [12] indicating a substantial model.

The findings indicate that 6 out of 13 hypotheses are significantly supported. The finding shows there were six information quality dimensions, known as accuracy, the amount of data, completeness, objective, reliability and verifiability were significantly influencing the quality of information gathering for ISRM.

Table 4
Discriminant validity of measurement model.

	ACC	AMD	AVA	BEL	COP	CNR	CRP	REL	OBJ	QofInfo	RLB	TIM	UND	VRF
ACC	**0.864**													
AMD	0.416	**0.842**												
AVA	0.558	0.458	**0.895**											
BEL	0.621	0.506	0.546	**0.899**										
COP	0.610	0.591	0.443	0.514	**0.881**									
CNR	0.349	0.631	0.319	0.377	0.545	**0.941**								
CRP	0.540	0.647	0.424	0.479	0.693	0.606	**0.865**							
REL	0.516	0.711	0.440	0.598	0.612	0.566	0.687	**0.935**						
OBJ	0.614	0.487	0.512	0.657	0.574	0.421	0.599	0.609	**0.818**					
QofInfo	0.619	0.589	0.451	0.556	0.640	0.503	0.603	0.618	0.638	**0.825**				
RLB	0.626	0.529	0.380	0.540	0.652	0.435	0.639	0.609	0.594	0.660	**0.878**			
TIM	0.524	0.703	0.556	0.593	0.616	0.470	0.635	0.606	0.571	0.555	0.569	**0.923**		
UND	0.508	0.626	0.466	0.500	0.539	0.608	0.712	0.648	0.611	0.603	0.625	0.585	**0.889**	
VRF	0.555	0.592	0.496	0.539	0.589	0.402	0.628	0.632	0.630	0.661	0.653	0.614	0.582	**0.965**

Note: ACC=Accuracy, AMT=Amount of Data, AVA=Availability, BEL=Believability, COP=Completeness, CNR=Concise Representation, CRP=Consistent Representation, OBJ=Objectiveness, REL=Relevancy, RLB= Reliability, TIM=Timeliness, UND=Understandability, VRF= Verifiability, QofInfo=Quality of Information

Table 5
Results of the structural model analysis.

Relationship	Standard deviation	Path coefficients	*t* value	*p* value	R^2	Results
ACC→QofInfo	0.114	0.168	1.471*	0.071	0.629	Supported
AMD→QofInfo	0.091	0.135	1.489*	0.068		Supported
AVA→QofInfo	0.079	−0.019	0.237	0.406		Not supported
BEL→ QofInfo	0.073	0.021	0.291	0.385		Not supported
COP→ QofInfo	0.098	0.135	1.372*	0.085		Supported
CNR→ QofInfo	0.070	0.085	1.207	0.114		Not supported
CRP→ QofInfo	0.096	−0.059	0.616	0.269		Not supported
OBJ→ QofInfo	0.090	0.152	1.694**	0.045		Supported
REL→ QofInfo	0.127	0.027	0.213	0.416		Not supported
RLB→ QofInfo	0.100	0.150	1.499*	0.067		Supported
TIM→ QofInfo	0.088	−0.066	0.756	0.225		Not supported
UND→ QofInfo	0.116	0.067	0.583	0.280		Not supported
VRF→ QofInfo	0.097	0.200	2.063**	0.020		Supported

Note: ACC=Accuracy, AMT=Amount of Data, AVA=Availability, BEL=Believability, COP=Completeness, CNR=Concise Representation, CRP=Consistent Representation, OBJ=Objectiveness, REL=Relevancy, RLB= Reliability, TIM=Timeliness, UND=Understandability, VRF= Verifiability, QofInfo=Quality of Information

6. Discussion and conclusion

Information quality dimensions can ensure that an organization has a good level of information quality to support the information they gathered throughout the ISRM activities. This is because decisions are only can be considered as good as the information on which they have relied. Therefore, by knowing the acceptable information quality dimensions for ISRM can be a strong foundation for organizations to have confidence in gathering quality information during ISRM implementation.

This research can be a stepping stone to determine which information quality dimensions constitute the quality of the information throughout the process of gathering information during ISRM. The findings determined there are six dimensions can influence the quality of information gathering for ISRM. The dimensions are accuracy, the amount of data, completeness, objectives, reliability and verifiability. These dimensions can guide information security practitioners to define their own quality evaluations criteria for ensuring the information gathered for ISRM is considered quality and can lead information security practitioners to make evidence-based decisions.

Thus, the determined information quality can be used to ensure the process of conducting ISRM activity is quality by setting their own criteria measurement. It is undeniable that, only with information of high quality can lead organization to make correct decision on allocating resources and responsibility, applying appropriate controls to reduce the risks, maintaining appropriate protection of organizational assets, making well-informed risk management decisions and acting correctly in the combination of high consequence nature of disasters with the aim of successfully deliver their organization's business objectives.

In addition, quality in information is highly recommended in order to make correct decisions and in turn to get successful planning in ISRM. This is evidenced by many researchers have shown the influence of IQ on decision making [1,7–9,14,21,26,33,35–38,46–48,61].

It can be concluded that process of gathering quality and complete information would encourage in making a plan that leads to a clear direction, and ultimately help to make decisions that lead to success in conducting ISRM. Therefore, ISRM practitioners need to work towards collecting information of high quality in order to protect the integrity, confidentiality, and availability of their information assets and networks as strategic objectives.

Previously, researchers have proposed eight dimensions: data resolution, data structure, data integration, temporal relevance, generalizability, chronology of data and goal, construct operationalization and communication in order to assists researchers in evaluating the information quality at the study design stage (before information collection), post-information collection stage and also during the study implementation stage [24,25].

As this study aimed to serve as stepping stone for integrating IQ dimensions (Accuracy, Amount of Data, Completeness, Objective, Reliability and Verifiability) in the ISRM field, in the future, practitioners and also researchers are encourage to develop new methods or integrating previous researchers' methods [24,25] for assessing and improving information quality dimensions in ISRM field.

Appendix

Information quality dimensions

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Part 1: I find that, INFORMATION which is collected throughout the process of risk management have to be:

Accuracy	ACC1	The information is **accurate**
	ACC2	The information is **correct**
	ACC3	The information is **reliable**
	ACC4	The information is **believable**
	ACC5	The information is **meaningful**
	ACC6	The information is **certified error-free**
Objective	OBJ1	The information is **based on objective**
	OBJ2	The information is **based on facts**
	OBJ3	The information was **objectively collected**
	OBJ4	The information is **collected without influenced by personal feelings or opinions**
	OBJ5	The information **collected without using subjective judgments which leading to bias**
Believability	BEL1	The information is **credible** (capable of being believed)
	BEL2	The information is **believable**
	BEL3	The information is **trustworthy**
	BEL4	The information is **referred as true**
	BEL5	The information is **accepted as correct**
Availability	AVA1	The information is **easily retrievable** by other information security practitioners in team.
	AVA2	The information is **easily accessible** by other information security practitioners in team.
	AVA3	The information is **easily obtainable** by other information security practitioners in team.
	AVA4	The information is **quickly accessible** when needed by everyone in risk assessment team.
Timeliness	TIM1	The information is **sufficiently timely**
	TIM2	The information is **sufficiently current for our work**
	TIM3	The information is **sufficiently up-to-date for our work**
	TIM4	The information **is can be used on timely for risk response decisions**
	TIM5	The information is **current (up-to-date) at the time creation and revision dates**
	TIM6	The information is **initiated and assessed with respect to a specific time frame**

Part 2: - I find that, INFORMATION which is collected throughout the process of risk management have to be:

Completeness	COP1	The information is **complete**
	COP2	The information **includes all necessary values**
	COP3	The information **covers the needs of our tasks**
	COP4	The information is **sufficiently complete for our needs**
	COP5	The information has **sufficient breadth and depth for our tasks**
Understandability	UND1	The information is **easy to understand**
	UND2	The information is **easy to comprehend (find, receive)**
	UND3	The meaning of the **information is easy to understand**
	UND4	The information is **easy to interpret**
Consistent Representation	CRP1	The information is **presented consistently**
	CRP2	The information is **represented in a consistent format**
	CRP3	The information is **consistently presented in the same format**
	CRP4	The information **provide a consistent response to risk in accordance with the organizational risk frame**
	CRP5	The information is **communicated consistently within the organization**
	CRP6	The information **continuously monitor and update risk assessment**
Reliability	RLB1	The information is **from a trustable source of information**
	RLB2	The information is **trustable**
	RLB3	The information is **unreliable**
	RLB4	The information **comes from a reliable source**
	RLB5	The information is **concerned with the degree of accuracy**
	RLB6	The information **for risk assessment rely upon well-defined attributes of threats, vulnerabilities, impact and other risk factors**
Verifiability	VRF1	The information is **verified**
	VRF2	The information is **unverified**
	VRF3	The information is **checked for correctness**
	VRF4	The information is **confirm the validity by expert**
	VRF5	The information **verify that planned risk responses are implemented**
	VRF6	The information **verify risk assessment results provide essential information to enable authorizing officials to make risk-based decisions**

Part 1: I find that, INFORMATION which is collected throughout the process of risk management have to be:		
Relevancy	REL1	The information is **useful to our work**
	REL2	The information is **relevant to our work**
	REL3	The information is **helpful for task at hand**
	REL4	The information is **applicable to our work**
	REL5	The information is **appropriate for our work**
Amount of data	AMD1	The information is **sufficient volume for our needs**
	AMD2	The amount of **information match our needs**
	AMD3	The amount of **information is sufficient for our needs**
	AMD4	The amount of **information is neither too much nor too little**
Concise representation	CNR1	The information is **well organized**
	CNR2	The information is **well formatted**
	CNR3	The information is **presented concisely**
	CNR4	The information is **presented in a compact form**
	CNR5	**The representation of the information is compact and concise**

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