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Perceived critical success factors of electronic health record system implementation in a dental clinic context: An organisational management perspective

Yusof Haji Sidek[a], Jorge Tiago Martins[b],*

[a] The University of Sheffield, Information School, United Kingdom
[b] The University of Sheffield, Information School Regent Court, 211 Portobello Street, S1 4DP Sheffield, United Kingdom

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ABSTRACT

Background: Electronic health records (EHR) make health care more efficient. They improve the quality of care by making patients' medical history more accessible. However, little is known about the factors contributing to the successful EHR implementation in dental clinics.
Objectives: This article aims to identify the perceived critical success factors of EHR system implementation in a dental clinic context.
Methods: We used Grounded Theory to analyse data collected in the context of Brunei's national EHR – the Healthcare Information and Management System (Bru-HIMS). Data analysis followed the stages of open, axial and selective coding.
Results: Six perceived critical success factors emerged: usability of the system, emergent behaviours, requirements analysis, training, change management, and project organisation. The study identified a mismatch between end-users and product owner/vendor perspectives.
Discussion: Workflow changes were significant challenges to clinicians' confident use, particularly as the system offered limited modularity and configurability. Recommendations are made for all the parties involved in healthcare information systems implementation to manage the change process by agreeing system goals and functionalities through wider consensual debate, and participated supporting strategies realised through common commitment.

1. Introduction

Healthcare organisations are information-intensive professional settings, where clinical decisions and the provision of patient-centred care rely on the timely accessibility of accurate information. The use of electronic health records (EHR) facilitates healthcare professionals' access to electronically-stored health information in a digital format [1–4], but its successful implementation depends on a combination of both technical and socio-organisational factors [5]. In particular, the confident adoption and use of EHR systems by clinicians is crucial for the overall success of EHR systems implementation, whereas a hasty deployment combined with lack of support and user resistance may result in implementation failure [6].

The implementation of EHR in various contexts has consistently attracted the attention of medical informatics research [7–11], but less so in a dental context or, more specifically, focusing on the nation-wide implementation of EHRs with integrated dental components. Studies addressing the use of EHR within a dental context have mostly focused on the benefits of integrating medical and dental EHR [12]. There is limited consideration of the challenges related to harmonising the dental care clinical workflow with the collection, review and representation of clinical data in EHR [13]. Similarly, and despite the acknowledgement that dentists' transition to EHR has been slowed by limited incentives and technical assistance [14], studies focusing on EHR in a dental clinic context are scarce.

In addressing these gaps, this study seeks to identify the perceived critical success factors of an EHR system implementation in a dental clinic context, as recognised by clinicians (general dental practitioners and specialists), IT officers and the system's operational manager. The focus of the article is on a nation-wide, recently implemented EHR – the Bru-HIMS system in Brunei Darussalam.

In what follows we present the theoretical context of the study. We then proceed to introduce the Grounded Theory methodology followed in the empirical part of the study. The research findings are presented

* Corresponding author.
E-mail address: jorge.martins@sheffield.ac.uk (J.T. Martins).

subsequently in the form of major themes, after which they are discussed and integrated with the literature. The article closes with a summary of the study's contributions and research implications.

2. Theoretical context

The International Organization for Standardization defines the main purpose of an EHR system as the provision of a patient-centred record of health information that supports care within a medical environment [15]. The implementation of EHR systems and other health information technology initiatives in support of health care delivery has become common in countries' national healthcare systems (e.g. [16–22]. An important stream of research that analyses EHR systems has focused on patient concerns about the dimensions of patient-oriented usability [23,24], privacy [25,26] and security [27,28], but the focus of this article is on clinicians as end-users of Bru-HIMS, and on the organisational management challenges associated with the implementation of health information technologies [29].

The wide adoption of EHR systems is supported by reports of their positive impact on the quality and cost of healthcare delivery. More specifically, EHR systems are reported to contribute to reducing the incidence of problems such as lost records, duplication of effort, mistaken identity, drug administration errors, idiosyncratic clinical decisions and inefficient billing [30–34,5].

In an attempt to understand what determines EHR systems failure and success, [35] developed a framework that could illuminate the process of implementation. The proposed "design-reality" gap framework illustrates the differences in expectations and requirements from the two key stakeholders in the system: end-users and system designers. The framework evaluates these differences using a set of dimensions that operate as intervening factors: information; technology; processes; objectives; staffing; management systems; and other resources (IT-POSMO). An example of how disparities in access to resources and technology operate as an intervening factor lies in the public-private sector gap at the level of technology use in public and private hospitals [36].

In terms of implementation, the dental context may experience similar challenges to those of general EHR systems, such as technical glitches, consistency in data records and episodes of data loss [37–40]. In the dental context, problems have been reported at the levels of partial information coverage by computer-based patient record formats in comparison with paper-based records [41], negative impact on communication with patients due to use of the EHR system [42], and persistence of usability problems (e.g., unexpected ways of displaying diagnoses; presence of superfluous functions and absence of important functions; insufficient visibility; missing and mis-categorised terms) that impede clinicians from completing routine tasks, thus reducing efficiency, increasing frustration and potentially compromising patient safety [43].

Accordingly, in order to prevent and mitigate such challenges, it becomes essential to investigate the critical factors determining the implementation and adoption of health information systems (HIS), most notably the factors "related to the characteristics of users, tasks, systems, environment, and the impact of technology" [7].

3. Methods

Focusing on a deep exploration of the complex nature of HIS and how it is influenced by the particularities of context [44–46], we employed an interpretive Grounded Theory approach. In Grounded Theory, concepts are inductively generated from empirical qualitative data and the emerging result is presented as a theory built up around a core category and related categories [47]. For this study, data was collected in a single case-study research design. The implementation of Bru-HIMS in a dental clinic context was selected as the case-study context.

3.1. Setting

Bru-HIMS is Brunei Darussalam's nation-wide EHR system. It was promoted by the Ministry of Health, in partnership with a local IT company (Ministry of Health, 2014). Its development was part of a wider e-government initiative aimed at improving managerial effectiveness in public services, and represented an overall investment of B \$1 billion in information systems infrastructure [48] Brunei Darussalam Public Sector Journey towards e-government, 2003). The Bru-HIMS system provides access to patients' health records to all clinics and hospitals in Brunei Darussalam Ministry of Health, 2014. It was developed taking into account all the different departments, workflows, and scope of the Brunei Healthcare System. This allows medical professionals and hospital administrators to access patients' health records at the point of care, regardless of their location. The dental clinic component under analysis in this article was part of Bru-HIMS's initial design. Most regions in Brunei have dedicated dental clinics (a total of 15 clinics throughout the country), and dental clinics represent one of Bru-HIMS's major components. Dental clinics are separate from the 4 main hospitals in the country. In the dental clinic context, the system is used daily by the totality of dental care providers: 34 general dental practitioners, 28 specialists, and 40 nurses and therapists. Fig. 1 offers an overview of the current dental information contained in Bru-HIMS.

3.2. Participants and interviews

In line with the University of Sheffield's ethics procedure, an ethics review form was submitted and approval granted on 3rd June 2014. The study did not involve any participant below the age of 18 and all interviewees were given the opportunity to read and sign a consent form. Participation in the study was voluntary and no financial reward or incentive were offered.

Participant selection operated through the combination of purposive and theoretical sampling techniques [49,50]. At a first stage, purposive sampling (i.e. the identification of major stakeholders as advised in [51] ensured that initial participants were knowledgeable of Bru-HIMS, and able to provide relevant information. Subsequently, a theoretical sampling strategy (i.e. sampling on the basis of the emerging analytical concepts as proposed by [47] was employed to select further participants.

Data collection developed through in-depth semi-structured interviews. Appendix A illustrates how the literature review informed the design of the interview guide. The literature review contextualised the study [52] and helped to develop theoretical sensitivity [47], i.e. the researchers' capacity to think about the data in theoretical terms. For example, a review of the Technology Acceptance Model's construct of perceived ease of use [53] informed the design of a qualitative interview question focusing on which features of the Bru-HIMS could be changed, with a view to improving ease of use. Similarly, a review of Heek's (2006) ITPOSMO dimensions (information, technology, objectives and values, skills and knowledge, management systems and structures, technology, and other resources) informed the design of qualitative interview questions addressing the match or mismatch between the system design *vis-a-vis* the local user reality. Appendix B contains the interview guides used in the study. In keeping with the process of semi-structured interviewing, the interview guide was used flexibly [54], allowing opportunities for free flowing, yet focused conversation. This was to ensure that the questions brought out the most in terms of experiences from the participants [55]. Notes and probe questions in every interview were recorded and used appropriately in the subsequent interviews.

Participants were interviewed in Brunei Darussalam, at their preferred time and location. After each interview, the notes and tapes were reviewed to ensure that no relevant information was missed. The average duration of the interviews was approximately 1 h. Each interview was recorded with an audio recorder and then transcribed
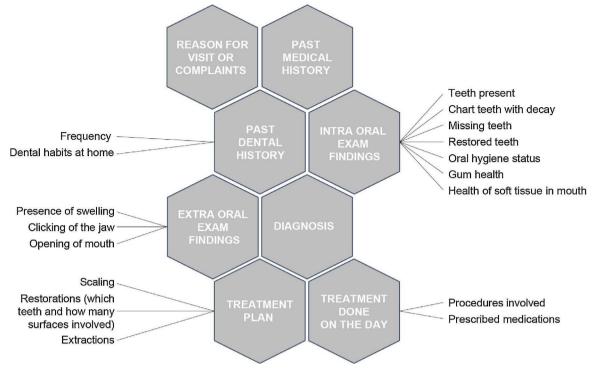
Fig. 1. Current dental information in Bru-HIMS.

verbatim. The interviews were randomly numbered with no names attached to the interviewees. The transcription was then printed to ease the analysis process. When the number of interviewees reached 9 no new themes were discovered. To validate the point of theoretical saturation [56], two further interviews were conducted yet no new codes were generated. In total, 11 in-depth interviews were conducted.

3.3. Analysis

The coding of all interview transcripts developed collaboratively between the two authors, who jointly analysed all transcripts. The comparison and discussion of emergent codes and their evolution to dominant categories [56,57] was also developed jointly, following the principle of consensus, to ensure interpretive agreement and best fit of coding to data. Concept maps were used to facilitate the process of identifying a unifying core category [58] consistent with the data, and integrated with the major categories that emerged from the analysis [54,59,60].

4. Findings: mismatch of perceived success factors

The interviews with 11 participants were analysed using the

constant comparative method proposed by [47]. Table 1 below provides a complete overview of participants and how the two-staged sampling strategy developed.

From the process of incident identification, comparison and extraction of themes, six main categories were identified, each representing a perceived critical success factor (CSF): 'Usability of system', 'Emergent behaviours', 'Change management', 'Project organisation', 'Training' and 'Requirements analysis'. The subsequent sections present the dimensions within each category, accompanied by illustrative citations extracted from the interviews. participants' roles are introduced by prefixes − D for dental clinic staff, M for IT officers at the Ministry of Health, and OP for the operational manager at the system's vendor

4.1. Usability of system

The usability of information systems from the perspective of end-users is a common proxy used to determine implementation success. From the analysis of the interviews conducted, there was an abundance of negative feedback from the end-users of the Bru-HIMS system in what concerns usability. The areas of concern around which participants expressed convergent perceptions included: lack of system

Table 1
Participants profile.

Interviewee Number	Gender	Age	Job Role	Experience	Sampling strategy
Interviewee 1	Female	< 25	Dentist	< 5 years	Purposive sampling
Interviewee 2	Female	25–30	Dentist	< 5 years	
Interviewee 3	Male	25–30	IT officer, Ministry of Health	5 years	Theoretical sampling
Interviewee 4	Male	25–30	Dentist	< 5 years	
Interviewee 5	Female	25–30	IT officer, Ministry of Health	5 years	
Interviewee 6	Male	35–40	Operational Manager (Vendor)	15 years	
Interviewee 7	Male	25–30	Dentist	10 years	
Interviewee 8	Male	25–30	Dentist	10 years	
Interviewee 9	Female	25–30	Dentist	10 years	
Interviewee 10	Female	25–30	Dentist	10 years	
Interviewee 11	Female	25–30	Dentist	10 years	

Table 2
Subcategories and illustrative quotations of the category 'Usability of system'.

Sub-categories	Illustrative quotations
Time consuming processes	"Sometimes it takes ages to do just one note with Bru-HIMS. Sometimes with writing it takes 30 min…" [D8].
The new process(es) imposed by Bru-HIMS is/are deemed as time consuming by end-users	
Excessive clicking	"…too many clicking. I hate that part. It takes 2 min and you go through that with every patient. Similar to the pharmacy as well. If I prescribe more than one drug, I do not know if there is a shortcut, but I have to click 'confirm', 'release', then you order, 'confirm', 'release'…." [D7].
Agreement amongst end-users that there was excessive clicking needed to navigate the Bru-HIMS interface and perform functions.	
Extra burden to clinicians	"If the dentist for example forgets to discharge the patient, then we cannot register him/her again. We then have to find someone who really understands the programme – there's this nurse – he is specifically trained for Bru-HIMS. We would have to text him and find him……it's not convenient!" [D4]
Additional processes/activities that clinicians have to perform – that are outside their job scope – due to the implementation of Bru-HIMS	
User unfriendliness	"Yes, there are codes available, but they are just for simple diagnoses that are not really, specific. With Bru-HIMS, everything is written in words so it is difficult" [D10].
Agreement amongst end-users in the dental clinics that Bru-HIMS is not user-friendly	
User adaptability period	"For example clinicians, they have to see patients and they also have to learn new things and also adapt to a new environment as they have never been used to" [D2].
The essential period of time end-users are given to adjust and adapt to using Bru-HIMS. This also applies to the ability to execute tasks with the new processes and activities brought about by the implementation of Bru-HIMS	
User resistance	"During implementation, some users were reluctant to use this. They didn't want to use it as they preferred the manual system" [D1].
The reluctance or disapproval coming from end-users in regards to adopting and using Bru-HIMS	
Lack of trust in system	"We still have to write the written records with Bru-HIMS, because people don't really trust Bru-HIMS in case it breaks down. If it breaks down, we would not have anything to look back on (no backup or file recovery)" [D4].
End-users show a lack of trust in the system by running a separate manual system to Bru-HIMS as well as performing activities that are not prescribed in the system use. These are all done in case of a system failure or error.	
Data accessibility	"Before Bru-HIMS, we basically just write things down in the patient's record file. (…) In the Bru-HIMS system we would already be able to see the patient's medical history automatically. But in the old system we would have to ask them if they have certain medical history or any new illnesses that have been diagnosed. In regards to this, Bru-HIMS does present a huge advantage" [D7].
Data is now accessible by clinicians regardless of their location (provided they are logged-in a clinic). Retrieval of data is also much faster with the new information system.	

customisation to dental department needs; time consuming processes; excessive clicking; extra burden to clinicians; user unfriendliness; user adaptability period; user resistance; lack of trust in the system; and data accessibility issues (*vide* Table 2).

4.2. Emergent behaviours

The implementation of Bru-HIMS gave way to a variety of end-user emergent behaviours, which are a response to the system's impact on workplace processes. These emergent behaviours ranged from resorting to a manual system running in parallel to BruHIMS, to the multiplication of unstandardized procedures, through to resisting using the system altogether (*vide* Table 3).

4.3. Requirements analysis

From the perspective of the product owner and the vendor, system requirements analysis was identified as being both a perceived critical success factor and a challenge, with difficulties being reported at the levels of pre-implementation goal-setting, neglect of end-user needs, and mismatch in requirements (*vide* Table 4).

4.4. Training

Training plays a fundamental role in delivering IS implementation, as the ways in which individuals first come into contact with any new

system and learn to use it affects engagement, motivation and willingness to change. Computer-based training was provided by the contractor with assistance from the MoH IT department, and participants identified a number of issues that emerged as obstacles to a fuller realisation of benefits (*vide* Table 5), including uncertainty about the frequency, methods and number of trainees within the dental department. In practical terms, some clinicians obtained computer-based training, whilst others did not. Some reported observing their supervisors for two days prior to using the system for the first time, whilst others did not benefit from any kind of induction and had to learn as they went along.

4.5. Change management

Change management refers to the activities, tools and techniques that are implemented to ensure that Bru-HIMS achieves the required project outcomes. Several factors were identified by participants as being particularly influential in designing a change management intervention that could successfully tackle the human and organisational aspects of the system's implementation. These include continuous enhancements to the system, an awareness of the perils posed by technophobia, the role played by training support in minimising the effects of technophobia, and a customised implementation strategy (*vide* Table 6).

Table 3
Subcategories and illustrative quotations of the category 'Emergent behaviours'.

Sub-categories	Illustrative quotations
Dual system	"If the server is down and lagging, say that the whole day we are not able to log in…the next day, they (the data) are not there. So the data is just gone….so we do it (write manual copies down) as a backup [sic]. We have a file as well so we need to write it in the file" [D9].
End-users are still running a manual system in parallel with Bru-HIMS Unstandardized procedures	"…if you want it (notes) to be neat, then you can draw a box. For example, different quadrants for the teeth. But personally for myself, I don't." "So different people have different methods?, Yes" [D7].
Unprescribed steps taken to use the system that differ according to end-users due to several reasons such as lack of training, information, support and necessity User resistance	"During implementation, some users were reluctant to use this. They didn't want to use it as they preferred the manual system" [D1].
The reluctance or disapproval coming from end-users in regards to adopting and using the new information system (Bru-HIMS).	

4.6. Project organisation

Project organisation refers to the planning, processes and activities that are conducted by the product owner/vendor. All these activities were carried out with both the product owner (Ministry of Health) and the vendor involved to a certain extent. Across interviews several recurrent themes emerged as problematic areas of project organisation, thus requiring revision (*vide* Table 7). Amongst these was the perception that implementation was rushed, and not particularly helped by site visits that were described as ineffective. A lack of effective burden sharing among stakeholders during the implementation was also considered critical by the Ministry of Health's IT department, who admitted to feeling overwhelmed with excessive responsibility, unable to manage the project from a public relations perspective, and frequently challenged by unclear lines of accountability and responsibility. A lack of effective communication further contributed to increased difficulties in achieving mutual understanding, which was aggravated by key decisions being made by a very narrow group of people, and the pressures of a bureaucratic setting, where hierarchical, centralised, and formalistic practices prevailed.

4.7. Mismatch of perceived success factors

At the selective coding stage of data analysis, the categories presented in the subsections 4.1–4.6 were interconnected. As a result of this stage in the analysis, the perceived critical success factors were arranged into two major spheres, representing respectively the dominant perspective of users, and the dominant perspective of the product owner and vendor. The two parties are captured in the diagram

depicted in Fig. 2, as they represent mutual interests in this project and have undertaken combined efforts in the implementation initiatives and related factors.

The combination of factors from both 'user-side' categories and 'product owner/vendor side' categories converge into an 'area of conflict' whereby a 'mismatch of perceived success factors' occurs. Both end-users and product owners/vendors have a mutual interest in implementing a successful project, however, both parties have seemingly different views and perceptions of the critical success factors. Furthermore, factors in each side of the diagram are interrelated. For example, a change in training methods will provoke a change in change management initiatives. Conversely, a change in the usability of the system will also influence the outcome of emergent behaviours.

5. Discussion

Within the Bru-HIMS project a gap has been found between what the end-users wanted and what the product owner/vendor developed. These findings resonate with the analysis of similar studies of healthcare professionals' (physicians and nurses) perceived facilitators and barriers to the use of EHR, where the incongruence between expectations, functional attributes and organisational support produce an environment that is not supportive of effective health information technology (e.g. [61,62].

5.1. End user issues

Bru-HIMS was introduced as an electronic integrated solution that combined the medical departments and modules in Brunei

Table 4
Subcategories and illustrative quotations of the category 'Requirements analysis'.

Sub-categories	Illustrative quotations
Poor goal setting pre-implementation	"First, during the tender requirement, the functional leads were there. But there were certain departments that were not called. In a way, they [dental clinical functional leads] were omitted. So when we went live, they were surprised at how small their part of the system was, very basic. So, they were neglected and they were not the main focus of the system" [M1].
The goals that were agreed by the stakeholders before the project were not properly investigated and examined User needs neglected	" We did meet the developers for the current module but they have never done a current module in any of the countries that they have worked at. So they were not able to help us. That is why we are on a free text module now" [D4]
The feedback, participation and suggested changes from end-users in the dental department are neglected by the developers Mismatch in requirements	"The dental system in Bru-HIMS does not really meet the requirements. So now we are trying to get requirements of what the dental department needs" [D1].
The functions given in the system do not match the requirements of the dental department, as articulated by the functional leads of the dental department stakeholders	

Table 5
Subcategories and illustrative quotations of the category 'Training'.

Sub-categories	Illustrative quotations
Insufficient training	"I was only given 3–4 h of training, or it was 2 sessions, 2 sessions of 3 h of training… but I think they are rushing through the training" [D5].
The lack of training for Bru-HIMS end-users whether it is in terms of content or duration	
Irrelevant and poor training materials	"I got trained on stock inventory! I don't even do it! This was not tailored for us" [D2].
The material given in training sessions to Bru-HIMS dental end-users is not tailored to their needs. The training covers aspects of the system that are not essential to the dental department	
Poor training schedule	"We had training?" [D7].
The training sessions are poorly scheduled. Some are scheduled years before the actual system implementation and the session durations are not consistent, even amongst clinicians in the same clinic	"A day (I think)…no, 3 afternoons!" [D10].
	"I did not receive any training at all" [D11].

Darussalam's public healthcare. Subjects in this study found that the system lacked customisation to their needs, in particular the absence of illustrated teeth charts and the inability to visually represent problems in patients' teeth [e.g. D1]. Insufficient customisation is also reported as a barrier to the successful implementation of EHR in previous studies conducted by [63] and [64]. Additionally, in the case of Bru-HIMS, it has also led to end-users taking more time to execute tasks, such as recording their diagnoses. This was a common trend detected in the interviews with end-users, with many of them agreeing that several of the system's functions – in particular the descriptive note taking – were excessively time consuming [e.g. D8] and often led to the addition of inefficient workarounds, as also identified in [65].

A perceived excessive clicking required to operate the system and the apparent absence of shortcuts that could generate time efficiencies [e.g. D7] were also identified by end-users. Fig. 3 illustrates the amount of clicking required to perform tasks such as assigning patients to a clinician, uploading digital X-ray images, or discharging patients, and Fig. 4 provides an overview of the system's interface for uploading digital X-ray images.

End-users' complaints about the time consuming nature of data entry in EHR are also found in the extant literature (e.g. [66,63]. Beyond excessive clicking, Bru-HIMS also raised the need for end-users to take certain additional steps, beyond their job scope, to overcome specific technical difficulties. This presents itself as an extra burden to the clinicians, particularly when performing the entry of patients' notes, and when registering and re-registering patients into the system [e.g. D4]. The perception that using the system entails additional effort can also be related to the consensual view that Bru-HIMS lacked customisation to the dental department's needs, consequently burdening end-users to develop creative ways in which to write detailed reports of their diagnoses without creating a substantial patient backlog.

End-users collectively found that the system was not user friendly. This is related to the difficulties faced when using the system. Alongside problems already identified related to data entry, excessive clicking and time required to navigate the system, a common concern expressed by clinicians was the fact the system relied excessively on text-based input. Even when coded information concerning diagnoses was preloaded into the system, it was often perceived to be of a very general nature [e.g. D10]. Furthermore, concerns expressed by the Ministry of Health that these problems would shift clinicians' attention from patients into learning how to use a new system built up the perception of Bru-HIMS being user unfriendly [e.g M1].

The cumulative effect of the difficulties experienced by end-users – and acknowledged by decision makers – resulted in a dilated end-user adaptability period, which was required in order to execute tasks with the system [e.g. D2]. Several authors have concluded that users and

Table 6
Subcategories and illustrative quotations of the category 'Change management'.

Sub-categories	Illustrative quotations
Continuous enhancements	"Right from day 1, every 4 months, we get a release [sic]. It is a version release, a major release, and within those releases we always include those major enhancements that have been sort of…already been identified, or we identify while we run the system. So those are the enhancements that we think that will help improve the user experience. This release is every 4 months, and so those upgrades/ updates are going on pretty regularly" [OP].
This involves the continuous gathering of end-user feedback pre-implementation. Patches/updates are released regularly to the system based on the developer's perceived requirements for the end-user	
Technophobia	"Our assistants, who tend to be 'veterans', they usually don't use computers. When they were told to learn how to use Bru-HIMS, some of them panicked. They were quite scared because they don't know how to use computers at all" [M1].
The reluctance of the senior staff to adopt and learn the new implemented system	
Training support	"When we go live, because we go live in phases, we provide on-location training and support. So, people will be sitting next to you or standing next to you. This support thing actually helped them to familiarise with it" [OP].
The technical and user support the contractor provides, especially prior to a recent implementation and/or a newly released system patch/update	
Customised implementation strategy	"All of our executive members suggested to us that before we roll out to KB [hospital], we needed to learn from Tutong [hospital]. They told us to see what the difficulties and challenges were. Then we were told to improve and implement the lesson learned in KB. So, when we implemented in KB the same thing (mistakes) happened!" [M2].
There is no standard implementation strategy for the system. The implementation method and strategy differs from amongst different clinics, hospitals and departments based on the circumstances and requirements	

Table 7
Subcategories and illustrative quotations of the category 'Project organisation'.

Sub-categories	Illustrative quotations
Rushed implementation	"A big system takes 2–5 years to develop. This one took several months. It should have taken at least another year to develop" [e.g. M1].
The implementation phase of Bru-HIMS was done too quickly in comparison with other similar projects overseas	
Ineffective site visits	"Yes, they have made site visits, I think to I Malaysia to see their health information system and how they do it. My boss, he went to Singapore. They were told that in terms of adaptability of the users, even for one hospital, a silo system, even that hospital that does not have a comprehensive system, it would take them 3–4 years to stabilise [sic]. Just one (system). My boss was shocked because in Brunei we expected everything to be ready in a few months" [M2].
Although overseas site visits were conducted to examine similar projects, the advice and lessons were not implemented into the Bru-HIMS project	
Overload of responsibilities under IT department	"Beyond IT duties we now do the promotion and publicity of Bru-HIMS" [M1].
The responsibilities of the in-house MoH IT department were overbearing, especially considering the number of staff employed	
Poor PR management	"It took a lot of time for the Ministry, we have done so many announcements because they [users] have to be patient. Now, patient is a patient, they never learn to be 'patient'. So, when they come in to the hospital they want this to be fast. But also they have to understand that some people are using this system for the first time and they are sort of getting used to it" [M2].
Public relations initiatives taken by the product owner/vendor are not sufficient to address public complaints and confusion	
Undefined responsibilities	"Back then, training was easily done but right now there is no responsibility being taken by anyone" [M1].
The lack of direction and planning in assigning responsibilities to the different teams in the project	
Poor communication	"OK, I'm not sure about what kind of preparation was done about increases in waiting time" [OP].
Poor information dissemination to Bru-HIMS that relates to the system functions. This has led to end-users taking different steps in order to complete a function or activity	
Restricted managerial circles of decision	"We don't have a choice and were not involved in the planning" [D7].
Decisions such as functions, additions, releases and other operational aspects of the Bru-HIMS project were determined by a restricted circle of people, therefore excluding end-users, support staff and other stakeholders	"Technically we are just involved, but not doing the system. We are just the IT support" [M2].
Red tape	"Sometimes, there is a difficulty in getting the third party…sometimes, from different ministries approval, to get clearance to get to their facilities…" [M1].
The bureaucratic processes that are prevalent in obtaining approvals and/or clearances in the government sector	

Fig. 2. Concept map illustrating the mismatch of perceived success factors.

workflow need a lot of time to adapt to the implementation of new information systems [67–69]. This view is supported by studies where clinicians believe work processes would take more time immediately post-implementation, although there would be a slight decrease in time taken once proficiency with the system is achieved [70,71,9,72]. However, the findings reported in this paper suggest that end-users were not given sufficient time to adapt to the changes. This was not without frustration, disappointment and entrenched end-user resistance among some of the clinical staff [e.g. D1].

Earlier studies have highlighted the importance of the nexus between technical expertise and end-user acceptance, as resistance from users may lead to system failure [73,7,74–78]. Although low levels of

expertise are not representative of every Bru-HIMS dental end-user, a significant number of end-users lacked sufficient technical knowledge. Furthermore, end-user resistance was exacerbated by 'technophobia' being prevalent amongst the 'veteran' Bru-HIMS end-users. In addition, the alteration of the traditional workflow has been found by participants as a creator of user resistance against Bru-HIMS.

An impact associated to end-user resistance was the expression of distrust in the system, which has led clinicians to running a separate manual system to Bru-HIMS and performing activities that were not prescribed in the system usage. The underlying reason for this was fear of system failure or error, as no file recovery is guaranteed [e.g. D4]. The emergence of a dual system where end-users recorded information
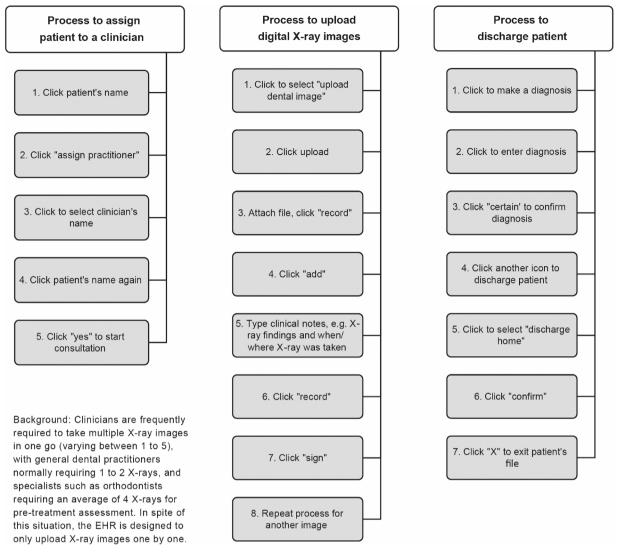
Process to assign patient to a clinician	Process to upload digital X-ray images	Process to discharge patient
1. Click patient's name	1. Click to select "upload dental image"	1. Click to make a diagnosis
2. Click "assign practitioner"	2. Click upload	2. Click to enter diagnosis
3. Click to select clinician's name	3. Attach file, click "record"	3. Click "certain' to confirm diagnosis
4. Click patient's name again	4. Click "add"	4. Click another icon to discharge patient
5. Click "yes" to start consultation	5. Type clinical notes, e.g. X-ray findings and when/where X-ray was taken	5. Click to select "discharge home"
	6. Click "record"	6. Click "confirm"
	7. Click "sign"	7. Click "X" to exit patient's file
	8. Repeat process for another image	

Background: Clinicians are frequently required to take multiple X-ray images in one go (varying between 1 to 5), with general dental practitioners normally requiring 1 to 2 X-rays, and specialists such as orthodontists requiring an average of 4 X-rays for pre-treatment assessment. In spite of this situation, the EHR is designed to only upload X-ray images one by one.

Fig. 3. Examples of excessive clicking.

manually in parallel with Bru-HIMS occurred due to a reported lack of trust in the system, which was not perceived to be convenient nor reliable due to the multiplication of failure episodes [e.g. D9] and the absence of a file recovery functionality. End-users concerns with failure episodes and the risks of inconsistent records is also reported in [76,64,63,79], who identify a lack of system reliability as a critical barrier to successful HIS implementation.

On the other hand, the overall goal of standardising workplace processes was also generally perceived to be unattained by Bru-HIMS in the specific dental clinic context, particularly as there is no standardised template or dental charting available through Bru-HIMS that allows diagnoses to be recorded in a single unified format. This was perceived to pose potential challenges to clinicians as they had to view and analyse medical records written in different formats by their peers [e.g. D7]. Similarly to what has been found in [46], Bru-HIMS end-users feared the potential for novel failure modes to occur due to changing working practices.

5.2. Product owner/vendor issues

Whilst the IT officers at the Ministry of Health agree on the vision for Bru-HIMS as a comprehensive system that would connect all hospitals and services in the country, the system operational manager admits failures at the level of system goal setting, since the pursuit of a

comprehensive system that aimed to integrate all the different health services and departments has at the end of the day led to a disparity between different departments with regards to their functions and usability. It is apparent that the complexity of the project was underestimated, which has also occurred in the implementation of EHR in other settings [80]. However, complexity is expected, given that design of an integrated system that meets the universal needs of the healthcare industry, with hospitals' and clinics' varying sizes and business needs, is nearly impossible [81].

In Bru-HIMS, the difficulty in harmonising procedures across departments with seemingly different needs and requirements was intensified by the reported lack of representativeness of the dental clinic department in requirement elicitation activities [M1]. This contrasts with the calls contained in the literature for end-user engagement in requirements' elicitation and system design [82–86], combined with the acquisition of detailed insight of everyday socio-cultural processes in the workplace [87,88]. In Bru-HIMS even when, at later stages, functional leads were appointed as focal points to gather requirements and present them to the product owner and to the vendor, no further changes or improvements were made in response to the needs identified [D4]. Despite the poor goal setting performed during planning and the reported neglect of end-user concerns, the development of the dental department module in Bru-HIMS proceeded. However, with the end-users' specific needs and concerns being largely neglected during the
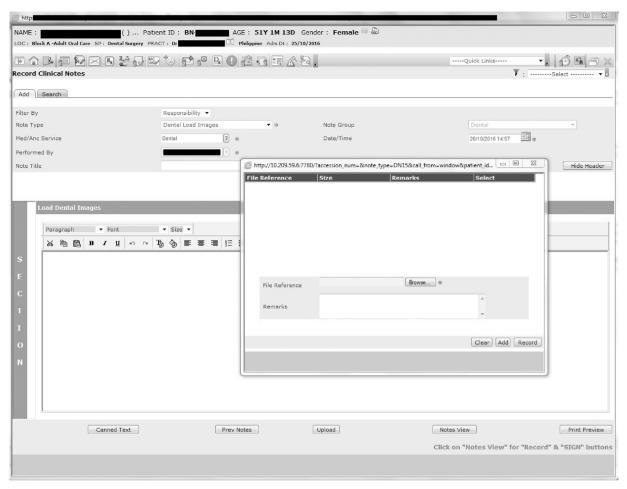
Fig. 4. Uploading digital X-rays to Bru-HIMS.

gathering of requirements, there was a mismatch in requirements [e.g. D1]. The features available in the dental module of Bru-HIMS were not configured to the specific needs of the end-users which negatively affected the usability of the system.

A major goal of Bru-HIMS was to provide a comprehensive and integrated system for all the public medical services and departments in Brunei. However, the shortcomings in gathering requirements and responding to end-user feedback, acted as one of the main contributors to the mismatch in perceived success factors between end-user and product owner/vendor.

Concerning end-user training, official numbers report that at national level 4800 professionals – clinicians and non-clinicians − were covered by training initiatives. Nevertheless, participants in the study report a different experience, describing training it as insufficient, marginally relevant, and poorly scheduled, although initial support was in place when the system went live [OP]. The standard training sessions that were developed after the initial support session concentrated most of the participants' criticisms: for not being comprehensive, for facilitators not going deep enough into the content, and for the erroneous assumption that end-users only needed to learn about certain features of the system, whereas other features were neglected [e.g. D5]. Moreover, end-users observed that the training materials covered only the general features of the system, and that the content was generally irrelevant and untailored to the department's specific needs [e.g. D2]. This was aggravated by the fact that the training received by members of the dental department was inconsistent in terms of frequency, amount of training received, and schedule [e.g. D5, 7, 10, 11].

The intensity, timing, availability and quality of training has been found to reduce end-user resistance and improve end-users' outlook on

EHR systems, in several extant studies [89,64,90,91]. However, Bru-HIMS end-users were given training in functions that were not needed in the dental department, and they struggled to get appropriate technical training and support from the vendor – a problem that appears to be frequent with HIS implementation despite its impact in potentially improving the experience of clinicians [92,46,93].

Continuous enhancements performed by the vendor and product owner were identified as forming a large part of the change management initiative accompanying Bru-HIMS. A major part of this effort included the introduction of updates to the system, called patches, which were reportedly based on continuous end-user feedback [OP]. In addition to this, regular task force meetings were also held between functional lead end-users and the product owner to discuss any potential issues in regards to Bru-HIMS. Despite these initiatives, many of the patches were not noticed by end-users, as their impact was general and not focused on any specific module. This, again, could mean that the dental end-users' concerns were neglected and regular patches did not seek to address the dental module's shortcomings. It also seems to indicate, similarly to what has been found in Berg (2009), [94] and [95], that technology alone is insufficient for the successful implementation and use of EHR, which requires a holistic consideration of individual, psychological, behavioural and organisational factors.

Another challenge was posed by the late adoption of IT by some of the most senior staff. The diminished IT literacy of some staff was perceived to discourage engagement and adoption of the system [M1]. The initial training support that was provided by the vendor helped ease end-users in adapting to the system and they were guided through the operational tasks. This is especially important when it comes to minimising the effects of technophobia amongst the elder end-users. As

expressed earlier, the long adaptability period end-users undergo remained an issue. This was exacerbated by technophobia amongst the elder end-users.

Finally, the vendor implemented a phased customised implementation strategy that was not standardised and varied according to context. Bru-HIMS was implemented in stages by mainly dividing hospitals or clinics into groups based on their geographical location. A closer consideration of the IT infrastructure size, structure and capacity of a hospital or clinic affected the design of the implementation. However, there was limited evidence of organisational learning, as implementation failures were reported to surface recurrently [e.g. M2]. It is thus apparent that additional reviews and more stringent measures are required to ensure that mistakes from earlier implementations are not repeated.

Concerning project organisation, IT officers from the Ministry of Health admitted that the implementation stage of Bru-HIMS was undertaken at an excessively fast pace [e.g. M1]. They further elaborated that the rushed implementation and the tight deadlines had led to many of the problems faced by the project and end-users. This could be linked back to the poor goal setting occurring during the pre-implementation stages. The rushed implementation occurred despite several site visits made to investigate similar systems in the region. The site visits were ineffective as despite the advice and lessons learned from the visits, they were not implemented in the Bru-HIMS project [e.g. M2].

The consequences of a rushed implementation were intensified by the understaffed MoH IT department. The overload of responsibilities of the IT department was acknowledged during the interviews. The IT department was tasked with administrative jobs in assisting the vendor and public relations management work for the Bru-HIMS project [e.g. M1]. This was in addition to the IT-related tasks traditionally assigned to the department. Furthermore, there was only a total of 15 staff members in the department, tasked to undertake a concurrent, nationwide e-government project.

In regards to poor public relations (PR) management, there seemed to be a sense of confusion and poor public response towards the implementation of Bru-HIMS. The public showed a false sense of heightened expectation. Despite consulting with the PR department, the PR initiatives were still the responsibility of the MoH IT department [e.g. M2]. Undefined responsibilities were also prevalent in the project, in particular a lack of accountability and ownership for end-user training initiatives [e.g. M1]. The negative effects from this insufficient accountability and ownership, however, were exacerbated by the poor communication both on a horizontal and vertical level [e.g. OP].

In the Bru-HIMS project, decisions such as system functions, additions, releases and other operational aspects of the Bru-HIMS project were determined by a restricted circle of people, therefore excluding end-users [e.g. D7], and to a great extent even the Ministry of Health [e.g. M2]. Finally, red tape was also prevalent [e.g. M1]. This refers mostly to the bureaucratic processes in obtaining approvals and/or clearances within the government sector. Officers in the MoH IT department, which was already understaffed, dedicated a certain amount of time to expedite these approvals. Coupled with the tight deadlines and rushed implementation in place, this emerged as an additional barrier to the successful implementation of Bru-HIMS.

6. Conclusions

This paper explored the perceived critical success factors of the Brunei Healthcare Information and Management System (Bru-HIMS) implementation, within a dental clinic context. In particular, six perceived critical success factors have been identified: usability of the system, emergent behaviours, requirements analysis, training, change management, and project organisation.

Awareness of these perceived strategic critical success factors gives senior IT management, system integrators and political decision makers an evidence-based overview of the pitfalls, areas of tension and complexities that can throw a health information system's implementation off track in public services nation-wide roll-outs.

The areas of impact identified in this study also illuminate planning in terms of management practice to smooth implementation and achieve a greater degree of success in eventual end-user adoption and confident use of EHR. Based on these findings we propose a more reflexive approach to the implementation of health information systems, and a careful use of communication and change management procedures to handle their impact on professionals' work practices.

The implementation of EHR is typically a difficult process, and clinical staff are unhappy with what they perceive to be a time-consuming system, designed to respond more to bureaucratic demands than to the real needs of the clinical practice. This mismatch exposes major implementation difficulties and highlights the need to find ways to cope with the complexity of EHR delivery. Effective EHR delivery requires a transformation of managerial culture, an abandonment of hierarchical modes of implementation – through communication and horizontal collaboration – and a genuine concern with the generation of positive outcomes for the clinical staff who will use the system.

Conflict of interest

None.

Author contributions

- Conception and design of the study: Haji Sidek & Martins
- Acquisition analysis and interpretation of data: Haji Sidek & Martins
- Drafting/revising the article: Haji Sidek & Martins
- Final approval of the version to be submitted: Haji Sidek & Martins

Summary points

What was already known on the topic?

- EHR improve quality of care through reducing reliance on hand written records, enhanced documentation of patient interactions, and automation of communication;
- EHR improve organisational workflow efficiency and facilitate access to patient records at the point of care, when needed;
- The implementation of EHR is a complex, challenging process.

What has this study added to the body of knowledge?

- This study adds a dental aspect to EHR implementation challenges, with emphasis on the intersection of software practices and the overall management culture.
- Perceived EHR implementation success factors can be grouped under six main categories: usability of the system, emergent behaviours, requirements analysis, training, change management, and project organisation;
- Coping with the complexity of EHR implementation requires increased communication and horizontal collaboration amongst stakeholders;
- A fundamental shift is required from being focused on pushing healthcare technology to using EHR for improving the working practice of clinical staff.

Appendix A. How the literature review informed the design of the interview guide.

Themes/rationale	Literature	Question
Complexity Theory (Unpredictability)	Plsek and Greenhalgh (2001) [113]	What kind of improvements would you like to see in Bru-HIMS?
Interdependence between organisational culture, behaviour and technology	Avison and Myers (1995) [114]	Has there been a change in culture/behaviour/routine since the introduction of Bru-HIMS? How was the planning carried out? Who was involved? Any collaboration with other stakeholders? What was your old routine like before Bru-HIMS?
Technology Acceptance Model/DeLone and Mclean IS success model	Davis (1989); DeLone and McLean (1992) [53,115]	What kind of improvements would you like to see in Bru-HIMS? What would your ideal model of Bru-HIMS be like? What are the system requirements?
E-government systems implementation in Brunei	Kifle and Cheng (2009) [116]	Would you explain a typical work day? Run-down of activities. What are the sorts of major problems/issues that are common with the system? What are they key challenges in developing/maintaining Bru-HIMS? How would you explain your role/contact with Bru-HIMS?
Theory of Reasoned Action	Fishbein and Ajzen (1975) [117]	What additional steps/initiatives would you think would allow better usage of the system? What would your ideal model of Bru-HIMS be like? What are the system requirements?
ITPOSMO Design-Reality Gaps	Heeks (2006) [35]	How was the planning carried out? Who was involved? Any collaboration with other stakeholders? Has there been any evaluation done post-implementation? What kind of maintenance/ongoing activities are being carried out? What are the sorts of major problems/issues that are common with the system? What would your ideal model of Bru-HIMS be like?
Comparison between pre-adoption and post-adoption beliefs	Karahanna et al. (1999) [118]	Has there been any evaluation done post-implementation? What kind of maintenance/ongoing activities are being carried out? What would your ideal model of Bru-HIMS be like? What policies or recommendations can be suggested based on the lessons gained from this project?

Appendix B. Interview Guides.

Interview Guide (General)

- Introduction – Ice breaking. Explain the purpose of the interview to the participant and how he/she was chosen.
- How would you explain your role/contact with Bru-HIMS?
  - ○ **Prompt:** FOR DENTISTS, so you were not involved in planning? Would it have made a big difference?
- Would you explain a typical work day? Run-down of activities.
- What additional steps/initiatives would you think would allow better usage of the system?

Additional Interview Guide (Dentists/IT officers, Ministry of Health)

- What was your old routine like before Bru-HIMS?
- What would your ideal model of Bru-HIMS be like?
- What kind of improvements would you like to see in Bru-HIMS?
- What kind of changes/improvements do you think Bru-HIMS have made within the dental clinic?
- Has there been a change in culture/behaviour/routine since the introduction of Bru-HIMS?
  - ○ **Prompt:** Can you/how do you evaluate the changes being made?

Additional Interview Guide (Operational Manager − Vendor)

- How did the idea for the project start?
- How was the planning carried out? Who was involved? Any collaboration with other stakeholders?
- Has there been any evaluation done post-implementation? What kind of maintenance/ongoing activities are being carried out?
- What are the sorts of major problems/issues that are common with the system?
- What are they key challenges in developing/maintaining Bru-HIMS?

- What do you think are positive points of the system?
- What policies or recommendations can be suggested based on the lessons gained from this project?
- What are the system requiremen.

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