

Design, development, and implementation of a mobile application to empower hospitalized patients in a Swiss University Hospital

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Abstract

Background: Patient empowerment can be associated with better health outcomes, especially for chronic diseases.

Objective: Concerto is a mobile application designed to promote patient empowerment in an in-patient setting.

Methods: The application was conceptualized and prototyped during a hackathon. It uses Hospital Information System Data to offer key functionalities: a care schedule, access to targeted medical information, to practical information, to information about the on-duty care team, and to a medical round preparation module. Following a feasibility study, funding was obtained, and the application developed and implemented in 4 pilot divisions, using institution-owned iPads.

Results: The project lasted for two years with effective implementation in the 4 pilot divisions, within budget. The induced workload on caregivers impaired the project sustainability and warranted a change in our implementation strategy. The presence of a killer-function would have facilitated the deployment. Furthermore, our experience is in line with the well-accepted need for both a high-quality user-training and a good selection of super-users. Finally, by presenting HIS data directly to the patient, Concerto has highlighted them to be not fit-for-purpose and has triggered data curation and standardization initiatives.

Conclusions: This implementation report presents a real-world example of designing, developing, and implementing a patient-empowering mobile application in a University Hospitals' in-patient setting. One limitation of the study is the lack of definition of a Key Success Indicator.

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Original Manuscript

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Keywords: Patient Empowerment, Mobile Applications, Digital Health, Mobile Health

ABSTRACT

Background

Patient empowerment can be associated with better health outcomes, especially for chronic diseases. Digital health has the potential to promote patient empowerment.

Objective

Concerto is a mobile application designed to promote patient empowerment in an in-patient setting. This implementation report focuses on the lessons learned during its implementation.

Methods

The application was conceptualized and prototyped during a hackathon. It uses Hospital Information System Data to offer key functionalities: a care schedule, access to targeted medical information, to practical information, to information about the on-duty care team, and to a medical round preparation module. Following a feasibility study, funding was obtained, and the application developed and implemented in four pilot divisions, using institution-owned tablets.

Results

The project lasted for two years with effective implementation in the four pilot divisions, within budget. The induced workload on caregivers impaired the project sustainability and warranted a change in our implementation strategy. The presence of a killer-function would have facilitated the deployment. Furthermore, our experience is in line with the well-accepted need for both a high-quality user-training and a suitable selection of super-users. Finally, by presenting HIS data directly to the patient, Concerto has highlighted them to be not fit-for-purpose and has triggered data curation and standardization initiatives.

Discussion

This implementation report presents a real-world example of designing, developing, and implementing a patient-empowering mobile application in a University Hospitals' in-patient setting with a particular focus on lessons learned. One limitation of the study is the lack of definition of a Key Success Indicator.

Introduction

During the last decades, medicine has been moving from paternalistic approaches towards patient-centeredness and patient partnership and participation. Patient empowerment refers to a meta concept with no unique definition [1]. It is however commonly accepted that empowered patients possess key capacities and resources to be able to (1) participate in shared decision-making, (2) manage their own health, and (3) self-empower themselves [1].

Patient empowerment and clinical outcomes

Some studies have demonstrated a positive association between patient empowerment and improved clinical outcomes or their proxy. This is best documented for chronic diseases, especially diabetes. Wong and al. compared serum glycated hemoglobin (HbA1C) and Low-Density Lipoproteins Cholesterol (LDL-C) levels in a group following a Patient Empowerment Program (PEP) versus a group following the standard of care. Decreased LDL-C levels in the PEP group were reported [2]. Similarly, Lian and al. found a lower incidence of all-cause mortality, cardio-vascular events and diabetes mellitus complications following a PEP [3]. In a review of randomized control trials, a decrease in HbA1C and blood pressure levels was associated with empowerment interventions for diabetic patients in Sub-Saharan Africa [4]. In a meta-analysis, Baldoni and al. reported an improvement in HbA1C levels following collective empowerment strategies [5]. In a Systematic review, Shnaigat and al. identified patient activation, a concept related to empowerment, as a valid strategy to improve outcomes of Chronic Obstructive Pulmonary Disease patients [6].

However, it is important to highlight that several studies also reported no beneficial effects of empowerment programs. A 2017 meta-analysis found no statistically significant positive effect of empowerment on HbA1C levels, despite five included studies reporting positive results [7]. Santoso and al. reported a lack of evidence to demonstrate a positive association between women's empowerment and outcomes of child nutrition [8].

The lack of clear definitions and measures for empowerment may explain these controversial findings. Differences in program design could also contribute to this variability and further research identifying determinants for successful intervention is needed. Finally, authors of the cited studies often reported the poor availability of high-quality research.

Digital health and patient empowerment

With the variety of solutions that could be envisioned, digital health is seen as a promising tool to promote patient empowerment and, indirectly, outcomes. The literature reports mixed results.

In a systematic review, Johansson and al. showed that online communities support patient empowerment [9]. Sosa and al. reported that a text messaging-based empowering intervention following head and neck surgery was both highly appreciated by patients and feasible [10]. Bjoernes and al. described a dialogue-based web application designed to promote patient empowerment [11].

On the other hand, Ammenwerth and al. reported no clinically relevant effect of patient portals on patient empowerment or health-related outcomes in a systematic review [12]. Vitger and al. failed to demonstrate a positive effect of digital interventions to support shared decision making, probably due to the small number of high-quality studies available [13]. Verweel and al. found limited evidence demonstrating a positive effect of digital intervention for health literacy [14]. Thomas and al. reported that the quality and adequacy of the content of patient-empowering mobile application

varied greatly, urging for more rigorous design and test before implementation [15]. To our knowledge, no study has directly shown a link between mobile health applications-induced empowerment and direct health outcomes.

Overall, few high-quality studies assessing the effect of digital health interventions on patient empowerment are available. Research is needed to confirm or infirm the high perceived potential of digital tools.

Concerto: a mobile application designed to promote patient empowerment

Concerto is a mobile application designed to promote empowerment of hospitalized patients. It was initially designed during a hackathon in 2015 by a multidisciplinary team including healthcare and IT professionals, as well as one patient. Building on the hackathon prototype and after a feasibility study, the *Geneva University Hospitals* (HUG) launched a project aiming at developing and implementing a fully functional mobile application delivered on institution-owned tablets in four pilot divisions: oncology, neurorehabilitation, orthopedics, and pediatrics, and assessing its effectiveness. Following this pilot study, the mobile application was further refined and deployed institution-wide in a Bring-Your-Own-Device (BYOD) approach. This implementation report will focus on the pilot study only, with the objective to highlight lessons learned. It follows the iCHECK-DH guidelines [16].

METHODS

Design and agile development

Building on the prototype developed during the hackathon, the foreseen functionalities of Concerto were first confronted to patient's expectations using focus groups and a semi-quantitative questionnaire. A feasibility study was performed to assess the availability and quality of the necessary data in the hospital Health Information System (HIS), which has been developed mainly in-house during the last 30 years.

Based on the patients' insights, further described in [17], the V1.0 of Concerto was specified and developed using an agile methodology with frequent user-testing with hospitalized patients. Main functionalities included:

1. An up-to-date calendar on which patients can visualize their care schedule and better understand their daily planning, to reduce the impact of these events and be better prepared for them.
2. A care team module on which he can have information about his on-duty care team, like names and photos, to better know the professionals they will meet during their stay and facilitate communication.
3. A "questions" module on which they can prepare their questions for healthcare professionals during the medical round and thus elevate the level of communication.
4. An "information" module, on which they can have access to targeted medical information. Expected benefits for this module were: better situation awareness, better treatment adherence and early detection of complications.
5. A "practical information" module on which they can find useful information about their stay at the hospital, to improve their experience.
6. A social network module on which they can interact with HUG accounts.

In further versions, a new module was added, allowing the patient to choose his meal directly on the application instead than on a form filled-in by the nurse. This module was designed to improve the patient experience on one side and to decrease the nurse workload on the other.

The application was developed in web languages (an Angular project), encapsulated as an iOS application (with Apache Cordova), and deployed on institution-owned tablets using a Mobile Device Management (MDM) solution. The key arguments for internal development over acquisition of a commercial solution were that (1) a significant part of the development work was about interfacing with the HIS, and (2) as opposed to nowadays, no adequate and mature commercial solution was available at that time, to our knowledge.

The initial version of the application connected directly to the custom-made HUG HIS using its proprietary interfaces, for development simplicity and time-constraints. Further versions of the application have used industry standards such as Health Level 7 (HL7) Fast Healthcare Interoperability Resources (FHIR) with the vision to enable Concerto to connect more easily to other HIS in the future. This has required new developments on the HIS side and was not achievable during the pilot phase described in this study. Figure 1 presents the simplified architecture of concerto.

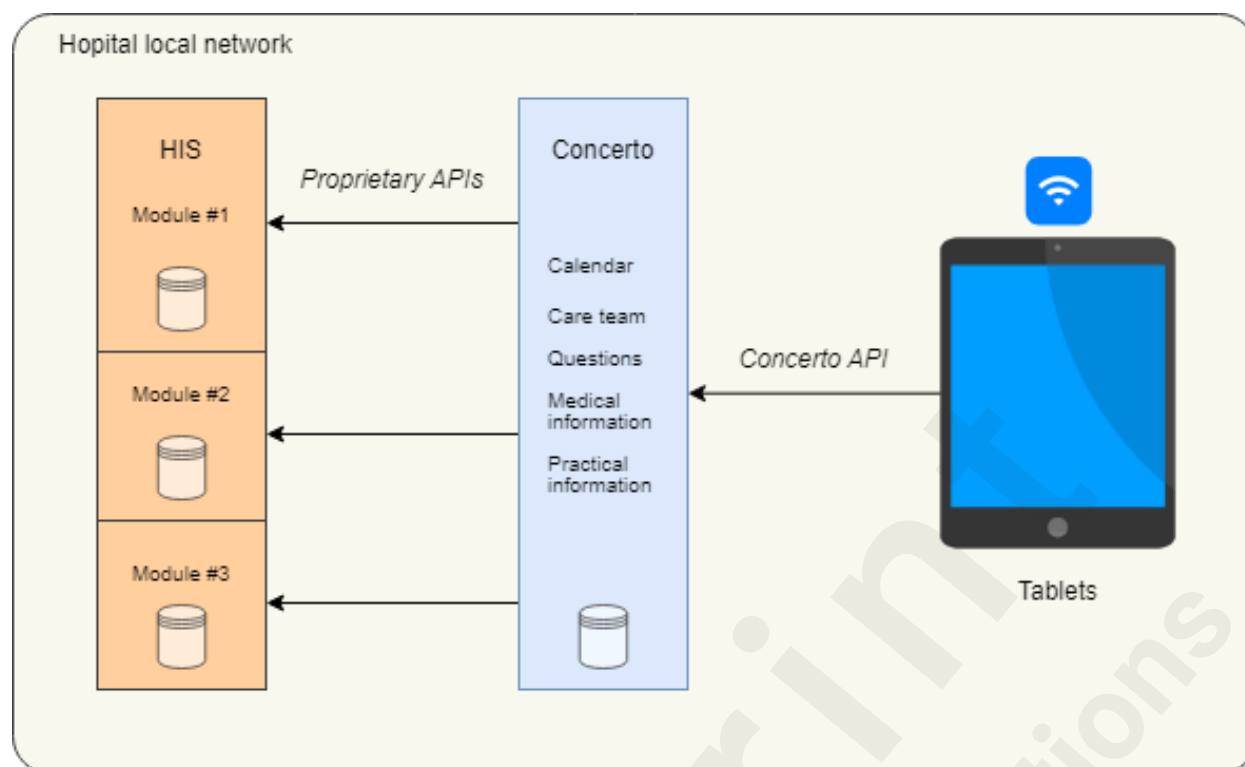


Figure 1. Technical overview of Concerto.

The figure presents the overall technical architecture of Concerto. Through the hospital private Wi-Fi, the patients' tablet connects to the Concerto server, which contains some patient-generated data and the business logic to provide the application data. The server connects to different modules of the HIS to retrieve other data, using diverse APIs.

Implementation

The definition of the logistics necessary to deliver Concerto on institution-managed tablets was an important part of the project. The following process was repeated for each patient: (1) setting-up of the tablet, including defining a personal passcode, (2) two-factor authentication in the Concerto application using the patient ID, scanned from the identification bracelet, and a SMS challenge, (3) charging on-demand, (4) disinfecting the tablet after the patient's discharge and (5) reinitializing and erasing the tablet. Tablets were charged and stored under a key-secured storage in the nurse office. They were protected by individual cases. Hygiene procedures were validated by the infection prevention and control division of the *Geneva University Hospitals*.

Once the V1.0 was available, caregivers of the different divisions were trained for 30 minutes during hands-on sessions in which (1) the project and application was presented to them, (2) the tablets logistics was explained, and (3) most importantly, they had the possibility to familiarize themselves with the tool. At least one caregiver was defined as a super-user on a voluntary basis and was implicated from the beginning of the project. Super-users responsibilities included (1) having a deep knowledge of the application, (2) be the focal point for exchange with the project team, (3) be the referent for day-to-day questions of caregivers. A typical division included twenty beds and comprised a pool of over fifty caregivers that were trained during different sessions. Importantly, as in many hospital projects, caregivers did not have dedicated time for the project. They had to manage making themselves available during a normal day of work.

One unit was scheduled for launch every 2 weeks, with constant presence of one member of the

Concerto team during the first days. Only patients able to interact with a mobile application were offered to use the application. To this end, caregivers used a communication flyer describing the functionalities of the application, the modalities of its use, as well as data and privacy considerations.

Bugs, feedbacks, and general satisfaction were systematically consigned to fuel the improvement and fix backlog.

Data considerations

At the stage presented during this report, Concerto worked mainly “read-only” for personal health data available in the HIS and for insensitive, impersonal information. The information patients accessed from the HIS were part of their medical record. According to the Swiss law, every patient owns data from his medical record, except for personal notes of healthcare professionals which were out of the scope of Concerto. Accordingly, Concerto facilitated the access to data already owned by the patients.

The access to this sensitive personal information required a secure login based on the patient ID number and a second factor with a SMS challenge. The use of institution-owned devices allowed us to data access to the hospital local network, preventing unwanted access from the rest of the world.

The only personal information entered in Concerto was questions patients may have before interaction with caregivers. This information was stored in the HIS and deleted after their hospital stay. Tablets were erased and reinitialized between patients, making sure no information leakage was possible between a patient and the next one.

To summarize, Concerto (1) facilitated the access to personal health information owned by the patient without the possibility to modify it from the application, (2) allowed for the entry of personal health information by the patient that was stored in the HIS, inaccessible to others, and systematically erased after their hospital stay.

Overall, the project was compliant with the *Swiss law for data protection* (LPD).

Funding and budget planning

The feasibility study and initial concept were self-funded by the *eHealth and Telemedicine Division* of the *Geneva University Hospitals* and included salaries for a junior developer and a senior project manager.

The project pilot was then funded by private foundations based in Geneva and included the salaries as well as necessary materials (tablets, covers and software licenses).

Overall, the order of magnitude of the project costs was comprised between 150k and 200k CHF, from which 25% was used for materials.

RESULTS

Project summary

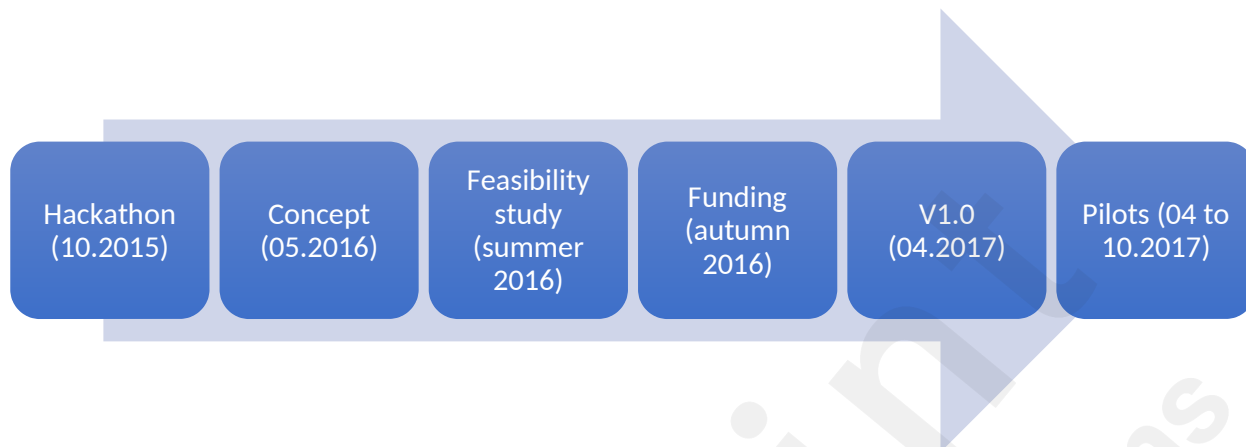


Figure 2. Timeline of the Concerto pilot project.

Figure 2 summarizes the timeline of the project main phases.

Concerto was implemented in four pilot divisions; a typical division includes twenty beds and comprises a pool of over fifty caregivers.

From the initial hackathon to the funding, approximately one year was necessary to refine the concept with patients and assess its feasibility. Following the funding, 6 months of development were needed, followed by 6 months of piloting in the four selected hospital divisions. Overall, the project took 2 years.

The budget was respected. However, additional funding to free caregivers from their clinical duties would have been welcome for a better implementation (further discussed below).

The agile development phase was experienced as efficient and productive by the development team. Critical to the development process, the organization of focus groups and 1-to-1 interviews with patients were facilitated by the clinical background of the project manager. Early contacts with the IT division during the feasibility study was reported by the development team as improving communication and, hence, efficiency. Finally, dedicated support of the management unlocked political stalling.

During the pilot phase, the application was proposed to all eligible patients (cf. Methods). The percentage of eligible patients was unfortunately not systematically monitored but varied importantly according to the profile of hospitalized patients and, consequently, across the different divisions and across time. An eligibility below 50% was not uncommon.

The percentage of acceptance was not systematically collected. However, it was recalled as less variable and consistently high (over 80%) by the project team.

Monitoring of the drop-out rate should also have been monitored carefully to identify their cause.

Most importantly, the tablets logistics was particularly challenging for caregivers. Despite the support of the project team, this impaired the inclusion of patients and *in fine* the usage of the application. More precisely, caregivers reported difficulties to assist patients with the login and reinitialization procedure, and all the logistics steps were reported as too time-consuming. Based on

this finding, it was decided to stop the pilot phase and move to a Bring-Your-Own-Device (BYOD) approach.

Lessons learned and determinants of success and failure.

As often reported in the field, most challenges were encountered during the implementation (pilot) phase.

Our strategy to use institution-owned tablets added an important workload on care teams because they were in charge to manage the tablet fleets in their division. This strategy had its rational for cybersecurity and development reasons, but we underestimated the additional work it would generate for already overwhelmed caregivers. With such a strategy, it is our experience that protected and dedicated time for training caregivers is mandatory, at least for superusers. It is well recognized, for Electronic Medical Record implementation, that the quality of training represents a key success factor [18]. Our impression is that this also applies to our project. Accordingly, our two first reported determinants of success are (1) having an implementation strategy that minimizes the impact on already overworked healthcare professionals, and (2) having quality training time, protected from the daily routine.

Similarly, we noticed that implementation was easier in care units in which the superuser was both convinced of the project benefits and influential among his peers. This represents our third observed determinant of success.

The presence of a “killer-function” – a function that by itself brings tremendous value – would have helped the adoption by stakeholders. Even though such a function was not identified during patient’s focus-groups, it was revealed during the implementation, as the possibility for the patient to choose and order his meal. Indeed, this function had the potential to both empower the patient and free time to caregivers. Having such a functionality before the full-scale implementation appears as particularly relevant to the authors.

The communication with project’s stakeholders was felt as key to maintain motivation and trust in the project. In particular, reactivity in fixing identified bugs or transparency about delays was appreciated.

Finally, we realized that the quality of the HIS medical information fueling Concerto was not always appropriate for display in a patient mobile application. This was either because it was not timely, or incorrect, or, most importantly, because its label was too technical. This has brought disadvantages such as a lack of confidence in the project but also advantages, such as a welcome transparency about HIS information, triggering continuous improvements. For example, specific agenda labels designed for patients were created in the HIS, thanks to Concerto.

DISCUSSION

This implementation report presents a real-world example of designing, developing, and implementing a patient-empowering mobile application in an in-patient setting of a Swiss Public University Hospital. Lessons learned, presented in the results section, are summarized in Table 1.

Lessons learned	Perceived relevance
Minimize the workload of caregivers or, if possible, decrease it.	5/5
Plan protected time for training end-users.	4/5
Select convinced and influential superuser.	3/5
Wait for a killer function to implement the application.	5/5
Maintain trust through reactivity and transparent communication.	4/5

Table 1. Main lessons learned and associated perceived relevance. Based on perceived experience, lessons learned were identified by the authors and their relevance assessed by consensus by a score ranging from 1 (minimally important) to 5 (maximally important).

As described in the background section, Patient Empowerment is a meta-concept. Hence, it is difficult to monitor with a single indicator. For this reason, a Key Success Indicator was not defined at the beginning of this project and has complicated its evaluation. It is a limitation of this paper, as an objective evaluation metric would have been important to report. Simple monitoring metrics (eligibility, number of users, dropout and acceptance ratio) should also have been collected and were planned for the next application version. A randomized control trial assessing the effectiveness of the Concerto mobile application on a patient situation awareness score has been designed and should be conducted soon. It will allow for a better evaluation of the cost-effectiveness of such project. Overall, data on the effectiveness of eHealth projects are often lacking, and the creation of the JMIR implementation reports is aiming to fill that gap.

The generalizability of our study is another limit. Indeed, the innovation ecosystem and the EMR landscape at HUG are very specific and different constraints may be experienced in other settings. However, we believe the lessons learned we report remain relevant in various environments.

Coming back to Concerto and in reaction to one of the main lessons learned, a BYOD version of the application was developed. With this version, every patient was able to use the application on their personal device including computer, tablet, or smartphone. This was done to limit the workload on caregivers and improve the adoption rate. New functionalities, such as the possibility for patients to choose their meal, were also developed to answer unmet needs for both end-users and stakeholders impacted by the implementation of the application (i.e., caregivers). Important challenges in terms of cybersecurity, inter-operability and compatibility had to be met with the development of the BYOD version. They will be further described in a coming implementation report focusing on this project phase.

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Damien Dietrich was project manager for Concerto during the project phases described in this report and wrote the manuscript.

Helena Bornet dit Vorgeat has been project manager for Concerto after the project phases described in this implementation report and reviewed the manuscript.

Caroline Perrin has reviewed the manuscript.

Quentin Ligier has been the lead developer for Concerto during the project phases described in this report and reviewed the manuscript.

CONFLICTS OF INTEREST

Authors report no conflicts of interest.

ABBREVIATIONS

BYOD: Bring Your Own Device

FHIR: Fast Healthcare Interoperability Resources

HbA1C: glycated hemoglobin

HIS: Health Information System

HL7: Health Level 7

HUG: Hôpitaux Universitaires de Genève

LDL-C: Low Density Lipoproteins Cholesterol

JMIR: Journal of Medical Internet Research

LPD: Loi sur la Protection des Données

PEP: Patient Empowerment Program

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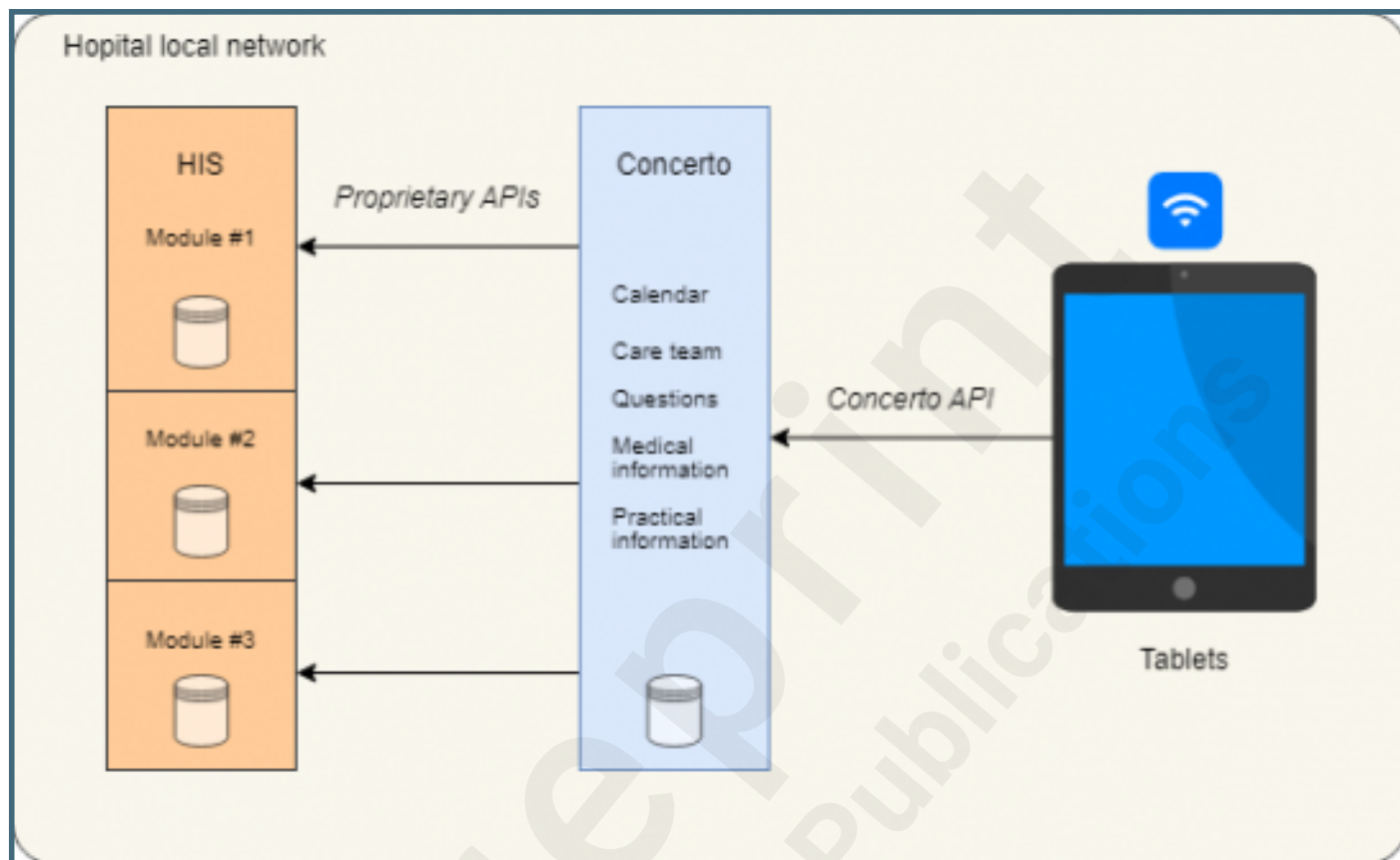
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Supplementary Files

Figures

Technical overview of Concerto. The figure presents the overall technical architecture of Concerto. Through the hospital private Wi-Fi, the patients' iPads connects to the Concerto server, which contains some patient-generated data and the business logic to provide the application data. The server connects to different modules of the HIS to retrieve other data, using diverse APIs.



The Figure 2 summarizes the timeline of the project main phases.

