


# Investigating the Impact of Outsourcing on IT Flexibility: The Conceptual Independence Perspective


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## ABSTRACT

Modern healthcare organizations try to leverage their IT infrastructures to enhance the efficiency of processes and the quality of patient services. The flexibility of the IT infrastructure is a critical factor in the process of establishing strategic and operational value. The authors examine how applied principles of conceptual independence (CI) in information systems (IS) influence the flexibility of IT infrastructures. Furthermore, it is presumed that IT outsourcing plays a role in IT flexibility. The second question asks whether IT outsourcing configurations change when CI has been applied or not. Quantitative and qualitative data have been collected in nine mental healthcare organizations. Findings based on integration of the data with a mixed-method approach, the authors suggest that the healthcare organizations that apply the principles of CI are better equipped to adapt their IT infrastructure to changing demands, requests, and needs. Likewise, results suggest that they have changed the government of IT outsourcing thereby increasing IT flexibility even further.

## KEYWORDS

Conceptual Independence, Electronic Health Records, Healthcare, Information Systems, IT Flexibility, IT Infrastructure, IT Outsourcing, Mixed-Methods Approach, openEHR

## INTRODUCTION

Adapting to changing conditions and to a changing context is crucial for the survival of enterprises. In research on IT flexibility the importance of adapting IT to support new business requirements has been confirmed many times. Researchers investigating IT flexibility distinguish dynamic capabilities in firms that enable organizations to adapt to new circumstances (Eisenhardt & Martin, 2000; Teece et al., 1997). These capabilities involve sensing and seizing opportunities in the environment and

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responding to changes with reconfiguring of business processes. This study focuses on the changes necessary in IT for supporting business process change. The authors view business functionality in information systems (IS) as the functionality to support the organization with information retrieval and information processing necessary for business processes.

The adaptability of IS differs across organizations. The authors have researched openEHR and found that new software based on the openEHR standard shows promise in opening rigid structures in software. The number of countries applying the standard increased, including Norway, Sweden, UK, China, Germany, USA, Australia, Slovenia, and the Netherlands (openEHR Foundation, 2020a, 2020b, 2020c). In Norway, a pilot application initiated for registration and monitoring of COVID-19 patients in hospitals has recently been deployed and is in use. In a mini-symposium of Stichting openEHR Nederland (openEHR Foundation in the Netherlands) Naess reports (2020) on a diagnosis and treatment decision support system based on openEHR models that were reviewed internationally. The software could be implemented within 11 days because the models have been added to existing openEHR implementations in hospitals. He noted that six hospitals had ordered the openEHR Covid-19 software. Since IS are a major part of the IT infrastructure, the authors presume that the flexibility of IS affects the flexibility of the whole IT infrastructure.

In practice, they have observed that the complexity of current distributed information systems makes adaptation of business functionality difficult (Tarenskeen et al., 2018). The need for flexibility of business information in the conceptual models in IS has not been named explicitly except in descriptions of conceptual independence (McGinnes & Kapros, 2015). No systematic studies are investigating the effects of IS characteristics on the flexibility of the IT infrastructure as a whole. The authors intend to fill in this gap, and therefore, they study a fast-changing sector, the healthcare sector in the Netherlands where a transition is taking place. The authors address the research gap by focusing on an alternative way of organizing software. McGinnes and Kapros (2015) launched the term conceptual independence (CI). In CI, conceptual models in software have been separated from the application logic thereby creating loosely coupled components in software. McGinnes and Kapros make the claim that implementing CI leads to better adaptable IS (McGinnes & Kapros, 2015). Here, the authors claim that CI can be detected as an underlying design principle in openEHR software, and they study the flexibility of IS in openEHR systems. The openEHR standard provides a meta-standard for conceptual models in the medical domain. It is argued here that openEHR is exemplary for CI.

The supplier as the owner and developer of software applications is a determining factor for how conceptual models have been implemented in software. For example, in the healthcare sector in the Netherlands, the determining factor can be found in the supplier of the commercial-off-the-shelf software (COTS).

Hence the authors formulate the research question as:

*What are the direct effects of the combination of IT outsourcing and conceptual independence on IT flexibility in healthcare organizations?*

They have applied a mixed-methods approach because of the scarce existing research on this subject. With a mixed-methods approach it is possible to examine the subject in different ways and complement minimal quantitative data with extensive questioning of respondents in interviews. Direct measuring of system characteristics would be preferred, but extensive documentation of IT infrastructure and software has not been available for research in practice. The researchers even doubted that information about details of programming code could be found in the current documentation. Therefore they chose interviews to examine the ideas of IT professionals further.

Afterward they synthesized quantitative and qualitative data to investigate the effects of implementing the conceptual model on IT flexibility. The qualitative data have priority over the quantitative data in this study.

The authors focus on the effects of openEHR and CI on IT flexibility in research question 1:

*Do the organizations that have implemented conceptual independence observe an effect on IT flexibility resulting from the openEHR software?*

The authors apply a measurement instrument to indicate differences in IT flexibility between organizations that have observed and applied CI principles and organizations that have not. Then the relation between information technology outsourcing (ITO) and IT flexibility is explored. Since the latter is a completely new research subject, they will phrase the conclusions cautiously.

Next, research question 2 explores the role of ITO and CI:

*Do organizations that have implemented conceptual independence differ from the other organizations by ITO capability factors or ITO governance factors?*

The authors investigate if the application of CI influences the control that the organization has over purchased software systems.

This paper is organized as follows. First, the literature concerning this paper's themes and research questions is summarized. A possible research gap can be inferred from the lack of studies on conceptual models and business terminology effects on IT flexibility. This study addresses the gap by studying concrete cases of openEHR systems in a changing healthcare sector. The paragraph on the research method explains the reasons for selecting a mixed-method approach. Then the results section is followed by a discussion and conclusion of the study.

## LITERATURE REVIEW

The literature, summarized here in the section 'theoretical background', concerns research on reorganizing IT to accommodate changed business processes. For the organizational aspects the authors evaluate the literature on dynamic capabilities. For flexibility in the organizational and technical aspects of the IT infrastructure, they study literature on IT flexibility. A long line of research on this IT flexibility resulted in description and validation of four dimensions in IT flexibility. This study builds on the survey validated by Mikalef et al. (2016). IT flexibility appears a critical enabler for dynamic capabilities according to Mikalef et al. (2020) and Mikalef et al. (2016) and needs to be aligned with dynamic capabilities in firms (Van de Wetering et al., 2018).

However, IT flexibility research did not focus on the conceptual models in IS. IT flexibility has been interpreted from a more technical perspective, where modularity of systems has been primarily seen as the decoupling of technical components. As a result the business terminology and business information needed for seamless execution of business processes did not receive the attention it deserved, even though difficulties in managing healthcare information have been described in Rector's paper (1999). He states that the terminology difficulties in patient systems in healthcare have been underestimated and that this problem leads to specific issues in software for patient systems. He mentions ten topics where misunderstandings can arise such as interpretations of medical specialists and observed test results. One study of medical systems suggests that medical specialists prefer free texts for the registration of medical data (Cios & Moore, 2002), thereby making the role of conceptual models in IS more unclear.

The influence of the software supplier on IT flexibility becomes prominent in cases where the amount of data from different devices grows, and integration of the data in the existing electronic health records (EHR) systems is needed. For a cost-effective solution, healthcare organizations must rely on standard packages of Commercial-Off-The Shelf (COTS) software systems. With COTS the

outsourcing partner becomes a factor in the IT flexibility of the organization. This paper reports on the relation of the conceptual model in IS and IT outsourcing in the context of IT flexibility.

## THEORETICAL BACKGROUND

### Design Principle for Conceptual Models in Conceptual Independence

CI is described by McGinnes and Kapros (2015) as a software design in which the conceptual models are decoupled from the application logic. The separation of conceptual models leads to flexible IS that can be changed without radically reprogramming the software.

In Table 1 the authors describe six subprinciples that are sufficient to achieve the separation. The authors refer to the subprinciples as the CI principles. CI principles 1 and 3 refer to decoupling conceptual models from the application logic. CI principle 2 states that archetypical categories can initiate semantically appropriate behavior based on categories of data entities. An example is that categorizing entities as “Location” tells the software that the entity can be shown on a map.

For identifying content, several preconditions must exist for data entities to be uniquely identified independently of the conceptual models. CI principles 5 and 6 concern the registration of data to model elements. CI principle 4 describes which constraints are enforced at the input of data to guarantee valid mapping of data to entities.

CI aims to solve an important issue in software development: changes in concepts in thinking and communicating in organizations are hard to implement in existing systems (McGinnes, 2011; McGinnes & Kapros, 2015). The causes of difficulties often originate in software with hardcoded expectations of terminology (Garlan et al., 1995, 2009; Tarenskeen, et al., 2018). In addition to incompatibility, other authors refer to the problem of low-level dependencies in code (Lehman, 1996; Qiu et al., 2013). CI provides an underlying software structure to vary and adapt conceptual models without breaking the programming code.

Table 1. Principles of Conceptual Independence

(CI) Principle	Description
1. Reusable functionality (leads to structurally appropriate behavior, <i>meaning behavior is based on structures of entities not on domains*</i> )	The Adaptive Information system (AIS) can support any conceptual model. Domain-dependent code and structures are avoided. Useful generic functionality is invoked at run time for each entity type.
2. Known categories of data (lead to semantically-appropriate behavior, <i>meaning behavior can be linked to semantic categories*</i> )	Each entity type is associated with one or more predefined generic categories. Category-specific functionality is invoked at run time for each entity type.
3. Adaptive data management (enables schema evolution, <i>meaning models can evolve using the same data*</i> )	The AIS can store and reconcile data with multiple definitions for each entity type (i.e., multiple conceptual models), allowing the end-user to make sense of the data.
4. Schema enforcement ( <i>guarantees domain and referential integrity, meaning data is attributed to entities consistently and correctly*</i> )	Each item of stored data conforms to a particular entity type definition, which was enforced at the time of data entry (or last edit).
5. Entity identification (guarantees entity integrity, <i>meaning data is uniquely identifiable even if used in different models*</i> )	The stored data relating to each entity are uniquely identified in a way that is invariant for a schema change.
6. Labeling (application of data management, <i>meaning data is labeled to find the applicable conceptual models*</i> )	The stored data relating to each entity are labeled such that the applicable conceptual models can be determined.

\*Text in italics added by authors

Source: McGinnes and Kapros (2015)

## openEHR

Electronic health records (EHR) are registrations of medical patient data used to improve cure and care and control medical costs (Heart et al., 2017). These systems have been studied. A need for standardization of medical terminology and care data has been evident since working with digital medical data started (Eichelberg et al., 2006). Later, the emphasis shifted towards personal health records that provided access to health information for patients. As is specified on the website of the community of openEHR, “openEHR is the name of a technology for e-health consisting of open specifications, clinical models, and software that can be used to create standards and build information and interoperability solutions for healthcare” (openEHR Foundation, 2020d). The standard of openEHR is not a standard for medical concepts but a specification, a meta-standard, in which medical concepts can be modeled. Because of the meta-character the standard has direct implications for system development. Here, the similarity between openEHR and CI can be observed. The software implementation of openEHR applies archetypes (Beale, 2002; Beale & Heard, 2007) that are flexible models dedicated to healthcare purposes. The openEHR standard has been applied and implemented in large-scale healthcare projects internationally (Ulriksen et al., 2017) to give medical professionals the tools to model their knowledge independent of IT applications. Older research compares the development of a standalone IS in openEHR to conventional development. The openEHR standard enables the fast development of systems. (Atalag et al., 2014). However, other real-life projects on changes in conceptual models related to IT flexibility have hardly been documented.

## IT Flexibility

IT flexibility is important for organizations that need to change. Without IT flexibility the organization encounters problems applying the dynamic capabilities of sensing, seizing, and reconfiguration of processes and systems. IT flexibility stands out as an IT capability because “the combined effect of the underlying dimensions of IT flexibility enables a firm to develop the IT-enabled dynamic capabilities that are necessary to cope with changing conditions” in a paper of Mikalef et al. (2016). The role of IT flexibility in a volatile environment has also been explained by Teece et al. (1997). Mikalef et al. (2016) conceptualize and operationalize IT flexibility with the following dimensions: modularity, transparency, standardization, and scalability. Each of these dimensions strengthens IT flexibility. For their research, the authors accept these definitions.

The dimension of modularity has been defined as a structure of loosely coupled independent subsystems that support system engineers with adapting the system to new uses and requirements. According to Simon (1962), the decomposability of the system in meaningful (technical) components will be a primary factor in the ease of changing the software system. Schilling (2000) emphasizes pressures in contexts or markets for products that will force products to evolve to modularity. She sees modularity as the separation of components in systems that will allow reconfiguration or recombination of components to form systems with new features. Mikalef et al. (2016) and Van de Wetering et al. (2017) concentrate on “loose coupling” as the main idea behind modularity. To summarize, the dimension of modularity is seen as enabling flexibility in software systems (Byrd & Turner, 2000; Duncan, 1995; Simon, 1965). The authors see a relation between CI and modularity because separating conceptual (domain) models from functionality is the main characteristic of CI. Hence separation of conceptual models from the application logic, will make applications easier to adapt.

The dimension of transparency in IT flexibility refers to using a diversity of IT applications in an existing IT infrastructure without confronting the user with the changeovers. Byrd and Turner (2000), and Chanopas (2006) explain transparency as seen from end-users. Transparency makes the system behave seamlessly integrated to users (Star, 1999). Pavlou and El Savy (2006) refer to cross-functional integration for this attribute of IT infrastructure. The authors define transparency as the seamless integration of data and processes measured as the ease with which users can access internal and external platforms and applications.

Standardization, the third dimension of IT flexibility has been defined as the degree of agreement in the organization on hardware, software, and data standards.

The last dimension of IT flexibility, scalability, measures how well the IT infrastructure can be scaled up and upgraded when adaptation is necessary due to growing demand and increasing number of users (Chanopas, et al., 2006).

## **IT Outsourcing**

The authors take a new approach to ITO: they want to focus on ITO's role regarding IT flexibility in the context of software based on CI.

IT outsourcing has been extensively researched since 1990. An overview of the extensive research on ITO in the years 1990-2009 (Dibbern et al., 2004; Gonzalez et al., 2006; Lacity et al., 2009) show that the research in the first decade primarily focused on exploring the concept of outsourcing IS in case studies, field studies, and surveys. Dibbern et al. (2004) describe the process of outsourcing as “the use of external agents to perform one or more organizational activities, here positioned in the IS domain.” They describe the results on the conceptualization of IS outsourcing responding to questions as “why, what, which, how and outcomes” for IS outsourcing. When analyzing the data to discover patterns that would lead to criteria for successful sourcing strategies and practices, Dibbern et al. remain careful. No conclusions could be drawn in the fast-evolving research area. IS outsourcing covers a broad area with a diversity of studies from which the relation of outsourcing characteristics and outsourcing success is difficult to determine (Dibbern, et al., 2004). In healthcare organizations the ISs in the IT infrastructure were most likely to be outsourced, as researched by Lorence and Spink (2004). The reported motivation for outsourcing consisted of a need to improve patient care and cost reduction. These authors also report a general satisfaction in healthcare organizations for the outsourcing outcomes. A negative influence of ITO has been remarked by Lacity et al. (2009). Outsourcing too much of the IT activities in the organization can have negative results, because in general, clients that outsourced more than 80% of their IT budget had relatively lower levels of success. Top management commitment and readiness of client firms for outsourcing prove to be important for success. Research after 2005 focuses more on the relationship between the outsourcer and client firms. Central themes are contractual governance, managing contracts, and which party takes the largest risks. Results from studies in the period shortly before 2009 suggest that combinations of ITO decision and contractual governance are associated with higher levels of ITO success, as are combinations of contractual governance and relational governance (Lacity, et al., 2009).

## **IT Outsourcing and IT Flexibility**

When viewing the relation between ITO and IT flexibility Lacity et al. (1996) prefer a selective approach to IT outsourcing because firms have to maximize their control on core IT activities as strategic planning. Since organizations apply many IT applications from different suppliers, the need for integration of systems arises. The strategy of the organizations needs to include a vision on how integration of systems will be arranged. According to Teece (2007), when organizations outsource resources and capabilities to suppliers to realize economies of scale, they risk handing over control over the dynamic capability of seizing and refactoring to the IS suppliers. Teece sees the important capability to capture value from innovation as “the ability of the innovating enterprise to identify and control the ‘bottleneck assets’ or ‘choke points’ in the value chain.” This capability is critical for strategic management.

Duncan (1996) found that outsourcing was negatively related to data modularity, data compatibility, and connectivity between systems. These are all indications of a decreasing IT infrastructure flexibility.

This research focuses on ITO configurations described by Bui et al. (2019). The authors compare ITO combinations applied by the openEHR and non-openEHR organizations. Bui et al. extend the

ideas of Cullen et al. (2005), who have explored the ITO domain to detect existing configurations of outsourcing approaches. They show that patterns of ITO exist (Cullen, et al., 2005). Bui et al. (2019) have distinguished several dimensions that can be applied to analyze organizations' ITO characteristics. The capability and governance factors are summarized in Table 2 (Bui, et al., 2019).

When studying the impact of partnership quality on outsourcing success Lee and Kim (Lee & Kim, 1999) found that partnership quality may serve as a key predictor of outsourcing success. Partnership quality is characterized by participation, communication, information sharing, and top management support. In addition, mutual dependency proved to be a negative factor. In this article it is presumed that openEHR affects partner quality because the suppliers of openEHR software can adapt the conceptual models of IS to specific information needs.

**MAIN FOCUS: CONCEPTUAL INDEPENDENCE IN INFORMATION SYSTEMS IN HEALTHCARE**

The paper's main focus concerns the interplay between conceptual independence, IT infrastructure, and information systems (IS). The authors hypothesize that the three factors determine a major part of the IT flexibility in an organization. Furthermore, since IT flexibility has been demonstrated to be a crucial factor for dynamic capabilities that help organizations adapt to a changing environment, every characteristic of IT flexibility should be researched and analyzed for its effects.

Conceptual models are an essential building block for development of IS, these conceptual models are needed for designing data models that order data for retrieval and processing. Therefore, conceptual models are painstakingly designed by care professionals in close consultation with IT developers.

Inflexible data models impede changes in business processes and increase development costs, even add to technical debt. For the reuse of conceptual models, discussions in the organizations are needed to attune conceptual models to the requirements of individual organizations. Furthermore, in the case of exchanging information with multiple ISs the necessity to agree on concepts and their relations becomes even more urgent. As conceptual models are formed in and support human communication, IS development must allow for flexibility. The authors research CI as a design for implementing conceptual models in IS and its impact on IT flexibility.

**Table 2. Dimensions of ITO**

<b>Attributes of ITO Configurations</b>	
<b>Capability Factors ITO</b>	
Service Level Strategy	The type of IT capabilities and the degree to which these capabilities are accessed through outsourcing
Supplier Strategy	How outsourced capabilities are provisioned and coordinated among various suppliers, and the number of suppliers involved
<b>Governance Factors ITO</b>	
Commercial Relationship	How economic exchanges between client and suppliers are governed
Pricing Strategy	How payment to the supplier is determined
Contract Commitment	The agreed duration of the contract and the built-in adjustment mechanisms that allow adaptation to changing circumstances

Source: Bui, et al. (2019)

## RESEARCH METHOD

### Mixed-Methods Research in a Multiple Case Study

Two sets of data have been collected in the multi-case study. The authors selected a mixed-method approach to integrate results collected with different means. The subject of conceptual independence (CI) is new in research, and different data types can complement each other to enhance understanding of the results (Creswell & Creswell, 2005). Since CI has not been directly implemented, they compare organizations that have and have not implemented openEHR in their IS. Because the number of organizations that have implemented openEHR in the Netherlands is small, the combination of qualitative analysis for improved understanding of quantitative data has been applied. Dennis and Garfield (2003) demonstrate how mixed methods increase understanding of quantitative data.

### Selection of Cases

Table 3 presents an overview of the selected nine mental healthcare organizations. IT architects and functional management have been interviewed. The standard of openEHR has been selected as a proxy for CI. The authors presume that CI principles are one on one detectable in the openEHR software. The authors study five organizations as the “openEHR organizations.” These have applied more than two modules of the openEHR software and describe themselves as applying openEHR. Four other organizations did not have openEHR modules at all or were testing modules. These organizations explicitly stated that they were not applying the openEHR software in the IT infrastructure, the “non-openEHR organizations.” All nine cases have outsourced software development and maintenance of application software.

## DATA COLLECTION

The quantitative data consist of scores on a questionnaire of 20 items on IT flexibility (Mikalef, et al., 2016). The questionnaire has been applied and validated in a large sample study of Mikalef et al. (2016). A full text of the questionnaire can be found in Appendix Table 8. In addition, the mean scores of organizations on the dimensions of IT flexibility and the total mean scores have been calculated to find differences between the groups of organizations.

The qualitative data have been collected from semi-structured interviews (Schmidt, 2004) performed in nine organizations with the IT architect or with the IT architect and IT functional

Table 3. Case organizations in mental healthcare

Organization	Number of interviewees	Number of employees in 2017 (full-time equivalent)	Number of modules openEHR
openEHR	1	1000-1500	12
openEHR	2	1000-1500	10
openEHR	1	1000-1500	2 + 2
openEHR	1	1500-2000	15
openEHR	2	1500-2000	9
non-openEHR	1	less than 500	None
non-openEHR	2	1500-2000	1
non-openEHR	2	2000-2600	1
non-openEHR	1	2000-2600	1



management. The interviews were structured according to the 20 questions in the questionnaire. After the interview on the questionnaire explicit questions about the recognition and application of CI principles followed. Questions about IT outsourcing were not included, but all organizations talked extensively about the relation with the suppliers and their ITO strategy when explaining the background and history of their organization.

## Analysis and Synthesis

The 13 interviews accounted for 15 hours of interviews, distributed about evenly over the organizations. All interviews were transcribed. After transcription the authors split the text in text fragments that focus on one subject. Then they applied content analysis by summarizing the fragments into an English statement (Gläser & Laudel, 2013). Afterward they applied the codings in Appendix Table 7 to categorize text fragments roughly. Every statement related to an item in the questionnaire as explained by the respondent. An independent researcher has discussed the relation of statements to items in the questionnaire and the coding.

The authors have taken all statements about CI principles and IT flexibility and transformed these into narratives one for each organization.

To explore the role of the suppliers of software in all organizations all statements about the suppliers were selected (Mayring, 2004). These statements were ordered in categories of Bui et al. (Bui, et al., 2019) in Table 2. The authors applied a positivist approach when analyzing the data as described by Burton-Jones and Lee (2017) and Paré (2004). Since the study is explorative, results were mapped to categories and roughly interpreted by counting.

The quantitative data have been analyzed with a statistical test for small samples in the SPSS package, the Independent-Samples Mann-Whitney U Test, to counteract the disadvantages of a small sample (Nachar, 2008).

## RESULTS

### Quantitative Data: openEHR and IT Flexibility

Results of the quantitative data confirm that a difference exists between the openEHR organizations and the non-openEHR organizations. The mean score on the IT flexibility questionnaire of the openEHR organizations is 5.2 on a scale of 1-7 (7 is more flexible), and the mean score of non-openEHR organizations is 3.7. The authors tested the null hypothesis that both sets of means originate from the same population of means. The test in Appendix Table 11 indicates that the null hypothesis can be rejected with  $p < 0.05$ .

The total mean scores show that the openEHR organizations evaluate the IT infrastructure of their organization as more flexible than the non-openEHR organizations do, see Appendix.

A second Independent-Samples Mann-Whitney U Test has been performed for mean scores on dimensions of IT flexibility. The test only gives reason to reject the null hypothesis for the dimension of transparency with  $p < 0.05$ . In detail the openEHR organizations have a mean score on the dimension of transparency of 5.7 (scale 1-7) and the non-openEHR organizations have a mean score of 3.3.

### Research Question 1A: Recognition and Application of CI Principles

To answer research question 1 the authors must first select the organizations implementing CI. In all interviews, the researcher explicitly asked for recognition of CI principles in the current IS of the organizations. For all organizations the perceptions of the respondents have been noted. In Table 4 and Table 5, a mark ü has been set in the row RECOGNIZED for every CI principle if the CI Principle has been observed in software. For openEHR the marks have all been related to openEHR software. If the organization explicitly states that the principle has been applied, a mark is set in the APPLIED row. The numbers of marks have been totaled for each case organization.

**Table 4. CI Principles in openEHR Software in openEHR Organizations**

Cases	CO1	CO2	CO3	CO4	CO5
CI-1 Reusable functionality (structurally appropriate behavior)					
• Recognized	✓	✓	✓	✓	✓
• Applied	✓	✓	✓	Partly	✓
• Reuse of data in architecture	✓		✓		✓
CI-2 Known categories of data (semantically appropriate behavior)					
• Recognized	✓	✓	✓	✓	✓
• Applied	✓	✓	✓	Partly	✓
CI-3 Adaptive data management (schema evolution)					
• Recognized		✓	✓	✓	✓
• Applied		✓	✓		✓
CI-4 Schema enforcement (domain and referential integrity)					
• Recognized	✓	✓	✓	✓	✓
• Applied	✓	✓	✓	✓	✓
CI-5 Entity identification (entity integrity)					
• Recognized		✓	✓	✓	✓
• Applied		✓	✓	✓	
CI-6 Labeling (data management)					
• Recognized		✓	✓		✓
• Applied		✓	✓		✓
TOTAL RECOGNIZED	3	6	6	5	6
TOTAL APPLIED	3	6	6	3	5

✓: perceived by respondents, empty cells: no statements have been found in the interviews.

As can be seen in Table 4 the openEHR organizations in general recognize the CI principles in the openEHR software. More than half of the CI-principles have been applied insofar as confirmed by the respondents.

As seen in Table 5, non-openEHR organizations do recognize the principles of CI incidentally in other IT applications, but not in the current EHR system. Furthermore, they have no knowledge of the implemented conceptual models except in data warehouse systems or business intelligence systems. CI Principle 4 is generally recognized by respondents stating that the supplier is responsible for checking consistency in the database.

### Research Question 1B: CI Principles in Relation to IT Flexibility

Since in the interviews, the openEHR organizations often refer to CI principles (CI-1 to CI-6) and non-openEHR organizations only incidentally recognize the CI principles, this section contains only the analysis of the transcripts of openEHR organizations.

#### Case CO1

In the interview with the IT architect and functional manager, the respondents observe that the software supplier is fast with adapting the information systems and that they can easily adapt forms to their

**Table 5. CI Principles in Other Software in Non-openEHR organizations**

Cases	CN6	CN7	CN8	CN9
CI-1 Reusable functionality (structurally appropriate behavior)				
Recognized	in questionnaire program			
Applied	✓			
Reuse of data in architecture				
CI-2 Known categories of data (semantically appropriate behavior)				
Recognized	in financial program and in BI - not in EHR system	no insight in applications at this level		
Applied	partly			
CI-3 Adaptive data management (schema evolution)				
Recognized			in data warehouse	
Applied			in management information systems	
CI-4 Schema enforcement (domain and referential integrity)				
Recognized	consistency checked by vendor		in applications	consistency checked by vendor
Applied	free text cannot be checked		in applications	
CI-5 Entity identification (entity integrity)				
Recognized			partly in other systems	consistency checked by vendor
Applied				
CI-6 Labeling (data management)				
Recognized				
Applied				
RECOGNIZED	3	0	2	2
APPLIED	1	0	2	0

✓: perceived by respondents, empty cells: no statements have been found in the interviews.

needs. They apply the medical database based on the openEHR structure to exchange data between applications. The IT architect plans to build a new IT infrastructure according to best of breed. They position the medical database in the center:

*The medical database offers specific data for researchers at the university (psychiatrists). With openEHR, we can make the data in the medical database accessible without developing point-to-point-interconnections. You can access the data directly from the information layer. We are working towards a new architecture based on openEHR.*

## Case CO2

This organization has implemented all modules of openEHR and applies all. The IT architect also remarks that openEHR is not the same as CI because the meta-model of openEHR is limited to the medical domain where in contrast CI supports a more generic meta-model. The organization finds that openEHR improves flexibility because the organization itself can partly add functionality.

The principle CI-3 is observed in openEHR, but the IT architect thinks that changing conceptual models is not always the solution because it leads to other difficulties regarding data migration.

An extra separation has improved modularity in the IT infrastructure, but modularity cannot be achieved easily:

*Our organization has separated the care registration and the billing system from the medical data. This is different from other organizations, where both systems have been integrated. This enables us to replace one system or the other, but it is not a simple process.*

He adds that exchanging data for working with workflows can be realized, but more tools are needed. He finds that integration is difficult. The standard of openEHR is valuable and should be adopted more broadly and could be applied for the new Dutch standard for ZIBs, care information blocks.

## Case CO3

In this healthcare organization all CI principles have been observed and are applied. The functional manager offers details of their method of working with the different conceptual models, called archetypes in openEHR. He states that functionality is easy to adapt when looking at the flexibility of the conceptual models. For CI-1:

*We have a library of archetypes, based on the standard. We do not use a lot of them. Some are for hospitals. They register different attributes than we do. We can download the conceptual models and use them in the application. Yes, we can download data schemas and then add functionality to them.*

Functionality can be added in the following way:

*The data schemas can be extracted from the (available) tool. There are many archetypes in stock. We can select one and make forms for them. We can also edit the data schemas with a dedicated tool for archetypes.*

*The principle CI-2 is seen in the forms, where the organization can develop forms itself. Forms determine what users can see on the screen, the user interface.*

The power of this way of working lies in flexibility of programming code and the collaboration with the supplier of the openEHR software.

*We receive the benefits of the standard by working together with the supplier of the openEHR software in developing new functionality, but we have not decided beforehand that we wanted software based on this standard. The supplier of the openEHR software knows what the benefits are for development and can apply the standard to make functionality rapidly and relatively less expensive.*

### Case CO4

The reason why openEHR software has been selected in this organization is to enable external access to their systems and collaboration with other institutes.

The functional manager states:

*The characteristic of openEHR, that we can run and process different models, is not recognizable in other software. Only in the openEHR software.*

and he follows up with:

*We are capable of making our own models, and the software supports different models. Low-level reuse, components of the supplier of the openEHR software can be used in other systems, such as EHR, but not the other way around.*

The organization is not satisfied with the flexibility of the IT infrastructure in its current state, e.g., when looking at the modularity of the IT infrastructure and ease of replacing applications by other applications:

*No modularity, in the sense that components can be isolated and replaced. Changes do affect the IT infrastructure. The modularity of our systems is not very high. I would score a 3 on a scale of 7.*

He adds that problems arise when you must migrate data, despite using standards.

### Case CO5

In case 5, all the CI principles have been recognized and five of these are applied. The IT architect mainly discusses the flexibility of different IT applications as seen from a technical perspective.

The IT architect notices the potential of openEHR software for increasing flexibility and integration in the IT infrastructure. The openEHR software offers functionality needed by the organization but not by the EHR system that the organization deployed before.

He observes IT flexibility in other software too:

*Other new software has possibilities that are lacking in old software, e.g. the internet, the openEHR software modules and Topdesk. New software is better structured and built.*

In contrary to case CO4 he observes that openEHR also offers the possibilities for integration, it aids in extracting data for reuse elsewhere. Data from the (old) EHR-system can be seamlessly presented in the openEHR system. CI principle 2 is mentioned specifically because it is a substantial part of openEHR software.

Then he adds that extra flexibility to adapt to different target groups of users is typical for openEHR:

*In a standard EHR there exists one process for all care workers and it is individualistic. We more often work in groups. In the openEHR software you can serve different groups with the same information.*

## SUMMARY

This section finds that openEHR organizations differ in working with CI principles. The organizations repeatedly mention the flexibility of openEHR software in relation to CI principles.

## Research Question 2: IT Outsourcing With CI

In the next stage the interviews have been analyzed for statements about IT outsourcing. The results summarized in Table 6 are interpretations based on respondents' statements. The authors searched in the qualitative data for all statements that mentioned how organizations view the goals of IT outsourcing and the strategy for achieving the goals.

**Table 6. Attributes of IT outsourcing configurations**

Attributes of ITO Configurations		CO1	CO2	CO3	CO4	CO5	CN6	CN7	CN8	CN9	Total (5) open EHR	Total (4) non-open EHR
<b>Capability Factors</b>												
Service Level Strategy	Outsourced: Development of applications	✓	✓	✓	✓	✓	✓	✓	✓	✓	5	4
	Outsourced: Development of integration between applications	✓	✓	✓	✓	✓	✓	✓	✓	✓	5	4
	Closed data models						✓	✓	✓	✓	0	4
	Outsourced: IT architecture function	N	N	N	N	N	N	N	N	N	0	0
	Outsourced: IT management function	N	N	N	N	N	N	N	N	N	0	0
	Outsourced: IT functional management	N	N	N	N	N	N	N	N	N	0	0
	Collaboration with suppliers about functionality of applications	✓	✓	✓	✓	✓					5	0
Supplier Strategy	Best of Breed	✓		✓							2	0
	Best of Suites					✓	✓				1	1
	Based on Enterprise Architecture	✓	✓	✓		✓	✓	✓	✓		4	3
<b>Governance Factors</b>												
Commercial Relationship	Direct contact with supplier of openEHR	✓	✓	✓	✓	✓					5	0
	User groups mainly						✓	✓	✓	✓	0	4
	User groups and extra contracts						✓		✓	✓	0	3

✓: statements support the presence of the attribute, N: statements deny the presence of the attribute  
 Empty cell: no explicit statements about the attribute have been expressed.

## SERVICE LEVEL STRATEGY

In Table 6 the first topic concerns the service level, how large is the proportion of IT functions and IT resources that have been outsourced. All organizations have outsourced the software development and maintenance function by purchasing COTS software to support the care organization. IT strategy, IT architecture, and IT management are not outsourced and are executed by the organization's IT architects and IT departments.

Differences exist between the openEHR organizations and the non-openEHR organizations regarding EHR systems with an open or closed data model and regarding collaboration with the suppliers.

In statements of openEHR organizations, the authors find that openness of data models exists in the software, although the database tables are not always understandable due to the implemented meta-model. For example, for the openEHR organizations, the statement of CO1 illustrates the application of data models:

*The manner in which the components of our information systems are organized and integrated allows for rapid changes, we can change the system fast with openEHR, we can change forms to work with data ourselves. Difficulties with openEHR are encountered when we reach the information layer and the (Archetype) standard, extra effort is necessary. But it can be done.*

The non-openEHR organizations view the data model as a responsibility of the supplier. A remark in case CN6:

*If you want to adapt functions and data structures in the EHR, you have a problem, because that is what is very difficult for the suppliers.*

Case CN9 confirms the former statement:

*We have no knowledge of the extent and techniques for data consistency.*

## SUPPLIER STRATEGY

The organizations differ in strategies to select suppliers in achieving a specific IT architecture. Often mentioned are best of breed or best of suites. However, almost all organizations apply an enterprise architecture with a detailed IT architecture to aid the IT architects in their purchasing decisions. The authors did not find consistent differences between groups of organizations.

## GOVERNANCE FACTORS

In governance factors the authors see similarities between all organizations. The organizations all mention the suppliers' efforts to implement adaptations in software required by governmental regulations and laws. The organizations all evaluate these implementations as satisfactory. However, there are also notable differences between the openEHR organizations and the non-openEHR organizations with regard to the relationship with the suppliers. Examples of differences can be found in procedures, consultations, and (costs for) requests for change.

All openEHR cases describe a close collaboration with the supplier of the openEHR software. The non-openEHR organizations comment on the slow procedures that have been experienced.

An example of a statements about collaboration with the openEHR supplier, for CO1:

*When we have questions or change requests for conceptual models, new archetypes must be developed together with the supplier of the openEHR software. This is possible, we do not have the need often, but it has happened.*

The current situation differs from the one with the former supplier, according to CO1:

*In the old EHR system every interconnection has to be developed separately and paid for separately.*

Despite realized customization the standard software could be even more flexible, according to CO2:

*Customization in software is added (by the openEHR supplier), but maybe we could have achieved the same result with better modeling. We are examining this with the supplier of the openEHR software. We see great potential, perhaps we could solve 80/90 percent of our requirements with standardization.*

In the third case, CO3, communication with the supplier made them realize the value of the standard of openEHR, see Case description CO3.

CO4 appreciates fast communication:

*We notice that if we have a question or problem, we immediately get a reaction from another mental health care organization with openEHR or the supplier of the openEHR software.*

The last IT architect of the openEHR organizations, CO5 describes how the organization will lessen the dependence on the supplier of the EHR:

*At this moment the gap is too big, so we extract all the information from the current database of the EHR and store it in the openEHR data base. Later we will take steps to migrate the financial registration from the old EHR to openEHR. We already apply the invoices functionality from another application. We already migrate necessary data to our data warehouse and then to the external platform. We are becoming less dependent on the supplier of the EHR and will eventually make the step described before.*

For the non-openEHR organizations, the User groups are a means by which change can be realized. User groups are groups of organizations applying software of the same IS supplier. If there are requests for change in these organizations, consensus about adaptations in the software has to be achieved before the supplier makes a move. The supplier's policy requires that changes in the IS have to be used by all affiliated user organizations. Customization of software will lead to bottlenecks in the future. The statements of the non-openEHR organizations describe the role of the User group in case CN7:

*The negotiations of the User group with the supplier of the EHR are important for us. We have to reach consensus to be able to really influence the supplier. Our organization is not involved in a movement for standards for exchanging data.*

Case CN9 adds:

*We can switch modules on and off in our EHR. But we are working on another design for the EHR with the User group of about 30 other Mental Healthcare organizations.*



Case CN8 adds:

*User groups have their disadvantages, because negotiation takes a long time.*

In CN9 the respondent remarks the discussions in User groups:

*This CI principle, flexible conceptual models, probably has not been implemented in our EHR. When I look at the application of our EHR, I can conclude that the system is not very flexible, that it is difficult to change. I base this conclusion on discussions in the User group of mental healthcare organizations and on discussions with the account manager of the supplier. We are part of a niche market and we cannot demand much. There are not many alternatives for our EHR.*

## **DISCUSSION AND CONCLUSION**

### **RQ 1A: CI Principles and openEHR**

From Table 4 and 5 it becomes clear that the openEHR organizations recognize CI principles in software more than the non-openEHR organizations. They explain how CI principles have been implemented and applied in openEHR software. The non-openEHR organizations encounter the CI principles incidentally in their software and they also discuss the CI principles in the context of flexibility. For instance, in data warehouse software, CI principles aid in realizing flexibility in conceptual modeling. The conceptual models can be changed by analysts when needed for categorizing relevant data.

One of the openEHR organizations, CO1, is less outspoken about the CI principles. The transcript reveals that the organization has implemented several openEHR modules but still uses another electronic health record system for its patient dossier. The latter software package dominates a large part of the IT infrastructure and the respondents are distracted by the characteristics of the current EHR. Moreover, they express minimal involvement with the technical details of the implementation of the IS.

Since the IT infrastructures of all organizations are complex and consist of many applications of different IT suppliers, it could have been more informative if the authors had drawn up a complete inventory of all systems and its characteristics. Unfortunately, due to multiple reasons, documenting a complete inventory was not feasible in the current research. Overall, they conclude that all CI principles have been implemented in openEHR software even though not all respondents have detected the CI principles.

### **RQ 1B: CI Principles and IT Flexibility**

The authors have only studied CI principles and IT flexibility in openEHR organizations. These organizations observe that CI contributes to IT flexibility, but they do not describe a standard approach for working with the openEHR software modules. Therefore, the authors compare the statements of respondents with each dimension of IT flexibility.

For the dimension modularity, three cases, CO1, CO3, and CO5 use the openEHR medical database to integrate the IT applications loosely. The medical database will decouple the applications by acting as a hub and avoiding point-to-point connections between single applications.

Other respondents of cases CO2 and CO4 speak of tight integration of applications, and they encounter difficulties when replacing or out phasing certain applications.

The flexibility of openEHR for IS has been recognized and applied by all organizations except CO4.

For the dimension of transparency, an effect of CI has been noticed and discussed by many organizations in the interviews. They mention the ease of integration of openEHR software and other

software. Two cases, CO2 and CO4, comment on difficulties in integrating different IT applications, specifically in the process of migration of data. However, case CO2 evaluates the openEHR possibilities as an improvement that did not evolve as far as he would have liked.

Standardization proved a topic for the openEHR organizations. The respondent of case CO2 appreciates working with the openEHR standard because it is dedicated to conceptual models for healthcare. He wants to apply the meta-standard for designing the Dutch Care information blocks standard.

One organization, CO3, informed the interviewer that standardization has not been the first reason for selecting the software, but later the flexibility of the IS was appreciated and the extra flexibility was contributed to the openEHR standard. Other respondents confirm a positive effect of openEHR on standardization. Issues of scalability did not prove to be a relevant for the respondents. However, in the scores of question 20 in the questionnaire in Appendix Table 8, it can be noted that scores on scalability in relation to business needs show a large difference between the openEHR organizations and the non-openEHR organizations. Overall, all dimensions except scalability have been mentioned and discussed in relation to CI principles.

When analyzing the quantitative and qualitative data the authors conclude that a difference exists in perceptions of IT flexibility between openEHR organizations and not-openEHR organizations: the openEHR organizations evaluate the IT infrastructure as more flexible than the non-openEHR organizations.

Qualitative data show that an improvement in IT flexibility can be contributed to CI principles and the collaboration with the supplier of openEHR. Furthermore, quantitative data provide extra support for the influence of CI principles on transparency.

Reconfiguration of systems is substantially supported by openEHR, the CI software helps the organizations to adapt especially the information systems (IS) rapidly. Furthermore, respondents did not mention technical obstacles caused by CI principles in the organization.

## **RQ 2: IT Outsourcing and IT Flexibility**

For IT outsourcing common characteristics exist in all nine organizations. For example, they have outsourced the development and maintenance of software. The respondents see themselves as mediators between the care organization and the IT department from this ITO strategy.

However, there are also remarkable differences in the relations of the organizations to their suppliers. Important differences exist between openEHR and non-openEHR organizations in communication with the IS supplier. The frequency of communication with the openEHR supplier is higher in the openEHR organization than in the non-openEHR organizations. Moreover, the procedure of requests for changes are different.

The authors summarize the results by stating that the supplier of openEHR has a more intensive contact than other suppliers with the organizations about conceptual models and business functionality. As a result, the openEHR software can be adapted by the software supplier with relative ease. All openEHR organizations refer to the CI principles in openEHR as the main cause for this flexibility.

The non-openEHR organizations describe the procedures for adapting software in user groups. In User groups of mental health organizations, consensus about adaptations must be achieved first, before the supplier acts. Customization of software is possible, but these changes' costs are passed on to the individual organizations. In addition, non-openEHR organizations complain about the closed data models maintained by the IS supplier. The IS suppliers do not provide access to the data models and the possibilities for the organizations to adapt the software, for instance by configurations, are limited.

When comparing their results to the research of Lee and Kim (1999) the authors observe that the communication with the supplier of the openEHR software becomes part of the IT function. By frequent consulting of the supplier, the organizations that apply CI can realize a more flexible IT. These results confirm the findings that partnership quality affects IT flexibility positively. Summarizing, ITO with CI strengthens the IT flexibility.

## IMPLICATIONS

Theoretically, the definition of CI enables flexibility for conceptual models in any domain. Furthermore, a separation of the conceptual models from the application logic can be applied in any sector. In this specific case study, openEHR offers an example of CI in the healthcare sector and thus CI can be studied in cases of openEHR.

In research in other sectors, this separation has not been examined in detail. IT professionals mention this separation now and then, but more research is necessary.

Possible disadvantages of the separation of conceptual models from application logic concern the understandability of the models because meta-models consist of abstract concepts. Moreover, the flexibility of the conceptual models brings out the differences in human interpretation of concepts and increases the need for consultation and agreements between stakeholders. Houy et al. (2012) explain how the understandability of conceptual models is an ambiguous characteristic in research. Future large-scale research on the comprehension of meta-models will be needed when large-scale application of CI principles is desired.

Next, this study indicates that the concept of modularity in IT infrastructure needs clarification. Questions about modularity lead to contradictory answers in the different organizations. Yoo (2012) and Yoo et al. (2010) think that the notion of modularity for flexibility, in general, needs rethinking. They extend the concept of modularity in digital systems with the concept of the layered modular architecture, where a digital layer references a physical layer. A layered modular architecture can be found in physical objects with an embedded digital component. Architectures with layers can be extended with subparts, and not all subparts need specification beforehand.

## LIMITATIONS

The authors experienced that the study of technical characteristics of IS encounters difficulties because of proprietary software. Suppliers of COTS software limit the possibilities of researchers to study details of software architecture. This limitation will also be experienced in other studies that examine detailed effects of the software structure and design. The authors stand up for extending IS research to include software structure and design effects on dynamic capabilities since hidden factors can influence the degrees of freedom businesses experience when operating in the market.

For ITO, the study has not included contracts or contractual agreements between organizations and suppliers. This is because these were not discussed in the interviews. Findings will be more complete when contracts can be studied in this context.

Lastly, there are only a few suppliers of the openEHR software in the Netherlands. All mental healthcare organizations in this study have consulted the same supplier. These results, however, seem to be in line with large-scale and longitudinal research on openEHR in Norway. In these studies, the collaboration of medical professionals and technical professionals appears crucial for the success of the implementation (Christensen & Ellingsen, 2016; Ulriksen, et al., 2017). In fact Christensen and Ellingsen (2016) doubt that a complete separation of the clinical and technological domain is feasible. They observe that medical professionals' expertise and software technology both remain necessary for the development of the openEHR models.

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## APPENDIX

### Content Analysis of Semi-Structured Interviews

Table 7. Topics for coding the statements in the interviews

CODE	Name	Description
CI	Conceptual independence	Direct reference to CI and implementation
D	Development	Outsourcing of Software development
ITF	IT Flexibility	Explanation of scores on the items in the questionnaire about IT flexibility
M	Management	Goals of IT Management
PDC	Process oriented Dynamic Capabilities	Processes and procedures in the organization to manage change in IT
SO	Strategy organization	Orientation of (Care and IT) strategy
V	Supplier	Statement about the supplier
F	Evaluation functionality	Functional requirements alignment with systems
ITO	Outsourcing strategy	Outsourcing strategy

### Mean Scores on IT Flexibility Questionnaire

Table 8. Mean Scores on IT Infrastructure Flexibility Questionnaire

Groups of organizations	Non-openEHR organizations	openEHR organizations
<b>MODULARITY</b>		
1. Our information systems are highly modular	3,0	5,3
2. The manner in which the components of our information systems are organized and integrated allows for rapid changes	1,9	5,0
3. Functionality can be quickly added to critical applications based on end-user requests	2,3	4,0
4. Exchanging or modifying single components does <b>NOT</b> affect our IT infrastructure	3,3	3,4
5. Organizational IT infrastructure and applications are developed on the basis of minimal unnecessary interdependencies	4,7	4,8
6. Organizational IT infrastructure and applications are loosely coupled	5,4	3,2
<b>TRANSPARENCY</b>		
7. Remote users can seamlessly access centralized data and processes	6,0	6,4
8. Our user interfaces provide transparent access to all platforms and applications	3,5	6,2
9. Software applications can be easily transported and used across multiple platforms	2,5	5,6
10. Data of one system can be easily used in other systems	2,0	4,9
11. Our firm offers multiple interfaces or entry points (e.g., web access) to external users.	2,8	5,6
<b>STANDARDIZATION</b>		
12. We have established corporate rules and standards for hardware and operating systems to ensure platform compatibility	5,8	6,3
13. We have identified and standardized data to be shared across systems and business units	3,0	5,4

*continued on following page*

**Table 8. Continued**

Groups of organizations	Non-openEHR organizations	openEHR organizations
14. Our systems are developed in order to incorporate electronic links to external parties	2,6	5,1
15. Organizational IT infrastructure and applications are highly interoperable	3,0	4,4
16. Organizational IT applications are developed based on compliance guidelines.	4,6	5,4
<b>SCALABILITY</b>		
17. Our IT infrastructure easily compensates peaks in transaction volumes	5,4	5,6
18. Our information systems are scalable	4,3	5,8
19. Our IT infrastructure offers sufficient capacity in order to fulfill additional orders for treatment or diagnosis	5,5	6,2
20. The performance of our IT infrastructure completely fulfills our business needs regardless of usage magnitude	2,6	6,0
<b>TOTAL MEAN</b>	<b>3,7</b>	<b>5,2</b>

Scores on scale 1 -7 (1 totally disagree, 7 totally agree)

**Table 9. Mean Scores for Organizations on IT Infrastructure Flexibility**

ID – random	IT Flexibility score	Outsourcing Organization-type
1	3,52	Non-openEHR
2	4,44	Non-openEHR
3	3,40	Non-openEHR
4	3,56	Non-openEHR
5	6,70	openEHR
6	4,45	openEHR
7	5,40	openEHR
8	4,50	openEHR
9	5,03	openEHR

**Table 10. Mean Scores for Groups of Organizations on Dimensions of IT Infrastructure Flexibility**

Dimension	openEHR	Non-openEHR
MODULARITY	4,3	3,4
TRANSPARENCY	5,7	3,3
STANDARDIZATION	5,2	3,8
SCALABILITY	5,9	4,5



## Nonparametric Test

Tests have been executed with SPSS software package with a configuration of significance = 0.05 and confidence interval = .95. The asymptotic significances are displayed.

**Table 11. Hypothesis Test Summary – Means of IT Flexibility**

	Null hypothesis	Test	Sig.	Decision
1	The distribution of IT Flexibility Scores is the same across categories of Groups of Organizations.	Independent-Samples Mann-Whitney U Test	.016 <sup>1</sup>	Reject the null hypothesis.

<sup>1</sup>Exact significance is displayed for this Table 5.

\*\*Groups of organizations are openEHR organizations and non-openEHR organizations

**Table 12. Hypothesis Test Summary – Means on Dimensions of IT Flexibility**

	Null hypothesis	Test	Sig.	Decision
1	The distribution of MOD* is the same across categories of Groups of Organizations**	Independent-Samples Mann-Whitney U Test	.286 <sup>1</sup>	Retain the null hypothesis.
2	The distribution of TRANS* is the same across categories of Groups of Organizations**	Independent-Samples Mann-Whitney U Test	.016 <sup>1</sup>	Reject the null hypothesis.
3	The distribution of STAND* is the same across categories of Groups of Organizations**	Independent-Samples Mann-Whitney U Test	.063 <sup>1</sup>	Retain the null hypothesis.
4	The distribution of SCAL* is the same across categories of Groups of Organizations**	Independent-Samples Mann-Whitney U Test	.063 <sup>1</sup>	Retain the null hypothesis.

\* Dimensions are: MOD = Modularity, TRANS = Transparency, STAND = Standardization, SCAL = Scalability

\*\*Groups of organizations are openEHR organizations and non-openEHR organizations

<sup>1</sup>Exact significance is displayed for this Table 6.

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