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Does the transcultural problem really matter? An integrated approach to analyze barriers to eHealth SMEs' development

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Abstract
eHealth market of UK is continually prosperous. However, empirical research related to eHealth SMEs (Small and Medium-sized Enterprises) from a less prosperous area of UK, such as Cornwall and Isles of Scilly (CIoS), seems to be neglected by scholars. Thus, this study fills this gap by employing an integrated approach to analyze the barriers to impede the development of eHealth SMEs of CIoS. Initially, semi-structured interviews were conducted to collect data from experienced eHealth SMEs' practitioners, followed by thematic analysis to generate barriers. The identified 16 barriers were used as inputs to perform total interpretive structural modelling (TISM) to build interrelationships among them and identify the key barriers. Finally, cross-impact matrix multiplication applied to classification (MICMAC) analysis was applied to validate TISM model and classified 16 barriers into four categories. The findings contribute to theory significantly by identifying new barriers, building interrelationships among them, distinguishing key barriers, and driver and mediator's barriers classification. Particularly, we identify that transculturally problem is the key barrier and may elicit the most of barriers of the system, therefore, should be given critical attention. eHealth SMEs originate from other cultural value orientations such as hierarchy and embeddedness that different from the affective autonomy of UK, these SMEs should increase their awareness about transcultural issues when they have appetites to exploit UK markets.

Keywords: eHealth SMEs; Cornwall and Isles of Scilly (CIoS); Barrier analysis; Transculturally problem; Qualitative approach

1. Introduction

eHealth is defined as "the cost effective and secure use of information and communication technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research" (World Health Organization (WHO). 2022). Other availability terms such as medicine 2.0, health 2.0, mhealth, telecare, telehealth, digital health, and telemedicine are used interchangeably with eHealth across the literature (Ahern et al. 2006; Boogerd et al. 2015; Scheibner et al. 2021). eHealth technologies promise a range of benefits, including those benefits to information management, time management, patient monitoring, consultations, information gathering, health record maintenance, medical education and training, and clinical decision-making (Ventola. 2014; Zaman et al. 2017; Gaspar and Lapao. 2021). Besides, eHealth technologies' application presents new opportunities to achieve one of the United Nation's Sustainable Development Goals (SDGs) – good health and wellbeing. Due to its potential for improving the quality, accessibility, and affordability of health care, significant investments have been invested in the eHealth industry. For example, over $21 billion was invested of 2020 across the global. It is expected that the global digital health market size will have a dramatic increase in the next few years from $334 billion of 2022 to $657 billion of 2025 (Statista. 2021).

Small and medium-sized enterprises (SMEs) are the major contributors to most industries and countries, including the eHealth industry (Li et al. 2016). For example, there were estimated to be 5.5356 million of SMEs in the UK of 2021, including 5.5 million small-sized enterprises had employees between 0 and 49, and 0.0356 million of medium-sized enterprises with 50 to 249 employees (Department for Business, Energy & Industrial Strategy. 2021). These SMEs contribute to 16.3 million employment and their turnover account for 52% (£2.3 trillion) of UK. SMEs are considered as the backbone of the UK's economy and growth and are also identified as having limited resources, weak financial structure, and limited business activities, therefore, have attracted researchers to investigate how to improve SMEs' managerial knowledge and competencies (de Araujo Lima et al. 2020; Crovini et al. 2021). Trending topics including risk management of SMEs (Testorelli et al. 2020), digital transformation of SMEs (Matarazzo et al. 2021), internationalization of SMEs (Falahat et al. 2020), and sustainability of SMEs (Schwab et al. 2019). However, barriers for impeding the development of SMEs seem to be neglected by scholars, especially from the eHealth companies' perspective (McCann and Ortega-Argiles. 2016; Jaramillo et al. 2019).

This study aims to analyze the barriers for impeding the development of eHealth companies in Cornwall and Isles of Scilly (CIoS). CIoS was selected because of several reasons. First, CIoS locates in the extreme southwestern peninsula of England, its rurality and sparse population makes it become an excellent testbed for different eHealth technologies (Austin et al. 2021). Unlike other areas of UK, such as Greater Manchester, London, and the South East has large and stable eHealth market. The eHealth market of CIoS remains precarious (Asthana et al. 2019). Second, the aging population of CIoS has reached 25.3% in 2020 in comparison of 19% of UK, which means that 145,457 people aged 65 and order (Cornwall Council and Council of the Isles of Scilly. 2020). The Cornwall Council and Council of the Isles of Scilly believe that eHealth can be a cost-effective solution for the rising demand of high-quality healthcare service. Third, we have wide connections with the eHealth SMEs of CIoS because of EPIC (eHealth Productivity and Innovation in Cornwall and the Isles of Scilly) project. This collaborative and interdisciplinary project was jointly funded by the European Regional Development Fund (ERDF) and the South West Academic Health Science Network (AHSN) with the aim to improve the regional eHealth sector. Thus, we had extensive opportunities to discuss with eHealth SMEs in terms of barriers to impede their development. Three research questions are formulated in this study: (1) What are the barriers to impede the development of eHealth SMEs in CIoS? (2) How are the identified barriers interrelated? (3) What are the key barriers that need to be tackled?

This study makes several contributions to the literature and managerial practice. First, this study is probably of the early studies employing an integrated approach to analyze seven categories of barriers that may impede the development of eHealth SMEs from a less prosperous area of UK - CIoS. A number of scholars have investigated obstacles to impede the development of SMEs within specific areas (Wang. 2016). However, a rare of research has been directed towards eHealth SMEs of CIoS. The findings of this study promise contributions to literature by revealing 16 barriers that affect eHealth SMEs development of CIoS. Second, this study through building a hierarchy framework to highlight the inter- and cross-relationships among the identified barriers and also point out the key barrier is transculturally problem. Our study contributes to the literature such as risk management and internalization of SMEs, especially for the SMEs originate from a cultural value orientation (e.g., hierarchy and embeddedness) that different from the UK (affective autonomy). Finally, this study helps to identify the driver and mediator barrier through classifying 16 barriers into four groups. As for the contributions to managerial practice, this study raises the awareness of eHealth managers about different barriers that may impede their development, enable managers to allocate

resources more critically through providing key barriers, and equip them with knowledge of insights into interrelationships among barriers and characteristic of each barrier.

The rest of this study is designed as follows. In Section 2, literature review is conducted followed by research methodology in Section 3. Then, empirical data collection process is presented in Section 4. In Section 5, data analysis is presented. Subsequently, the findings are discussed in Section 6. Finally, conclusions, contributions to managerial practices, and limitations and future research directions are drawn in Section 7.

2. Literature review

SMEs play a critical role in generating income, increasing employment and reducing poverty for a country (Cravo et al. 2012; Lin and Lin. 2016). However, approximately 50% of SMEs close down in five years after their constitution, and further 30% - 40% of SMEs fail in another five years due to a range of barriers (Parnell et al. 2015). Barriers are defined as the factors that hinder or limit the development of SMEs (Rahman et al. 2017). For example, limited access to finance, fierce competition, lack of knowledge and skill, lack of economic incentive policies, and inadequate management capacity are all frequently mentioned by researchers (Alquier and Tignol. 2006; Bajo et al. 2012; Karuppiah et al. 2020). Anderson (2007) stated that lack of access to capital, lack of related laws, privacy concerns, and complexity of eHealth applications are the significant barriers to impede the development of eHealth SMEs. After conducting a comprehensive literature analysis of the barriers and facilitators to the eHealth service applications, Schreiweis et al. (2019) summarize 76 barriers that may impede the adoption of eHealth service, the top five barriers are: limited knowledge of eHealth, lack of necessary devices, problems with financing eHealth solutions, cognition, and security. Namatovu et al. (2021) state that the cost of data services, internet intermittency, and lack of training prior to use the eHealth system are the top three barriers to hinder the eHealth technology uptake. Other barriers such as limited knowledge of eHealth, inadequate financing, corruption inside of company, and lack of economic incentive policies are all mentioned by other scholars (Krasniqi. 2007; Shi et al. 2008; He et al. 2014; Wildenbos et al. 2017). Different barriers that impede the development of SMEs are listed in Table 1. There are different typologies that can be used to classify barriers of SMEs. For example, Shi et al. (2008) proposed that barriers of SMEs could be grouped into four categories, including policy and market, financial and economic, technical and information, and managerial and organizational. Besides, barriers can be classified into internal barriers and external barriers (Jaramillo et al. 2019). Internal barriers are those barriers originate from the internal environment of the firm, whereas external barriers are those from the external environment, such as infrastructure, cultural and economic environments (Al-Hyari. 2012). A further typology is provided by Leonidou (2004), they categorized internal barriers into three categories, including informational, functional, and marketing; external barriers were further categorized into four categories, including procedural, environmental, task, and governmental barriers. Based on the above discussion, we choose the typology framework proposed by Leonidou (2004) to categorize the barriers identified in this study, as their work can be considered as the most comprehensive analysis of barriers to impede growth of SMEs and represent the major concerns of SMEs (Brustbauer. 2014; Dabic et al. 2020).

Table 1 Various barriers to impede the development of SMEs

Barriers		
Internal barriers	Informational barriers related to information inefficiencies	Lack of accessibility of data (Sulong et al. 2015); difficulties in obtaining information (Ghazilla et al. 2015); limited knowledge of eHealth (Wildenbos et al. 2017);
	Functional barriers related to inefficiencies of the various enterprise functions, such as human resource, production, and finance	Manager resistance to change (Baldwin and Lin. 2002); inadequate financing (Krasniqi. 2007); lack of technical training at workshop floor (Shi et al. 2008); lack of qualified personnel (Madrid-Guijarro et al. 2009); corruption inside the company (He et al. 2014); added workload (Varsi et al. 2015); lack of time (Hjorth and Brem. 2016); general low morale of businesses (Meath et al. 2016); problems with financing eHealth solutions (Radhakrishnan et al. 2016); outdated machines and tools (Ghadge et al. 2017);
	Marketing barriers related to the enterprise's product, pricing, distribution, logistics, and promotional activities	Lack of market preference or demands (Sulong et al. 2015); not understanding the market (Bocken. 2015); unsuited services, design does not fit users' needs (van der Meij et al. 2018);
External barriers	Procedural barriers related to the operating aspects of transactions	Copied business model from other industries (Bocken. 2015);
	Environmental barriers related to the economic, political-legal, and sociocultural environment of the external environment	Weak public awareness and pressure (Shi et al. 2008); rapid technological changes (Falkner and Hiebl. 2015); high initial capital cost to implement tool (Ghadge et al. 2017); difficulties in acquiring financial capital (Auer and Jarmai. 2017); ignorance about regulation (Auer and Jarmai. 2017); lack of industry 4.0 infrastructure (Nikolai et al. 2022);
	Task barriers related to the enterprise's customers and competitors	Concern about competitiveness (Shie t al. 2008); weak market position (Ghazilla et al. 2015); security (Wildenbos et al. 2017);
	Governmental barriers related to actions or inaction by the home government	Lack of economic incentive policies (Shi et al. 2008);

Since most eHealth firms are SMEs, this means that these companies do not have unlimited resources to tackle internal and external barriers and facilitate their development. Hence, multi-criteria decision-making (MCDM) methods have been deployed to analyze and prioritize decision alternatives for finding an appropriate solution. For example, Faber et al. (2017) investigate factors that influence the organizational adoption of eHealth among hospitals in The Netherlands using a structural equation modelling (SEM). Their research results indicate that hospital size, top management support, and organizational readiness are the top three factors that significantly influence eHealth adoption. After exploring factors that inhibiting the dissemination of telemedicine in Japan using interpretive structural modelling (ISM), Shimizu et al. (2021) identify that high implementation and operation cost, low research data, and risk for clinical safety are the main factors to impede the dissemination of telemedicine. In the context of developing countries (e.g., Bangladesh), the ease of use and the usefulness and trust of eHealth technologies are considered by patient as the two most important factors to influence the adoption of eHealth (Hoque et al. 2017). Besides, other MCDM methods are all adopted to tackle different problems of eHealth SMEs, including judgment-decomposition analytic hierarchy process approach (JD-AHP) for assessing the suitability of smart technology applications of eHealth (Chen and Wu. 2020), a combination of AHP and TOPSIS (The Technique for Order of Preference by Similarity to Ideal Solution) for evaluating and selecting mHealth applications (Rajak and Shaw. 2019), and DEMATEL-based

analytic network process (DANP) for identifying key factors in consumers' adoption behaviour of intelligent medical terminals (Liu et al. 2017). Detailed analysis of literature is shown in Table 2.

Table 2 MCDM methods for eHealth

Author(s)	Topic focus	MCDM method(s)	Country
Kijsanayotin et al. (2009)	Factors influencing health information technology adoption in community health centers	Partial least squares path modelling	Thailand
Faber et al. (2017)	To improve understanding of the phenomenon of an organizational eHealth adoption model	SEM	The Netherlands
Hoque et al. (2017)	Investigating factors influencing the adoption of eHealth in developing countries	PLS-SEM	Bangladesh
Liu et al. (2017)	To evaluate the key influential factors of consumer adoption behavior for improving and promoting intelligent medical terminals	DEMATEL-based ANP	China
Rajak and Shaw (2019)	Evaluation and selection of mhealth applications	AHP and fuzzy TOPSIS	India
Chen and Wu (2020)	Assessment the suitability of smart technology applications for eHealth	JD-AHP	Taiwan (China)
Garrido et al. (2021)	Analyze the scalability of EHR systems using blockchain technology	Simulation-based AHP	Colombia
Luyten and Marneffe (2021)	To differentiate between the enablers and barriers of EHR (Electronic Health Record) system acceptance prior to EHR implementation	SEM	Belgium
Shimizu et al. (2021)	Analysis of factors inhibiting the dissemination of telemedicine in Japan	ISM-MICMAC	Japan
Almathami et al. (2022)	To identify factors that influence users' motivation toward the use of teleconsultation systems	Delphi	Australia

From the above literature analysis, we can summarize several research gaps that merely mentioned by other researchers, which will open avenue for future research.

First, the literature is fragmented and has a focus on several parts, such as factors determining the success and failure of eHealth adoption at system, community, organizational, and professional levels (Hardiker and Grant. 2011; Li et al. 2013; Schreiweis et al. 2019), evaluation and integration of eHealth solutions into healthcare (Faber et al. 2017; Negro-Calduch et al. 2021), and eHealth technology improvement and optimization (Broekhuis et al. 2019). eHealth as a new domain of research, many areas of eHealth were developed in the last two decades. However, a rare of studies has investigated the barriers for impeding the development of eHealth SMEs, given the increasingly important role of SMEs for a country (Ballester et al. 2020; Oderanti et al. 2021).

Second, various MCDM methods have been used in the field of eHealth, such as PLS-SEM, DEMATEL-based ANP, AHP, TOPSIS, JD-AHP, Delphi, and ISM-MICMAC (Cross-impact multiplication applied to classification) (Hoque et al. 2017; Chen and Wu. 2020; Almathami et al. 2022) (see Table 2). However, barriers for impeding the development of eHealth SMEs were seldom analyzed by using TISM-MICMAC. TISM (Total Interpretive Structural Modelling) is a qualitative modelling technique that used for analysis the contextual relationships among different variables of a system (Sushil. 2012). Its adoption provides us a better understanding about the barriers for impeding the development of eHealth SMEs.

Third, there is a trend to analyze the factors that determine the success and failure of eHealth adoption across the global. For example, Austin et al.' research (2021) explores the barriers and facilitators to deliver eHealth from the university-industry collaboration perspective. Jang-Jaccard et al. (2015) summarize the barriers for delivering telehealth in rural Australia. In the UK, SMEs created 36% of eHealth industry employment and 22% of eHealth industry turnover in 2020. Approximately 56% eHealth industry practitioners are locating in Yorkshire and Humber, London, and the South East. The South West including CIoS only account for 6% of eHealth industry practitioners across the UK (Office for Life Sciences. 2020). Based on the authors' knowledge, there is a very rare of empirical research to investigate barriers to impede the development of eHealth SMEs from a less prosperous area of UK - CIoS. Analysis eHealth SMEs' barriers from a less prosperous area of a developed country would generate new findings and interesting insights.

3. Research methodology

An integrated approach was adopted in this study to analyze the barriers for impeding the development of eHealth SMEs of CIoS (see Figure 1). This includes semi-structured interviews to collect data with eHealth SMEs from CIoS, thematic analysis to generate barriers, TISM to build interrelationships among barriers and prioritize barriers through allocating barriers into different layers, and MICMAC analysis to validate the TISM model and identify the key barriers.

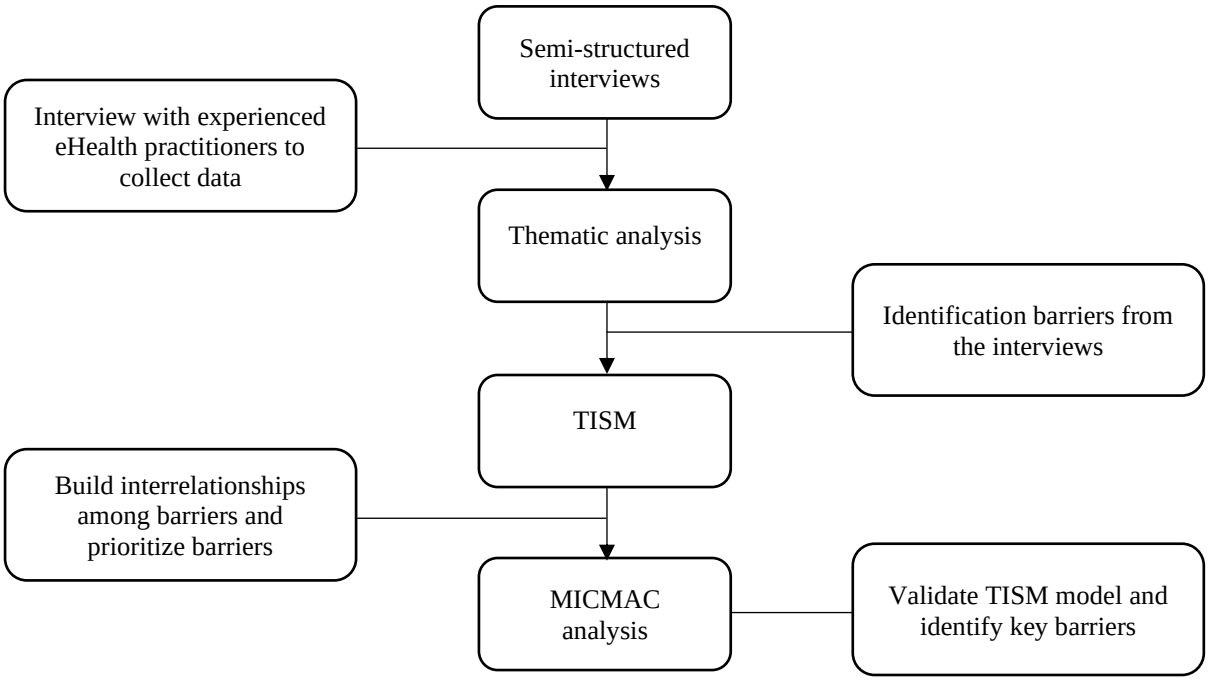

Figure 1 A integrated approach to analyze barriers

Semi-structured interview is considered as a useful technique to generate deep understanding of participants' experience and their interpretation of them (Schultze and Avital. 2011). We selected semi-structured interview as the data collection method due to several reasons. First, it enables probing more information and clarification of answers through asking more probing questions (Barriball. 1994). Second, eHealth practitioners may have different backgrounds (e.g., professional, educational, and personal histories), which preclude the use of standardized interview schedule. Other data collection method such as questionnaire may not be appliable in this study due to several reasons. First, we aim to achieve a deep understanding of the barriers to impede the development of eHealth SMEs, such as interrelationships among the barriers. Questionnaires fail to explain the reasons of interrelationship among barriers as

we need a significant number of open-ended questions (Saunders et al. 2015). Second, incorrectly or illegibly answers may emerge if we choose questionnaires, which will inevitably influence the quality of the data collected (Rowley. 2014).

Then, thematic analysis is used for identifying and describing barriers from the data collected from semi-structured interviews. Thematic analysis was selected because of several reasons. First, it is a well-structured approach for analyzing qualitative data and helping to generate clear and evidence-based themes (Holloway and Todres. 2003). Second, thematic analysis pertains high flexibility, which allows it to be modified based on the situations (Braun and Clarke. 2006). Third, thematic analysis is useful to generate unanticipated insights through highlighting similarities and differences across different data sets (Nowell et al. 2017).

TISM is a widely used modelling technique to build interrelationships among variables, provide interpretation of the linkage among variables, and prioritize variables through allocating them into different layers (Jena et al. 2017). Its key advantage over ISM is to provide interpretations for both linkages and nodes in the structural model (Sushil. 2012). Hence, TISM facilitates in answering "what", "why" and "how" in theory building. Other methods such as Delphi, AHP, ANP (analytic network process), ELECTRE, SAW (simple additive weighting), DEA (data envelopment analysis), and DEMATEL all have its drawbacks that cannot be applied in this study. For example, Delphi technique is shorts for participants to elaborate on their views and needs continuously commitment from participants (de Meyrick. 2003). AHP fails to consider the interactions and dependences among the criteria used to rank alternatives (Saaty. 2008). ANP may not appliable for tackling practical problem due to it acquires a weighted super matrix through allocating equal weight to each cluster (Kou et al. 2014). The process and outcomes of ELECTRE cannot be explained from a layman's perspective, whereas the estimates of SAW do not always reflect the real situation (Velasquez and Hester. 2013). DEA has the capacity to handle multiple inputs and outputs, but it assumes that all input and output are exactly known (Ji and Lee. 2010). DEMATEL ranks variables based on interdependent relationships among them, whereas other criteria are not considered in the decision-making problem (Si et al. 2018). Thus, TISM was used to build interrelationships among the barriers and prioritize them.

Finally, MICMAC analysis was utilized to identify the key barriers that drive the whole system. Through analysis the driving power and dependence power of each barrier, the key barriers are identified. The theory behind the MICMAC analysis is multiplication properties of matrices (Sharma et al. 1995).

4. Empirical data collection

An interview guide was developed through discussing with two research fellows in eHealth and one business support manager (see Appendix 1). It was used to help researchers to direct conversation towards the research topic during the interview (Cridland et al. 2015). There are three sections of the interview guide, including warm-up section about general information related to the participant and their company, follow-up section about barriers to impede their company's development, and final section about methods adopted to tackle barriers. Three pilot tests were conducted with one research fellow in digital health testbed, one research fellow in eHealth, and one eHealth business support manager to confirm the coverage and relevance of the content. These people were selected because they have been working with eHealth companies for more than three years and have significant knowledge about eHealth. Valuable guidance of critical information on the interview guide in general and wording and arrangements of questions helped us to improve the interview guide.

Purposive sampling was applied to identify participants that are most likely yield useful information and increase the depth of understanding (Palinkas et al. 2015). The justification for adopting purposive sampling is based on the assumption that specific kinds of people may hold valuable knowledge, important information, and different views in terms of barriers for

impeding the development of eHealth SMEs of CIoS, therefore need to be included in the sample (Robinson. 2014; Campbell et al. 2020). Several criteria were applied to recruit suitable participants. First, the participants should come from the SMEs of eHealth industry of CIoS. Second, they must be senior level members (e.g., founder, product manager, and technical director) of their company to ensure a high-level expertise and knowledge. Third, the selected eHealth SMEs should have collaboration relationships with the EPIC to ensure we can get sufficient information or have opportunity to discuss sensitive issues with them. Based on the above criteria, 20 eHealth SMEs were selected and promised to participate in this research. These include SMEs doing an app to record physical activities, support mental health wellbeing, empower GPs, and epilepsy management, as well as other companies doing diabetes management, AI-based voice technology, and mass vaccination booking platform. The detailed information of each SMEs is shown in Table 3, including their expertise and products, standard industrial classification (SIC) of their economic activities, and their technological readiness levels (TRLs) to assess technologies and their readiness for on-site deployment, and interviewee's position. In particular, TRLs range from TRL1 Basic principles to TRL9 Operations (Nuclear Decommissioning Authority. 2014).

Table 3 Detailed information of eHealth SMEs across CIoS

SMEs	Expertise and products	SIC code	TRL level	Interviewees' position
A	Modelling complex systems in health and wellbeing	62090 – other information technology service activities	TRL7 - TRL8	R & D director
B	An app for social prescribing	82990 – other business support service activities not elsewhere classified	TRL5 - TRL6	Founder
C	An app to record physical activities	86900 – other human activities	TRL2 - TRL3	Product manager
D	An app for young people to support their financial situations and mental health wellbeing	85600 – educational support services	TRL9	Founder
E	Using AI and natural language processing to create bots to answer questions and automatically fill in paperwork	62012 – business and domestic software development	TRL7 - TRL8	Head of narrative design
F	Online and live wellbeing community	86900 – other human activities	TRL8 - TRL9	Founder
G	An app to enable people to better support their mental and physical wellbeing	86900 – other human activities	TRL5 - TRL6	Founder
H	Diabetes app to improve patients' diabetes management mindset	86900 – other human activities	TRL5 - TRL6	Clinical psychologist
I	Use blockchain and smart contract 2.0 to analyze personal health data	72190 – other research and experimental development on natural sciences and engineering	TRL2 - TRL3	Founder
J	Computer-based therapy	86900 – other human activities	TRL5 - TRL6	Technical director
K	An app to empower GPs, healthcare professionals and patients	84120 – regulation of health care, education, cultural and other social sciences, not incl. social security	TRL5 - TRL6	Founder
L	Cost-effective listening technology for healthcare	62090 – other information technology service activities	TRL6 - TRL7	Technical director
M	AI-based voice technology to support with at home monitoring for the elderly living independent	62012 – business and domestic software development	TRL8 - TRL9	Business administrator
N	AI-powered surface cleaning robots for hospitals	47990 – other retail sale not in stores, stalls or markets	TRL8 - TRL9	Marketing manager
O	A proactive employee focused platform for corporate settings	62012 – business and domestic software development	TRL7 - TRL8	Founder
P	Delivering therapy through VR headsets to help release stresses and anxieties	86220 – specialist medical practice activities	TRL2 - TRL3	Founder
Q	Software-based medical device, used to measure and report vital signs of a patient	62012 – business and domestic software development	TRL8 - TRL9	Marketing manager
R	Community platform focusing on women's health	86900 – other human activities	TRL2 - TRL3	Founder
S	Mass vaccination booking platform	62012 – business and domestic software development	TRL9	Co-founder
T	Epilepsy management app	62020 – information technology consultancy activities	TRL8 - TRL9	IT manager

Note: TRL – TRL1 Basic principles; TRL2 Invention and research; TRL3 Proof of concept; TRL4 Bench scale research; TRL5 Pilot scale; TRL6 Large scale; TRL7 Inactive commissioning; TRL8 Active commissioning; TRL9 Operations

The interviews with eHealth SMEs were conducted between January and April of 2022 through virtual meetings. We secured the time slot through sending enquiry emails to potential participants. A copy of the interview guide was sent to interviewees three days before the interview session to ensure that they were familiar with the topic, structure, and process of the interview. Pre-project training was conducted among interviewers in terms of the purpose of the research, how to store and use information, and how to elicit answers from participants, and informed consent. Each interview was lasted 30 to 40 minutes to allow interviewees had sufficient time to clarify their answers and express their ideas. During each interview, meetings were recorded through Zoom with permission and probing questions were asked as much as possible to ensure sufficient information emerge from the interview. Furthermore, a research fellow in digital health was asked to participate in these meetings to take notes. After each interview, the notes taken during the interview were shared with the other colleague to avoid misunderstanding.

5. Data analysis

Three data analysis methods were used in this study. First, thematic analysis was used to generate barriers from the data collected through semi-structured interviews. Then, barriers generated through thematic analysis were used as inputs to process TISM – building interrelationships among barriers and prioritization barriers through allocating them into different layers. Finally, MICMAC analysis was implemented to identify key barriers through classifying barriers into different groups and validating TISM model. Detailed data analysis process is shown in the sub-sections.

5.1 Barriers generation through thematic analysis

The thematic analysis adopted in this study consists of four steps, including transcribing, coding, categorizing, and presenting (see Figure 2). First, transcribing. Interview audio files were uploaded to Otter – a professional transcribing software to support speech to text transcription. Each interview audio file was transcribed word-by-word to ensure that we did not miss any elements that emerged from the interviews with eHealth industry practitioners. After immersive, repeated and active reading of the transcripts several times, irrelevant data were removed from the transcripts, which resulted in a cleaned transcript for the next step. Then, coding. The main aim for conducting coding is to identify interesting sections, sentences or paragraphs that related to barriers to impede the development of eHealth SMEs. During the coding process, we used the qualitative data analysis software NVivo 12 to assist the coding process. The codes extracted from the transcripts were then collapsed into themes, which were labelled using established constructs from existing literature (e.g., risk management of SMEs) related to barriers to hinder SMEs development. Besides, an iterative approach was adopted in this stage to refine codes and themes through moving back and forth of relevant literatures and theories (Inkpen and Tsang. 2005). Thereafter, we categorized various barriers (themes) into different categories that used in previous research (Leonidou. 2004) and also linked with relevant codes. Finally, we presented our findings by using the framework proposed by King and Horrocks (2010): (1) Descriptive coding (first-order codes): the researcher extracts the data from the transcripts that relevant to the research questions and allocates descriptive codes across the whole transcript; (2) Interpretive coding (second-order themes): the researcher categorizes the descriptive codes that have similar meanings and create an interpretive code to represent this; and (3) Defining overarching themes (aggregate dimensions): the researcher identifies a number of overarching themes that characterize key concepts in the analysis. Table 4 summarizes the coding structure of this study.

Thematic analysis was also used to identify data saturation point of this study. There is no universally accepted rule about how many interviews should be conducted. For example, Guest et al. (2006) proposed that data saturation point occurred within the first twelve interviews, whereas others such as Fusch and Ness (2015) argued that data saturation point

emerged between six and twelve interviews. After analyzing 17 interviews with eHealth industry practitioners, we found that barriers such as “lack of access to funding”, “skills gap”, and “poor staff support” appeared frequently in our data and new information emerged little. Thus, we decided to conduct further three interviews to confirm the data saturation point (Morse et al. 2014). After conducting three further interviews, new themes did not emerge, which indicated data saturation point reached. Thus, the sample size of this study is 20 interviews.

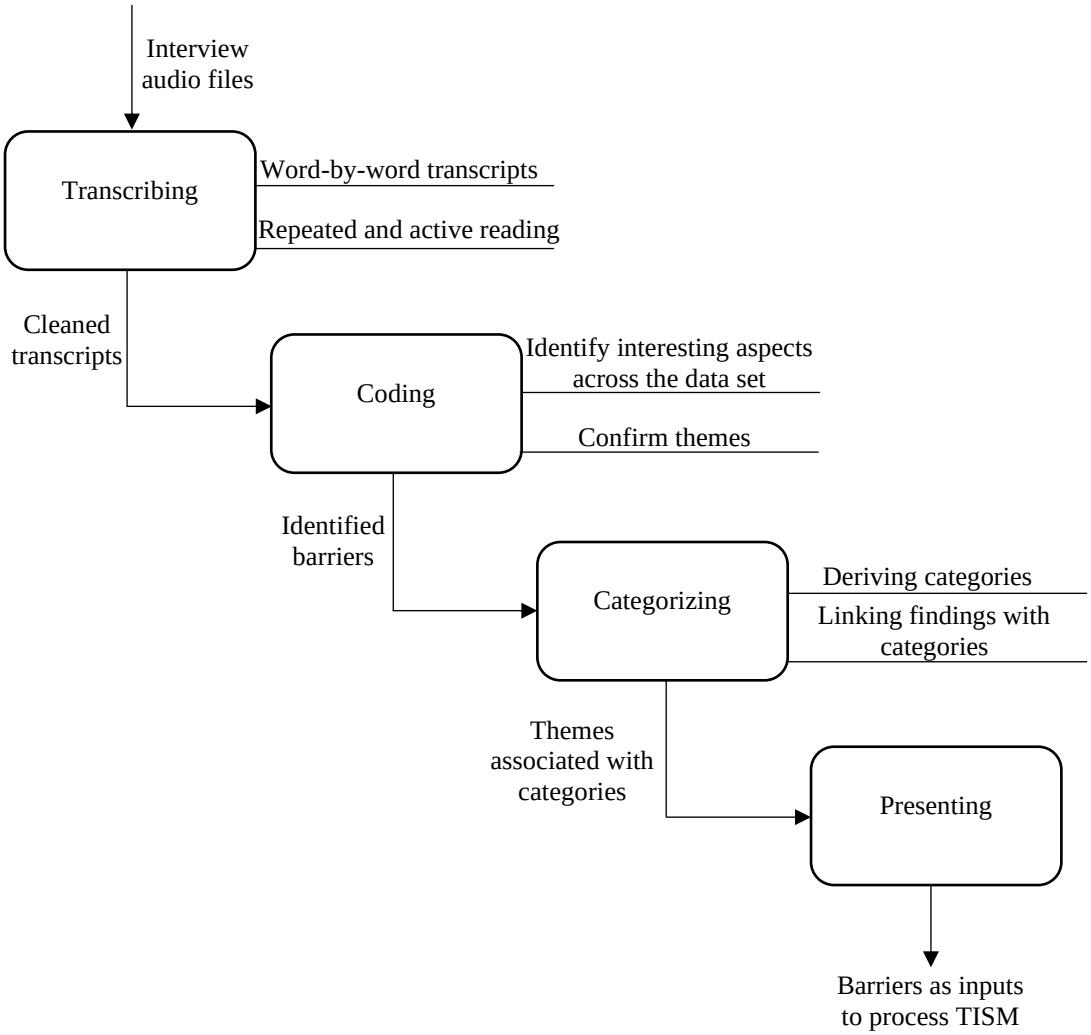

Figure 2 Thematic analysis process

Throughout thematic analysis, this study identified 16 barriers that could impede the development of eHealth SMEs in CIoS. These barriers were categorized into 7 groups, including informational, functional, marketing, environmental, procedural, task, and governmental barriers (Leonidou. 2004). It is interesting to note that lack of links of NHS procurement side, limited re-innovation capability, transculturally problem, lack of specific digital skills, and limited product scalability are seldom identified in prior literatures (Kim and Xie. 2017; Alshahrani et al. 2019). For example, several eHealth SMEs involved in this study are running their apps successfully in other countries, such as China, India, Greek, Finland and Norway. However, these SMEs experiencing problems in the UK because of transcultural issues. Although previous studies identified various barriers could hinder the development of eHealth SMEs, transcultural issue seems to be neglected by them (Jaramillo et al. 2019; Schreiweis et al. 2019).

Table 4 Coding structure of barriers to impede development of eHealth SMEs

First-order codes	Second-order themes (Barriers)	Support from eHealth SMEs in CIoS	Aggregate dimensions
"We want to build relationships with hospitals with spending power. Apparently, we are lacking this kind of relationships."	Lack of links of NHS procurement side (E1)	E,I, K,N,S	Informational barriers
"Our company is experiencing labour shortage problem because some of employees are part-time works and volunteers."	Labour shortage (E2)	A,B,C,D,E,F,G,H,I,J, K,L,M,N,O,P,Q,R,S,T	Functional barriers
"We do not know how to apply funding or involve in a project. Thus,	Difficulty in accessing funding (E3)	A,B,C,D,E,F,G,H,I,J, K,L,M,N,O,P,Q,R,S,T	
"We are trying to modify our platform to make it applicable for primary care."	Limited re-innovation capability (E4)	B,C,D,G,K,S,T	
"We do not have any staff support plan, such as training sessions and reward systems, due to we are SMEs."	Poor staff support (E5)	A,B,C,D,E,I,J,K,L,M,N,O,P,	
"The CEO lacks vision about technology development direction.	Poor leadership (E6)	H,I,J,K,L,M,N,O,P,Q,R,S,T	
"Our product performs well in India. However, we have problems in the UK market."	Transculturally problem (E7)	B,C,D,E,F,H,N,T,O,P,Q	Marketing barriers
"The app is focusing on the women's health. We do not have plans to upgrade our app to make it suitable for other areas."	Limited product scalability (E8)	A,C,D,F,G,H,I,J,L,M, N,O,Q,R,S,	
"We do not know how to promote our product online and offline. Thus, we need experts in marketing to help us."	Lack of knowledge about product promotion (E9)	A,B,D,F,G,I,J,K,L,M,N,O, P,R,S,T	
"Elderly knows little about eHealth technology. Most of them do not believe eHealth technology."	Public weak awareness about eHealth (E10)	A,B,C,D,E,F,G,H,I,J,K,L,M, N,O,P,Q,R,S,T	Environmental barriers
"The COVID-19 makes our work slowdown. We have connected our partners for several months, but nobody replies to us."	The impacts of COVID-19 (E11)	A,B,C,D,E,F,G,H,I,J,K,L,M, N,O,P,Q,R,S,T	
"Our people lack skills related to machine learning and code design."	Lack of specific digital skills (E12)	A,B,C,D,E,F,G,H,I,J,K,L,M, N,O,P,Q,R,S,T	Procedural barriers
"It is difficult for us to get enough people to trial our products. Thus, we ask EPIC for helping."	Problems in user experience evaluation (E13)	B,C,D,E,F,G,H,I,J,K,L,M, N,O,Q,R,S,T	
"We need experts especially from the business side to let us know the routes to market and who wants to use our platform."	Lack of knowledge about their end user and routes to markets (E14)	C,D,E,F,G,H,I,J,K,L,M, N,O,P,Q,	Task barriers
"We know there are supports from government to disseminate eHealth technology, but we lack details."	Problems in eHealth policy dissemination (E15)	A,B,C,D,E,F,G,H,I,J,K,L,M, N,O,P,Q,R,S,T	Governmental barriers
"Sometimes, we are experiencing latency problems."	Lack of adequate infrastructure (E16)	D,E,F,G,H,I,J,K,L,M,N,O,P,Q	

5.2 Prioritization and interrelationships building among barriers through TISM

In this study, TISM was used to build interrelationships among barriers and prioritize them. It includes nine steps (Sushil. 2012; Zhao et al. 2020).

- Step I – Identification and define elements: this step involves identification and define elements to be modelled. Elements can be identified through existing literature or brain storming session or other idea generation technique (Jena et al. 2017). In this study, the 16 barriers to impede the development of eHealth SMEs were generated through interviewing with experienced eHealth practitioners across CIoS. Thus, the 16 barriers were used as inputs to process TISM.
- Step II – Determination of contextual relationship: it is critical to state the contextual relationship between the barriers. This study aims to know the interrelationships among the barriers and identify the key barriers to impede the development of eHealth SMEs. Thus, the contextual relationship between two barriers could be: "barrier A will cause barrier B".
- Step III – Interpretation of relationship: this step involves interpretation of relationships between the barriers to achieve a deep understanding. Thus, three experts' opinion were captured to clarify the relationship between barriers through asking two questions: (1) whether barrier A will cause barrier B; if their answer pertains yes, a following question will be asked (2) in what way barrier A will cause barrier B. Three experts involved in this study are two research fellows in digital health and one business support manager.
- Step IV – Interpretive logic of pair-wise comparison: an interpretive logic-knowledge base was developed for pair-wise comparison of the 16 identified barriers. For paired comparison, the i*th* barrier is compared individually to all the barriers from (i+1)*th* to the n*th* barrier. Since each pair of barriers (i,j) may have two possible directional links, such as barrier i may cause barrier j, or barrier j may cause barrier i. If one study has n elements need to be modelled, there will be n×(n-1) rows in the knowledge base. Thus, there are 16×(16-1)=240 rows in the knowledge base for performing this study.
- Step V – Reachability matrix and transability test: the initial reachability matrix was developed based on the interpretive logic-knowledge base. Thus, we transformed "Y" entry code of interpretive logic-knowledge base into 1 of initial reachability matrix (see Appendix 2) and "N" entry code into 0. "Y" represents "Yes", which is achieved based on the relationship between the barriers. For example, if barrier A cause barrier B, a "Y" entry code will be presented in the interpretive logic-knowledge base. Then, we prepared for transability checking. The transability rule is if barrier A relates to barrier B and barrier B relates barrier C, which indicate that barrier A necessarily relates to barrier C. Based on the rule, we transformed initial reachability matrix into final reachability matrix (see Appendix 3).
- Step VI – Level partition based on the final reachability matrix: the level partitioning is implemented to know the level-wise placement of elements (Warfield. 1973). This step ends till the levels of all 16 barriers are determined (see Appendix 4). There are several important concepts for implementing the level partitioning process. For example, in this study, the reachability set for one barrier consists of the barrier itself and any other barriers within the same level which the barrier may cause, whereas the antecedent set consists of the barrier itself and any other barriers that may cause it. The intersection set is determined by the reachability set and antecedent set. If the barriers of the intersection set are the same as the reachability, which will achieve the top level in the TISM hierarchy. Thus, the barriers are removed from the element set and the same procedure is performed till all the levels are determined.

- Step VII – Development of the digraph: the digraph (see Appendix 5) is developed through allocating barriers into various levels and drawing directed links as shown in the final reachability matrix. The important transitive links are also shown in the digraph through brainstorming session with the experts involved in this research.
- Step VIII – Interpretive matrix: the binary interaction matrix is developed based on the final digraph through depicting all interactions by "1" in the respective cell. For each cell with "1" entry, the corresponding interpretation is picked from the interpretive logic-knowledge base to form the interpretive matrix.
- Step IX – Total interpretive structural model: based on the digraph and the interpretive matrix, the TISM model for barriers to impede the development of eHealth SMEs is built. The nodes in the digraph are substituted by the interpretation of the barriers placed in boxes. The interpretation in the cells of interpretive direct interaction matrix is depicted by the side of the respective links in the structural model. The final TISM model is shown in Figure 3.

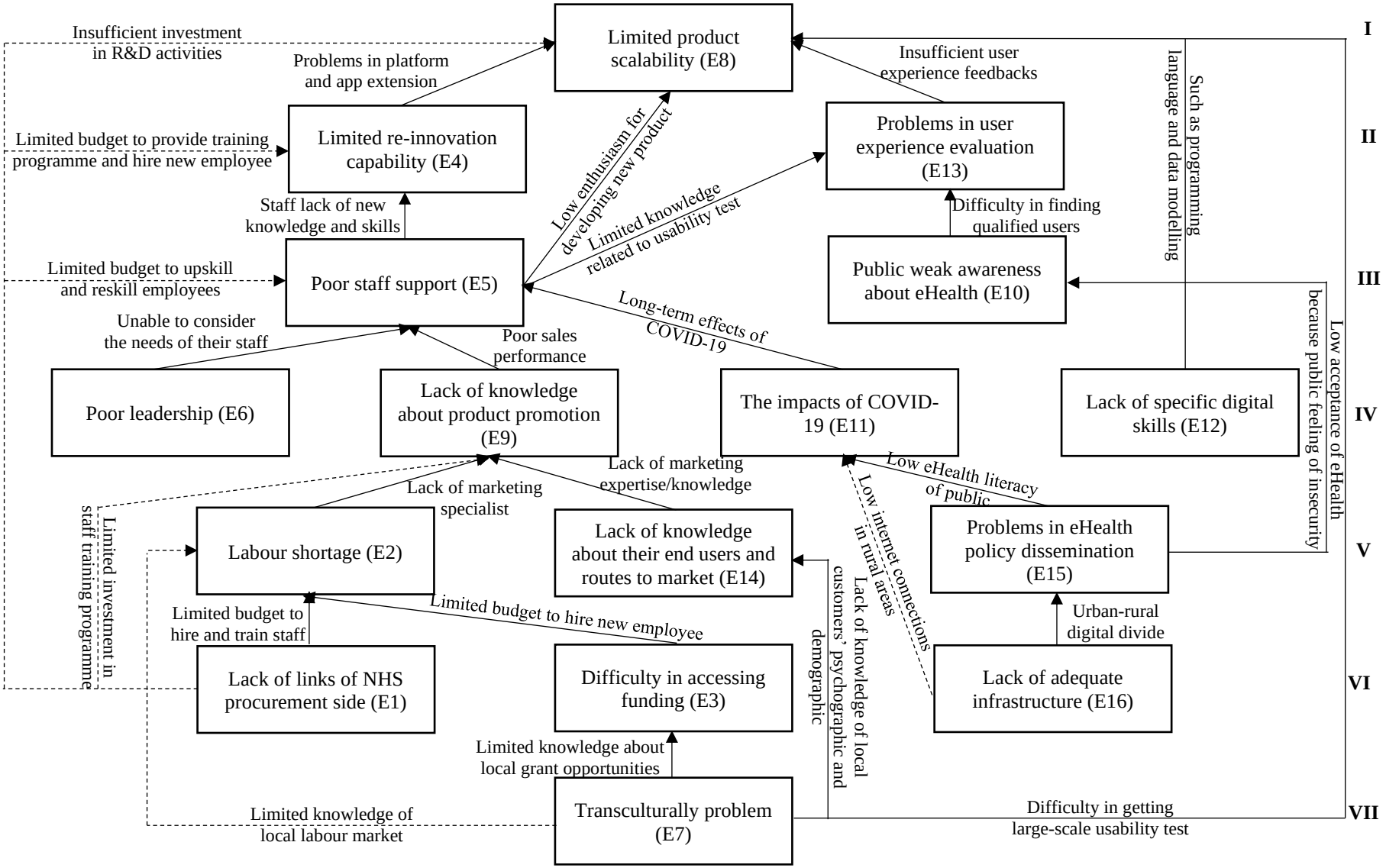

Figure 3 TISM model of barriers to impede the development of eHealth SMEs

The TISM analysis of barriers to impede the development of eHealth SMEs resulted in a TISM model of seven levels (see Figure 3). For example, limited product scalability (E8) occupies the level I in the TISM hierarchy, whereas other barriers such as limited re-innovation capacity (E4), problems in user experience evaluation (E13), and other 13 barriers occupy level II to level VII. The barriers locate in the lowest level of TISM hierarchy indicate that these barriers act as drivers of the system and have the capability to trigger more barriers, whereas the barriers locate in the highest level of TISM hierarchy indicate that these barriers have less impact on the system and rely on other barriers to achieve them. For example, transculturally problem (E7) locates in the lowest level of TISM hierarchy may directly and indirectly cause other nine barriers of the system. Limited product scalability (E8) locates in the highest level of TISM hierarchy, which may be elicited by other 15 barriers of the system. Transculturally problem (E7) may cause difficulty in accessing funding (E3) due to eHealth SMEs' managers' limited knowledge about local grant opportunities. In particular, some managers either are migrants from other countries (e.g., India and China), or they want to exploit UK markets, such as SMEs originate from Greek, Finland and Norway. These managers have a common problem because they are not familiar with the local grant opportunities, such as National Institute of Health and Care Research (NIHR) i4i FAST (Funding at the Speed of Translation Awards) and funding opportunities of Cornwall Council. External funding is critical for eHealth SMEs' development, especially for the SMEs with less than 10 employees, as external finance from banks is impossible for them to get (Enterprise Research Centre. 2016). Thus, it is no doubt that labour shortage (E2) is a common problem for the eHealth SMEs participated in this research, as they have limited budget to hire new employees. For tackling the problem, eHealth SMEs tried to form university-industry collaboration and proposed some student internships. In this study, eHealth SMEs' establishment because of several reasons. First, the founder or co-founder has experienced illness (e.g., diabetes, mental health problem, and nutritional problem), therefore, they want to share their experience or build tools to help more patients. Second, the founder and co-founder has expertise in several areas, such as machine learning, artificial intelligence, blockchain technology, sleep training, epilepsy management and others, therefore, using cutting-edge technology to generate positive effects on patient experience is their vision. However, these SMEs seem to neglect other perspectives, such as lack of linkages of NHS procurement side (E1) which will cause limited investment in staff training programme and lack of knowledge about their end users and routes to market (E14) which will cause lack of marketing expertise and knowledge. The missing of linkages with NHS procurement side and knowledge about marketing would elicit other negative effects such as lack of knowledge about product promotion (E9) and poor staff support (E5). In particular, reskill and upskill employees through different training programmes is critical in the digital age, such as training programmes related to data analytics (e.g., R or Stata, big data, and data science). However, due to limited budget, training programmes are difficult implemented in eHealth SMEs. Without sufficient programming and data analytic skills, re-innovation on existing platform or mobile application is impossible, which will cause limited product scalability (E8). Other barriers such as problems in user experience evaluation (E13) results eHealth SMEs cannot get sufficient user experience feedbacks and lack of specific digital skills (E12) such as programming language and data modeling all can cause limited product scalability (E8). In particular, user experience evaluation is a widely existing problem of eHealth SMEs in CIoS. We assumed that public weak awareness about eHealth (E10) results these companies cannot find sufficient qualified users.

Besides, the TISM analysis results also generate interesting insights that different from previous research. For example, the TISM analysis result shows that transculturally problem (E7) should be given critical attention, especially for those running eHealth businesses successfully in other countries that has different cultural value orientations from UK, such as

Finland, Norway, Greece, India, and China, as well as they have ambitious to exploit UK markets. There are seven types of cultural value orientations, including egalitarianism, intellectual autonomy, affective autonomy, mastery, hierarchy, embeddedness, and harmony (Schwartz. 2006). In this study, one of the eHealth SMEs originate from India, where cultural value orientation is hierarchy, and they want to expand the UK market with the same eHealth app. However, they were not successfully due to transculturally problem. In the hierarchy environment, people are encouraged to fulfill collectivities with priority rather than pursue their unique ideas and aspirations, whereas in the affective autonomy environment such as UK, people are encouraged to pursue affectively experience for themselves, such as pleasure, exciting life, and varied life (Schwartz. 2006). Thus, the cultural conflicts between UK and India requires Indian managers to tolerate differences, understanding varied expressions, collaborate with peers, and enhance their interpersonal and psychological skills. Besides, data privacy also needs to be considered, especially for the eHealth managers from the countries such as China and India. For example, India do not have a unified privacy law, whereas in the UK – the General Data protection Regulation (GDPR) of The Data Protection Act 2018 requires information to be used fairly, lawfully and transparently.

5.3 Categorization barriers and validation TISM model through MICMAC analysis

MICMAC analysis was performed to validate TISM model and classify 16 barriers into four categories based on the driving power and dependence power of each barrier (see Figure 4). Driving power represents the power of a barrier to drive the system, whereas dependence power represents the power of a barrier to dependent on the system. Each barrier's driving power and dependence power are calculated by summing the "1" entry of each row and column in the final reachability matrix, respectively (see Appendix 3). For example, transculturally problem's (E7) driving power is 10, which means that transculturally problem can cause other 10 barriers; whereas its dependence power is one, which indicates that only one barrier can elicit transculturally problem. Thus, we classified 16 barriers into four categories: independent, linkage, autonomous and dependent variables.

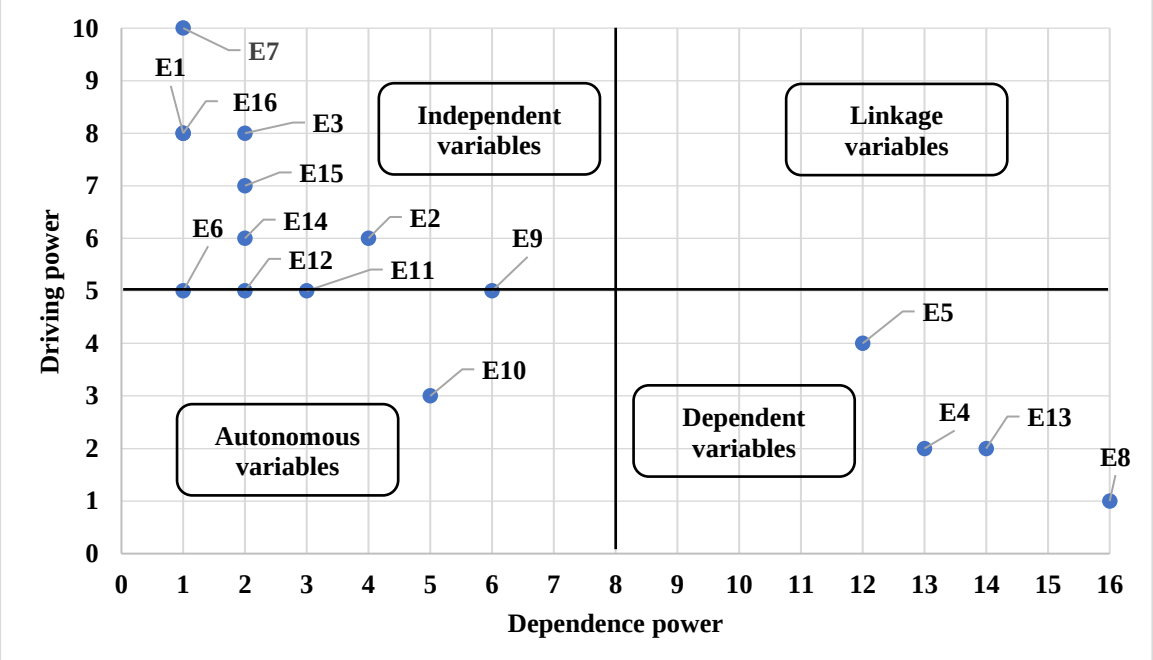

Figure 4 MICMAC analysis of barriers to impede the development of eHealth SMEs

- Independent variables characterize with strong driving power and weak dependence power, which are the drivers of the system. In this study, we identified 11 barriers that act as drivers of the system, such as transculturally problem (E7), lack of links of NHS procurement side (E1), difficulty in accessing funding (E3), lack of adequate infrastructure (E16), and other 7 barriers. In particular, transculturally problem (E7) locates in the lowest level in the TISM hierarchy and has the strongest driving power, therefore, can elicit the most of barriers in the system.
- Linkage variables has strong driving power as well as strong dependence power, which act as linkages of the system. However, no linkage variables were identified in this study.
- Autonomous variables have weak driving power as well as dependence, which are considered do not have much influence on the system (Zhao et al. 2020). This study identifies only one autonomous variable, which is public weak awareness about eHealth (E10). It was identified not so much influence on the system because of two reasons. First, CIoS is the ideal testbed for eHealth innovations, as many of populations living in rural areas with limited access to primary care (Cornwall Trade and Investment. 2020). Thus, eHealth technology is the only feasible choice for the people living rural areas. Second, populations in CIoS have positive attitudes towards new eHealth technologies, such as virtual assistant (Buckingham et al. 2022).
- Dependent variables are identified as having strong dependence power and weak driving power, which locate in the top levels in the TISM hierarchy. This study identifies four barriers are dependent variables, such as limited re-innovation capability (E4), poor staff support (E5), limited product scalability (E8), and problems in user experience evaluation (E13). In particular, limited product scalability (E8) locates in the highest level in the TISM hierarchy and can be elicited by other 15 barriers in the system, therefore, should be tackled from various ways, such as hire new employees, reskill and upskill employees, and involve in bid application.

6. Discussion and contributions

This study focused on the empirical evidence of barriers to impede the development of eHealth SMEs that locates in CIoS, where is an ideal testbed for new eHealth technologies. Through conducting interviews with experienced eHealth SMEs' managers and analyzing the data by an integrated approach, the findings of this study generate interesting insights into barrier analysis and have made a number of contributions to the existing knowledge while answering the three research questions outlined in the introduction section: (1) it provides empirical evidence of barriers that may impede the development of eHealth SMEs of CIoS. For example, we identified 16 barriers and categorized them into seven categories. (2) It develops interrelationships among the 16 identified barriers through TISM and also identifies the key barrier is transculturally problem. (3) We classified 16 barriers into four categories based on its dependence and driving power, which could help us to understand the role of each barrier in the system, such as act as drivers and linkages.

First, among the identified 16 barriers that may impede the development of eHealth SMEs, the majority of them are new barriers. For example, previous studies such as Shi et al. (2008), Bocken (2015), Falkner and Hiebl (2015), and Nikolai et al. (2022) identify that not understanding about market, lack of industry 4.0 infrastructure, lack of technical training, ignorance about regulation, rapid technological development, and weak public awareness are obstacles to impede the development of SMEs (see Table 1). This study confirms that barriers such as lack of knowledge about their end user and routes to market, lack of knowledge about product promotion, difficulty in accessing funding, public weak awareness about eHealth, lack of specific digital skills, lack of adequate infrastructure, poor staff support, poor leadership, and problems in eHealth policy dissemination are all exist in the context of eHealth SMEs.

Other barriers such as transculturally problem, problems in user experience evaluation, lack of links of NHS procurement side, and limited product scalability are seldom mentioned by scholars. For example, transcultural issue is a challenge for the health care staff working in clinics and hospitals (Amiri et al. 2016), and always been mentioned by researchers in nursing and healthcare (Shahzad et al. 2021). However, from the business perspective, its effects seem to be neglected, especially for the migrants with different cultural background that running a business in the UK. Iyer et al. (2005) highlights that the relationship between product scalability and the performance of web applications, which is reinforced in this study that limited product scalability may cause unsatisfied performance of eHealth SMEs. There are several ways for eHealth SMEs to access to NHS procurement channels, such as selling products directly to trusts or primary care organizations, selling through NHS supply chain or collaborative purchasing arrangements, or selling through national framework collaborations and government tenders (National Health Service. 2018). However, the complicated certification process makes eHealth SMEs difficult to participate in the NHS procurement process, especially for the SMEs not familiar with the local public procurement market (Akenroye et al. 2020).

Second, this study allocates 16 barriers into 7 layers through conducting TISM and identifies transculturally problem is the key barrier. Rana et al. (2019) highlights that "perceived risk" is the key barrier to impede the m-commerce adoption in manufacturing SMEs, whereas Alawamleh and Popplewell (2011) reinforces four risk sources are critical for a virtual organization, such as "geographic location", "culture differences", "ontology differences", and "heterogeneity of partners". Our study generates interesting insights that different from previous research, that is, transculturally problem may elicit various barriers, therefore, should be given critical attention. In this study, SMEs from other countries such as Finland, Norway, Greece, India and China, all encountered transcultural issues when they exploited the UK eHealth markets. This is because these countries' cultural value orientations are different from UK. For example, the cultural value orientation of China and India is extremely high in hierarchy and embeddedness and low in autonomy, which results eHealth managers from these countries have characteristics such as obeying expectations from authority (Gopalan and Rivera. 1997). Closer cultural value orientations of employees will accelerate knowledge sharing and technology innovation, the situation even better in a collectivism cultural (Dwyer et al. 2005). However, UK's cultural value orientation emphasizes on affective autonomy, which encourages individuals to pursue their own ideas and affective positive experience for themselves (Street. 2011). The totally different cultural value orientation between India, China and UK pertains barriers such as poor staff support, poor leadership and limited re-innovation capacity. As for the cultural value orientation of Finland and Norway, these two countries are high in egalitarianism, intellectual autonomy, and harmony. Although these countries have similar cultural value orientations with UK, it shows difference. eHealth managers from Finland and Norway characterize with responsibility and loyalty to their work, whereas UK employees maybe show less loyalty, as UK employees pursue exciting and varied life (Schwartz. 1999; Kirca et al. 2009). Apparently, loyalty issues may cause workforce mobility, and further induce knowledge loss, shortage of skills and talent at the organizational level (Massingham. 2018). The Greek shows a diverse cultural value orientation, but it demonstrates relatively high in embeddedness and low in autonomy (Schwartz. 2006). Countries focus on embeddedness presume that fulfill collective activities are more important than pursue his or her unique ideas. Thus, eHealth managers have a cultural value orientation of embeddedness may limit organization's innovation capacity, as it does not encourage different ideas and inspirations. The difference of cultural value orientations in these countries must have effects on the managers' leadership style, behaviour, and cultural-personal trait, therefore, may cause

more barriers to the SMEs. Our research results remind researchers that transcultural issues of eHealth SMEs cannot be ignored and provide a new research direction for them to investigate.

Finally, the MICMAC analysis of 16 barriers makes researcher more clearly understand the nature of each barrier, such as acts as linkages or drivers in the system. In this study, 11 (n=11, 68.75%) barriers were identified as independent variables, 4 (n=4, 25%) barriers were classified into dependent variables, 1 (n=1, 6.25%) barrier was categorized as autonomous variables, and no autonomous variables were identified.

7. Conclusions, implications, and future research directions

This study has explored the barriers that impede the development of eHealth SMEs in CIoS of UK. An integrated approach includes semi-structured interview, thematic analysis, TISM, and MICMAC analysis has been applied in this study. For example, we conducted 20 semi-structured interviews with experienced eHealth SMEs' managers, followed by thematic analysis to generate 16 barriers. Then, we used TISM to build interrelationships among the identified barriers and distinguished the key barrier. Finally, MICMAC analysis was applied to categorize the barriers and validate the TISM model. The findings highlight that transculturally problem should be given critical attention, especially for the eHealth managers originate from other countries associated with different cultural value orientations from UK, such as eHealth managers has a cultural background of hierarchy and embeddedness.

7.1 Implications to managerial practice

This study also generates a number of contributions to managerial practice. First, our study raises the awareness of eHealth SMEs' managers in terms of transculturally problem. For the eHealth managers originate from China and India and have appetites to exploit UK markets, we suggest them should practice their self-awareness and reflection skills, facilitate themselves to accept different views, values, practices and norms, as well as learn to cooperate with each other. This is because UK's cultural value orientation is affective autonomy, whereas China and India is hierarchy. Second, this study shows that eHealth SMEs in CIoS face a range of barriers, such as functional, marketing, environmental, governmental, and other barriers. The situation makes them difficult to develop capabilities to improve their competitive advantage with limited budgets and resources. A feasible way to tackle different barriers is to formulate university-industry collaboration relationship. University has advanced facilities, knowledge, experienced researchers, and also has funding (e.g., knowledge transfer partnership) can be applied, which should be considered by eHealth SMEs across CIoS. Finally, managers should allocate budgets to reskill and upskill their employees, take into consideration that digital skills are critical for eHealth SMEs' development. This is because dependent variables such as poor staff support, limited re-innovation capacity, and limited product scalability are all more or less related to lack of knowledge and skill. Thus, training programme should be provided to all employees to force them to master basic level digital skills (e.g., productivity software). As for senior level employees, training programme such as online course should equip them with sufficient understanding of the latest trend in the eHealth area. Regarding for critical technician, specific digital skills such as programming language, computer and networking support, data analytic skills should be delivered through online course and scenario-based learning.

7.2 Limitations and future research directions

This study does have some limitations. First, this research focuses on the eHealth SMEs of CIoS of UK. For example, 20 semi-structured interviews were completed by experienced eHealth managers of CIoS. This narrows the scope of results. To generalize the findings of this study, using a large sample of countries to evaluate the research results maybe a feasible method, such as conducting international surveys with eHealth SMEs' managers in 7 – 10 countries. A minimum of 7 – 10 countries is suggested as researchers believe that this number of countries can support credible international generalizations (Franke and Glenn Richey Jr. 2010). Second, we focus on barrier analysis in this study, such as barrier identification,

categorization, and assessment. We tangentially propose some strategies in the discussion section that may have positive effects for tackling the barriers, but its shorts in providing a systematic way. Thus, from organizational resilience perspective to propose a holistic framework to tackle barriers is a valuable future research direction (Lengnick-Hall et al. 2011; Hillmann and Guenther. 2021). Third, this study raised concern that transculturally problem is the key barrier that may elicit other barriers. eHealth SMEs originate from other countries, such as Finland, Norway, Greek, India and China, all running their businesses in CIoS of UK. However, this study shorts in providing detailed obstacles that caused by different cultural value orientations. For example, eHealth businesses from cultural value orientation of egalitarianism (Finland and Norway), hierarchy (India and China), and embeddedness (Greece) to affective autonomy (UK), respectively (Schwartz. 2006). Conducting cross-country comparative analysis in terms of transcultural issues must be a valuable future research direction and will generate practical guidance for businesses to expand their international markets.

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Appendix 1 Interview guide

I. Introductory questions

a) Interviewee information

1) What is your current designation?
2) Can you give me a brief overview of your job within the company operations?
3) How many years have you been working in this company?

b) Company information

1) Can you give me a brief overview of your company? For example, expertise and products.
2) How many employees are working for the company?

II. Barriers to impede the company's development

1) How would you describe any informational barriers related to information inefficiencies?
2) How would you describe any functional barriers related to enterprise functions, such as human resource, production and finance?
3) How would you describe any marketing barriers related to the enterprise's product, pricing, and promotional activities?
4) How would you describe any environmental barriers related to the economic, political-legal, and sociocultural environment of the external environment?
5) How would you describe any procedural barriers relate to operating aspects of transactions?
6) How would you describe any task barriers related to enterprise's customers and competitors?
7) How would you describe any governmental barriers related to actions or inaction by the local government?

III. Relationships among barriers

1) What does the term "relationships among barriers" bring to your mind?
2) How would you describe the relationships among different barriers? For example, governmental barriers may cause functional and marketing barriers.

IV. Barrier mitigation strategies

1) How would you describe any strategies or measures have been adopted to mitigate informational barriers?
2) How would you describe any strategies or measures have been adopted to mitigate functional barriers?
3) How would you describe any strategies or measures have been adopted to mitigate marketing barriers?
4) Ho would you describe any strategies or measures have been adopted to mitigate environmental barriers?
5) How would you describe any strategies or measures have been adopted to mitigate procedural barriers?
6) How would you describe any strategies or measures have been adopted to mitigate task barriers?
7) How would you describe any strategies or measures have been adopted to mitigate governmental barriers?

Appendix 2 Initial reachability matrix

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16
E1	1	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0
E2	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0
E3	0	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0
E4	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
E5	0	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0
E6	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
E7	0	0	1	0	0	0	1	1	1	0	0	0	1	1	0	0
E8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
E9	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
E10	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
E11	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0
E12	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0
E13	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
E14	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0
E15	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0
E16	0	0	0	0	1	0	0	1	0	1	0	0	0	0	1	1

Appendix 3 Final reachability matrix

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	**Driving power**
E1	1	1	0	1*	1*	0	0	1	1*	0	0	1	1*	0	0	0	8
E2	0	1	0	1	1	0	0	1*	1	0	0	0	1*	0	0	0	6
E3	0	1	1	1*	1*	0	0	1	1*	1	0	0	1*	0	0	0	8
E4	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	2
E5	0	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0	4
E6	0	0	0	1*	1	1	0	1*	0	0	0	0	1*	0	0	0	5
E7	0	1*	1	1*	1*	0	1	1	1	1*	0	0	1	1	0	0	10
E8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
E9	0	0	0	1*	1	0	0	1*	1	0	0	0	1*	0	0	0	5
E10	0	0	0	0	0	0	0	1*	0	1	0	0	1	0	0	0	3
E11	0	0	0	1*	1	0	0	1*	0	0	1	0	1	0	0	0	5
E12	0	0	0	1	1	0	0	1	0	0	0	1	1*	0	0	0	5
E13	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	2
E14	0	0	0	1*	1*	0	0	1	1	0	0	0	1*	1	0	0	6
E15	0	0	0	1*	1*	0	0	1*	0	1	1	0	1*	0	1	0	7
E16	0	0	0	1*	1	0	0	1	0	1	1*	0	1*	0	1	1	8
Dependence power	1	4	2	13	12	1	1	16	6	5	3	2	14	2	2	1	

Note: * represents transability

Appendix 4 Partitioning the reachability matrix into different levels

Variable	**Reachability Set (RS)**	**Antecedent set (AS)**	**RS ∩ AS**	**Level**
Iteration 1				
E1	1,2,4,5,8,9,12,13	1	1	
E2	2,4,5,8,9,13	1,2,3,7	2	
E3	2,3,4,5,8,9,10,13	3,7	3	
E4	4,8	1,2,3,4,5,6,7,9,11,12,14,15,16	4	
E5	4,5,8,13	1,2,3,5,6,7,9,11,12,14,15,16	5	
E6	4,5,6,8,13	6	6	
E7	2,3,4,5,7,8,9,10,13,14	7	7	
E8	8	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	8	**Level I**
E9	4,5,8,9,13	1,2,3,7,9,14	9	
E10	8,10,13	3,7,10,15,16	10	
E11	4,5,8,11,13	11,15,16	11	
E12	4,5,8,12,13	1,12	12	
E13	8,13	1,2,3,5,6,7,9,10,11,12,13,14,15,16	13	
E14	4,5,8,9,13,14	7,14	14	
E15	4,5,8,10,11,13,15	15,16	15	

E16	4,5,8,10,11,13,15,16	16	16	
Iteration 2				
E1	1,2,4,5,9,12,13	1	1	
E2	2,4,5,9,13	1,2,3,7	2	
E3	2,3,4,5,9,10,13	3,7	3	
E4	4	1,2,3,4,5,6,7,9,11,12,14,15,16	4	**Level II**
E5	4,5,13	1,2,3,5,6,7,9,11,12,14,15,16	5	
E6	4,5,6,13	6	6	
E7	2,3,4,5,7,9,10,13,14	7	7	
E9	4,5,9,13	1,2,3,7,9,14	9	
E10	10,13	3,7,10,15,16	10	
E11	4,5,11,13	11,15,16	11	
E12	4,5,12,13	1,12	12	
E13	13	1,2,3,5,6,7,9,10,11,12,13,14,15,16	13	**Level II**
E14	4,5,9,13,14	7,14	14	
E15	4,5,10,11,13,15	15,16	15	
E16	4,5,10,11,13,15,16	16	16	
Iteration 3				
E1	1,2,5,9,12	1	1	
E2	2,5,9	1,2,3,7	2	
E3	2,3,5,9,10	3,7	3	
E5	5	1,2,3,5,6,7,9,11,12,14,15,16	5	**Level III**
E6	5,6	6	6	
E7	2,3,5,7,9,10,14	7	7	
E9	5,9	1,2,3,7,9,14	9	
E10	10	3,7,10,15,16	10	**Level III**
E11	5,11	11,15,16	11	
E12	5,12	1,12	12	
E14	5,9,14	7,14	14	
E15	5,10,11,15	15,16	15	
E16	5,10,11,15,16	16	16	
Iteration 4				
E1	1,2,9,12	1	1	
E2	2,9	1,2,3,7	2	
E3	2,3,9	3,7	3	
E6	6	6	6	**Level IV**
E7	2,3,7,9,14	7	7	
E9	9	1,2,3,7,9,14	9	**Level IV**
E11	11	11,15,16	11	**Level IV**
E12	12	1,12	12	**Level IV**
E14	9,14	7,14	14	
E15	11,15	15,16	15	
E16	11,15,16	16	16	
Iteration 5				
E1	1,2	1	1	
E2	2	1,2,3,7	2	**Level V**
E3	2,3	3,7	3	
E7	2,3,7,14	7	7	
E14	14	7,14	14	**Level V**
E15	15	15,16	15	**Level V**
E16	15,16	16	16	
Iteration 6				
E1	1	1	1	**Level VI**
E3	3	3,7	3	**Level VI**
E7	3,7	7	7	
E16	16	16	16	**Level VI**
Iteration 7				
E7	7	7	7	**Level VII**

Appendix 5 Digraph with significant transitive links