DESIGNING A MOBILE APPLICATION FOR AD-HOC TUMOR BOARD SCHEDULING

Research in Progress

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Abstract

Tumor boards are multidisciplinary meetings of medical experts who consensually decide about diagnosis and treatment recommendations for cancer patients. They are decisive for treatment quality and patient survival. At the same time, they are highly resource-intensive, time-consuming, and complex to schedule. Hospitals compensate this by scheduling tumor boards well in advance. However, this causes delays in cancer treatment and psychological stress for patients. To address this issue, ad-hoc tumor boards may constitute a viable alternative to traditionally scheduled ones if they are properly supported by information systems and effectively integrated into physicians' busy and unpredictable work day. In this design science research, we therefore propose (1) a prototypical process of carrying out ad-hoc tumor boards and (2) design features of an information system that supports ad-hoc tumor board scheduling and fosters the intrinsic motivation of physicians to participate in them. The development of the process and the design features has been informed by interviews and surveys conducted in 11 hospitals in Europe. We are currently developing the information system. For future evaluation, we outline the properties of a study with students and a clinical trial.

Keywords:Design science research, Ad-hoc tumor board, Intrinsic motivation, Healthcare.

1 Introduction

The number of cancer patients is rapidly increasing (Stewart and Wild, 2015), and already today, hospitals are struggling to provide cancer patients with timely and individualized therapy while using their scarce resources efficiently. Tumor boards are an essential component in individualized, multidisciplinary patient care, but are at the same time very resource-intensive and time-consuming. The National Cancer Institute defines a tumor board as "a treatment planning approach in which a number of physicians who are experts in various medical disciplines review and discuss the medical conditions and treatment options of a patient" (National Cancer Institute, 2016). Tumor boards improve patient management (Wright et al., 2007) and quality of patient care (Newman et al., 2006) as physicians from multiple different medical disciplines discuss diagnosis, treatment options and strategies for each patient individually. Tumor boards have positive effects on the treatment plans (Van Hagen et al., 2011) as well as diagnostic and staging decisions (Wheless et al., 2010), which in turn decreases operative mortality while increasing 5-year survival of patients (Stephens et al., 2006; Forrest et al., 2005).

At the same time, tumor boards are highly resource-intensive and time-consuming. Particularly the scheduling of tumor boards is very complex. A central reason is that the exact composition required

for a tumor board decision is subject to strict regulations, therefore, time restrictions of multiple specialists have to be considered on a case-by-case basis. To compensate for this complexity, hospitals schedule tumor boards well in advance, typically between one week and one month (El Saghir et al. 2014). As a patient's diagnosis and treatment planning can only begin after the consensus decision of a tumor board, this causes significant delays in therapy. Consequently, patients are exposed to more stress, anxiety and a higher risk of the disease to progress (Korsgaard et al. 2008; Ristvedt et al. 2005; Shen et al. 2016).

Current research addressing this issue mainly focuses on the feasibility and effectiveness of virtual tumor boards that enable meetings distributed over different locations (Stevenson et al., 2014; Chekerov et al., 2008; Marshall et al., 2014). However, there is a lack of knowledge on how such meetings can be planned at short notice and how information technology can support the scheduling process efficiently. In fact, short-term tumor boards, called ad-hoc tumor boards, may be an efficient way to minimize process delays and decrease planning efforts of tumor boards. However, ad-hoc tumor boards face one major challenge: the nomination of physicians. It requires a lot of information about the physicians' availability, their personal preferences and the individual patient cases. Due to time restrictions, any solution requiring active data input from physicians will likely not be accepted in a clinical context (Bhattacherjee and Hikmet 2007) and would therefore be unsuitable. Physicians' daily routine is typically busy and hard to plan as emergencies can come up at any time, which makes ad-hoc appointments of physicians by management unlikely to succeed. Therefore, it is essential that physicians are motivated to voluntarily participate in ad-hoc tumor boards. Addressing these issues, we suggest that a process and a supporting information system should be developed to support the planning of ad-hoc tumor boards and that design features should be taken to foster physicians' intrinsic motivation to volunteer in these tumor boards. Therefore, we aim to achieve two research goals:

RG1: Define a prototypical process of carrying out ad-hoc tumor boards with the help of a mobile application.

RG2: Propose design features specific to the hospital context that need to be taken into account to promote intrinsic motivation of physicians so that they participate voluntarily in ad-hoc tumor boards.

2 Conceptual and theoretical foundations

2.1 Tumor boards

Tumor boards are no novelty in cancer treatment and are known to play a decisive role in the planning of care for cancer patients (Petty and Vetto, 2009). They pursue several goals: first and foremost, they are care conferences that allow physicians to reach consensus decisions on diagnosis and treatment of a patient. The participating physicians come from different medical disciplines, such as radiology, surgery, oncology and radiation therapy (Charara et al., 2017). Ideally, all participants should have the same information about the case at hand. At the end of a tumor board, all participants need to have reached consensus on diagnosis and treatment options for each patient. Tumor boards are conducted similarly in most developed countries. However, there are variations in the process and no unified definition Jessup (2007). Physicians are a valuable resource for hospitals. Hence, if several medical specialists meet in a tumor board, not only one, but usually between 5 and 25 patient cases are discussed. This reduces the planning effort per patient and increases the efficiency of meetings. Also, in tumor boards, not only new patient cases are discussed, but also the effectiveness of ongoing treatment for an existing patient is reviewed in order to adjust the treatment plan if necessary. Tumor boards also have an educational function (Jazieh, 2011): since numerous physicians with different backgrounds exchange information on often difficult patient cases, cross education between medical specialists takes place. Moreover, medical students frequently passively participate in the meetings. In oncology, the increase in knowledge is very large and causes physicians to specialize in different types of tumors (Gesme and Wiseman, 2011). This results in the establishment of tumor boards for different tumor entities. Each type of tumor board has different requirements with respect to the medical disciplines

represented. As a result, the quality of decisions can be significantly improved patients (Stephens et al., 2006; Forrest et al., 2005). However, it leads to a situation where large hospitals have to perform multiple different tumor boards in parallel. Physicians have to receive the information about the patient's case in a clearly arranged manner and in time, to allow them to prepare themselves for the tumor board (Jazieh, 2011). Because of the resource and time intensity of tumor boards, they usually take place weekly or less frequently (El Saghir et al. 2014). In a worst case scenario, this results in delaying the discussion of a patient case by the length equal to the interval between two suitable tumor boards for that case. This in turn delays treatment onset and causes patient stress, anxiety and increasing risk of disease progression during the waiting period (Korsgaard et al. 2008; Ristvedt et al. 2005; Shen et al. 2016).

2.2 Ad-hoc tumor boards

We define ad-hoc tumor boards as medical expert meetings that take place on demand but on short notice. A demand exists when a given patient case has reached a state where a tumor board decision is necessary in order to ascertain diagnosis, establish a treatment plan or re-evaluate a current treatment plan. This presupposes that all relevant information is aggregated in the shortest possible time and that a group of available physicians qualified to hold the meeting is determined. This can hardly be achieved without technical support because the amount of information needed is too large in order to be collected manually. To ensure mobility, this support could be provided by a mobile application. However, the hospital context is very unique. Physicians' are usually under time pressure and their day to day work is highly demand driven. Often they have only limited resources and have to make several fast decisions in parallel. For physicians this is often both physically and mentally exhaustive (Burgess, 2015). A mobile application that supports ad-hoc tumor boards should therefore ensure that physicians are not exposed to even more pressure and stress. The application must therefore be easy to use and motivate continuous use (Venkatesh et al., 2003). There remains a risk that physicians will not use the application, ignore or reject requests although they are actually available. Incentivizing physicians is not an option as the effect of extrinsic motivation decreases over time and moreover can harm physicians' intrinsic motivation (Deci et al., 1999). As a consequence, the only option is to rely on physicians' intrinsic motivation in order to make them volunteer for ad-hoc tumor boards.

2.3 Intrinsic motivation

The Self-Determination Theory (SDT) (Ryan and Deci, 2000; Deci and Ryan, 2000) is a psychological theory of intrinsic motivation which has been applied for designing artifacts that require users to volunteer in a task. For example, Giesbrecht et al. (2012) have mapped the requirements of an IT-based citizen advisory support system to the basic psychological needs proposed by SDT. Hamari et al. (2014) use the SDT as part of a literature review for studies on gamification. Ford et al. (2012), used the principles of the SDT to maximize the effectiveness of a software suite for educational games. According to the SDT, intrinsic motivation is developed if three psychological needs are met. Firstly, the need for competence, which "concerns succeeding at optimally challenging tasks and being able to attain desired outcomes", secondly, the need for autonomy, that "concerns experiencing choice and feeling like the initiator of one's own actions", and thirdly, the need for relatedness, that "concerns establishing a sense of mutual respect and reliance with others" (Baard et al., 2004, p. 2046).

Competence: The need for competence describes individuals' desire to feel mastery and a positive sense of challenge in what they do. If task is perceived as not important or too simple, individuals do not satisfy their need for competence (Deci and Ryan, 2000). Research has shown that providing positive feedback, moments of success and a feeling of mastery can foster the need for competence (Wang et al., 2015). Small challenges and gamifications target this need by providing manageable tasks and positive feedback at the same time (French, 2014, Reiss, 2004).

Relatedness: To develop intrinsic motivation, individuals need to experience a sense of belongingness. One key aspect of relatedness is social contact (Reiss, 2004), which can be either real or perceived. Anonymity counteracts the need for relatedness. Research acknowledged for instance that so-

cial support (Sakakibara et al., 2017), social presence (Short et al., 1976) or social comparison (Klein et al., 2017) foster usage of information systems. For our proposed artifact it could be an important motivator that physicians see first who already participated in the tumor board meeting and second if they could select specific colleagues to participate with.

Autonomy: The last basic need is considered to be the need for autonomy, the ability to decide freely without influence from others. Literature indicates that autonomy can be accomplished by an IS design, which flexible adapts to the user and provides options of choice (Ryan and Deci, 2000; Neben et al. 2015) without activity restriction or time constraints (Muraven et al. 2008). However, to enable physicians to decide in an autonomous way, the application has to take the social and cognitive constraints of physicians into account. Because physicians have low scare cognitive and emotional resources for the scheduling task, more perceived autonomy can be achieved by restricting unnecessary options so that physicians do not experience a choice overload but instead perceive to choose in an autonomous way (blinded). Especially for physicians', professional autonomy is one important driver for technology acceptance (Walter and Lopez, 2008).

To successfully develop an ad-hoc tumor board scheduling application, all three needs have to be addressed. But, also the specifics of the hospital context have to be taken into account. In hospitals, physicians face high pressure, uncertainty and emotional demands (Burgess, 2010) making features such as providing more user choice not applicable (blinded).

3 Research approach and preliminary results

3.1 Research context

Our study takes place in the context of a major research project in cooperation with a public hospital with more than 1,300 beds. In this context, a team of biologists, engineers, physicists, medical scientists and IS researchers, develop new methods for effective and minimally invasive methods in cancer therapy. One part of this project is devoted to the research of ad-hoc tumor boards. Each week, over ten tumor boards with 5 to 25 patients are conducted in this hospital. The hospital has an administrative unit dedicated to the tumor board administration. Tumor board patients have to be registered 24 hours in advance, however the average waiting time for them is still more than five days. Especially ad-hoc tumor boards in emergency cases are currently linked to enormous planning efforts and require intensive involvement of administrative staff. Our context offers us excellent opportunities to interview physicians of all disciplines, conduct quantitative surveys and show prototypes to the end users. The opportunity to carry out clinical evaluations is also given and has already been used by us several times in past projects.

3.2 Methodology

In our work we follow the design science research methodology as described by Peffers et al. (2007) because the process sequence of this approach nicely fits not only our internal but also external project requirements. We adhere as strictly as possible to the recommendations in the process model. As a first step, we identified and motivated the problem. To this end, we first identified a planning problem through observations in a hospital, interviews with physicians, a survey conducted in ten hospitals and a thorough literature search. Moreover, we conducted a market analysis to ensure the novelty of the solution approach. In the next step, we have defined the goals of our work. Here too, eight interviews with physicians were conducted. The interviews and the knowledge accumulated previously resulted in a first prototype of a process. A small survey with a dozen radiologists revealed features for the application as well as first user interface designs.

Currently, we have started the design and development phase. One of the main problems is to motivate physicians to use the application. Therefore, we have conducted a targeted literature research to find out which features are especially relevant in the hospital context to increase the intrinsic motivation of physicians. The development of a prototype has already begun. After completion of the first develop-

ment iteration, the prototype will be evaluated in a first study. The prototype is then improved in a further development iteration and finally evaluated in a clinical study. Between the two studies, further iterations can be carried out in which the prototype is gradually improved. In Table 1, the individual results of the steps are presented.

Process steps	Activities	Results
Identify problem and motivate	- Observations in hospitals (tumor boards) - Interviews (physicians and administrative staff) - Survey with 10 hospitals (N=20) - Literature review & Market analysis	- Business problem - Practical and theoretical relevance - Novelty of solution
Define objectives of a solution	- Interviews with physicians (N=8) - A survey with radiologists (N=12)	- Prototype of application process - Goals and features of the application
Design & development (current step)	- Literature review - Start of prototype development	- List of design features adapted to the hospital context
Demonstrate & evaluate (next step)	- Evaluation in a first study (students) - Prototype refinement iteration(s) - Evaluation in a clinical study	- Findings for increasing intrinsic motivation in the clinical context - An application to solve to ad-hoc tumor board planning problem

Table 1. Process Steps (based on Peffers et al. 2007)

3.3 Results

Identify problem and motivate: First of all, it was necessary to identify a suitable business problem. For this purpose, we often met with physicians in the hospital and noticed early on that tumor boards are very important and complex, but also use a lot of resources. In order to better understand the process, we interviewed both physicians and administrative staff. Due to our position in the project, we took the opportunity to participate in numerous tumor boards. These insights showed us that there is a long delay between the registration of a patient for the meeting and the tumor boards. Further discussions then revealed that this delay may have negative effects on the condition of patients and may increase the risk for interim disease progression. In the literature we could find evidence that shorter treatment times for cancer patients can increase chances of cure (De Santis et al., 2014). The high personnel expenses incurred by the hospital result in costs that could be avoided. We conducted a survey in ten hospitals in Europe. A total of 20 employees was surveyed. Among them were 18 physicians who regularly participate in tumor boards, one pharmacist and one hospital assistant. The survey showed that tumor boards in all hospitals take place on a weekly or even monthly basis, confirming our findings from the literature (El Saghir et al. 2014). Short-term tumor boards can only be conducted in two of the hospitals which, however, is very rare due to high costs and manual effort. Furthermore, it has been found that patients usually wait 3-7 days for their case to be discussed in the tumor board. In some cases, they have to wait up to 14 days. We conclude that ad-hoc tumor boards are useful and important but most likely difficult to perform. Therefore, an application that supports the planning process of ad-hoc tumor boards is necessary. A market analysis and literature analysis showed that there are currently only solutions for virtual tumor boards but not for ad-hoc scheduling available. Furthermore, there is a gap in current literature that deals with design guidelines for the context of healthcare practitioners. Most features found are context free or only generally applicable for mHealth applications. This makes the work also relevant from a theoretical point of view.

Define objectives of a solution: In further discussions with physicians who regularly participate in tumor boards, we have gradually developed a prototype process for the application which supports the planning of ad hoc tumor boards. A basic requirement is that the application has to be seamlessly integrated into the daily routine of physicians. Several physicians have expressed the wish that they would

like to access information on patient cases and respond to inquiries, regardless of their location. It is essential for physicians to receive all relevant information about their patient cases in advance so that they can prepare sufficiently for the tumor board (Jazieh, 2011). To meet these requirements, the application will be implemented as a mobile smartphone application. In addition, the physicians have indicated that they specialize in different tumor board types and therefore have preferences that are already taken into account in the long-term planning. These preferences must therefore be queried and used in the application when selecting potential participants for ad-hoc tumor boards. The information about preferences allows us to develop algorithms that pre-select the participants and reduce the amount of physicians that are contacted to a minimum. If contacted physicians do not have time, the next physicians can be contacted until a suitable constellation of physicians has been found or no physicians that can be contacted are left. This pre-selection has a decisive side effect. Physicians are not contacted for every patient case, but ideally only for selected patient cases where the likelihood for them to volunteer and participate is very high. This reduces the number of requests per physician and thus the frequency of interruptions. Some physicians fear that they will be overloaded with inquiries and must be ready for a tumor board at any time. To relieve them of this fear, the process has to be adapted accordingly. The first feature is the pre-selection that has been incorporated into the process. Furthermore, we decided that ad-hoc tumor boards are not suitable for all patient cases, but only for cases that are pre-filtered. The pre-filtering of cases is done on the basis of properties that need to be worked out in more detail. Currently, we simply consider patient cases that are discussed again in a tumor board for a follow-up as less critical than new patient cases. Besides that, we incorporate how many days it would take until a patient case is discussed in the next regular tumor board. The further away this day is, the more important it is to perform an ad-hoc tumor board. The physician who registers the patient case receives a recommendation if the case is suitable for an ad-hoc tumor board and then decides whether he or she wants to follow this recommendation. The last adjustment of the process is to standardize the daily schedule of ad-hoc tumor boards to some degree. We therefore distinguish between four phases and tasks that are assigned either to the physicians or the application (see Figure 1). The day begins with a registration phase in which physicians can register patients for ad-hoc tumor boards. This is followed by a consultation phase in which the physicians are informed about the current cases and can decide whether and when they would like to participate. This phase should start every day at the same time so that physicians may start checking their smartphone out of habit, during that time. The phase should also be long enough to allow the aforementioned pre-selection of physicians as this prolongs the consultation phase. However, the phase has to end early enough so that the physicians are informed in time about whether they will actually participate in the meeting they volunteered for. The notifications are sent out in the information phase. All physicians assigned to the meeting need a sufficiently long time to prepare themselves for the meeting during the information phase. The fourth phase represents the actual meeting of the physicians. It is important that the time slots offered in the second phase are all chosen in such a way that physicians most likely have short walking distances to the meeting point and that it is very unlikely that they are involved in another task which they can't interrupt. Based on the interviews and the assumption that most physicians go to the cafeteria at noon and that the cafeteria is located very centrally, we initially decided to choose timeslots before and after the lunch break. These timeslots seem to be ideal in the hospital described in our research context but must be evaluated for other hospitals.

Design & development: In order to increase the motivation of the physician to participate voluntarily in ad-hoc tumor boards, we have combined the results of the interviews with a further targeted literature research. The results are design feature that are shown in Table 2 and are currently being implemented in prototype development. Each feature is associated with one of the three psychological needs that foster intrinsic motivation. The list is not yet extensive and will be updated in the future. We have already conducted the validation of the amount of user choice in the interface in an empirical study (blinded). All other design features will be evaluated subsequently.

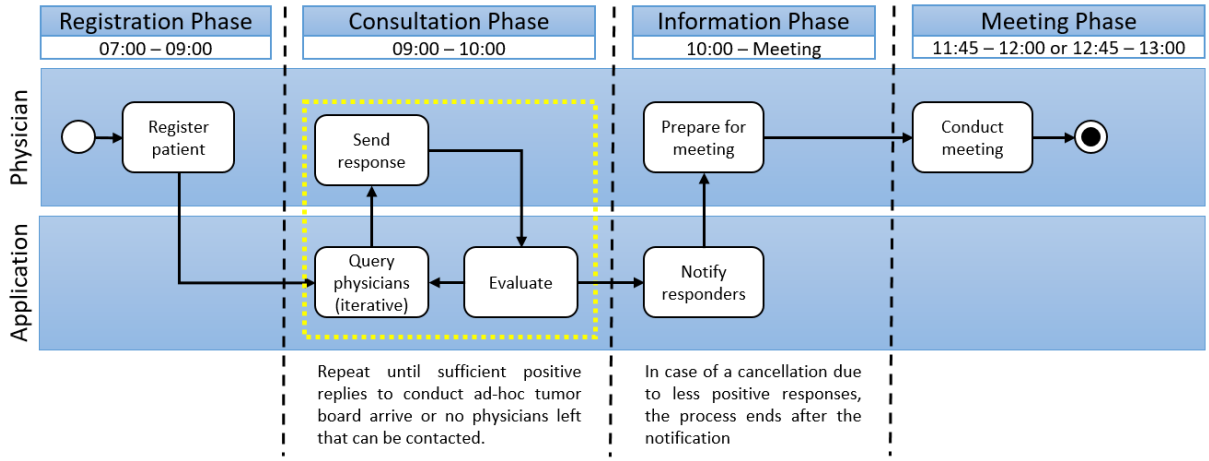

Figure 1. Preliminary Process Model

4 Conclusion and next steps

In this research in progress we use the design science research methodology Peffers et al. (2007) to systematically develop and evaluate an ad-hoc tumor board scheduling application. We have shown that there is a lot of potential in ad-hoc tumor boards that can benefit patients, physicians and hospitals. For our application we have to rely on physicians' intrinsic motivation to volunteer for the tumor boards. To develop design guidelines, we apply the Self-Determination Theory (Deci and Ryan, 2000. The theory states that the needs for autonomy, competence and relatedness have to be met for intrinsic motivation. However, the hospital context is a highly specific context with specific affordances (Burton-Jones and Volkoff, 2017). Physicians are known to resist new processes and IS particularly when they feel constrained by them (Bhattacherjee and Hikmet, 2008). Moreover, physicians daily work is characterized by high levels of cognitive and emotional pressure, which makes it difficult to apply design guidelines developed for other contexts. To address these issues we developed a specific process model and concrete design features by mapping the design features to the three psychological needs described in the SDT (Deci and Ryan, 2000). From a practical perspective, we offer an alternative solution to traditional tumor boards. Our application helps to resolve the planning complexity of virtual and traditional tumor boards. As next steps, we plan to execute several implementation iterations between which we evaluate the features and functionalities. First we will develop a scenario study with students to test the technical functionalities as well as some design functionalities. The developed student scenario includes some important coordination aspects of the hospital context. We plan that students will have to arrange meetings between each other with specific requirements to the participants. In parallel we will make sure that the results are also applicable for physicians. Therefore, we will validate the results and features with further interviews. Ultimately, a clinical trial is planned where the prototype will be tested with real patient cases. Further developments also include the implementation of an intelligent algorithm to automatically classify and evaluate the patients' medical records. Our application is helps the effective scheduling of ad-hoc tumor boards and makes their success possible. A consequent reduction of the delay before cancer patients receive their treatment plan may well save many lives in the future.

	Feature	Evaluation
Autonomy	Segmented notification (pre-selected physicians)	Reduces the disturbance caused by notifications significantly, decreasing choice overload and therefore increases perceived autonomy. .
	Exclude physicians based on their work schedule, calendar or location	Significantly reduces annoyance by notifications but increases the difficulty to find enough volunteers. Physicians perceive the applications to consider their perspective and to increase their autonomy.
	Allow the deactivation of notifications	Physicians gain a higher sense of autonomy when they are actively allowed to restrict the application from contacting them. This is useful for example during surgeries. The duration of the deactivation is temporary.
	Send notifications only if physicians interact with their smartphone	Notifications only appear if physicians decide to check their phone and thus do not interrupt their daily work. The physicians can decide on their own according to their workload if to be notified about ongoing tumour boards. However, if such a silent notification is not seen after a while, it should notify the physician normally to receive enough responses.
	Provide options of choice in a reasonable response time	Physicians should be provided with options to select between different proposed time slots without overwhelming them. For the application it is essential to find the optimal balance between restricting response time and number of options for the scheduling algorithm to process and providing user choice for physicians' sense of autonomy.
Competence	Show information on the expertise fit of a case	Increases the perceived competence by showing how valuable the contacted physician's expertise is.
	Insert a score and ranking system	This small gamification feature affects the perceived competence if the physician has a high ranking. Furthermore, it is an element of social comparison and can be linked to the need of relatedness as well.
	Include case information into the request	Increases the perceived competence of physicians if the case matches the physicians' preferences and skills. Otherwise, it will decrease the perceived competence.
Relatedness	Show information about responses from own medical disciplines	Increases feeling of social obligation if a physician is the only remaining physician of his discipline that did not answer, while others responded to have no time.
	Show information about other responders (quantity and response)	Can create social obligation to respond if all other physicians responded in time. If no other physician answered it may motivate physicians to do so as it seems that everybody else is too busy. If the response itself is displayed (e.g. reject/accept request), this can strengthen the effects.
	Choose specific colleagues to participate with or automatically get matched with colleagues from previous tumor boards	One key driver for volunteering in tumour boards is the exchange with medical colleagues. Therefore, it is essential to provide physicians with the choice to select colleagues with whom they want to participant and satisfy their need for relatedness.

Table 2. Excerpt of features and their evaluation

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