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Development of User Interface Quality Questionnaire (UIQHS), An Instrument for Evaluating User Interface.

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Abstract

As a part of the healthcare management system, the patient registration system was developed to record patients' social and medical data. User interface evaluation is increasingly essential for health workers to avoid errors and difficulties when using the system during registration. The research aims to develop and validate the User Interface Question for Healthcare System (UIQHS), an instrument for evaluating the user interface of hospital systems. This study employed a quantitative approach in three steps: expert review, pre-test, and field test. UIQHS comprises 25 questions based on the 10 elements of user interface competencies. Ten academicians from the university evaluated the questionnaire in the first stage. The second stage involved a pilot study with 30 and 29 staff, respectively. The final stage was a field test with 233 staff in Semarang hospitals. This study used Pearson's product-moment correlation for validity checks and Cronbach's alpha coefficient to assess internal consistency. This study developed 22 questions based on the stages of expert review, pilot testing, and field testing. The final IUQHS comprises 10 heuristic elements and 22 questionnaires. Enhancing the user interface in the hospital system is urgent to support successful health IT adoption, especially for the registration system. Future studies need to be conducted to test the validity and reliability of a wider area of hospital management systems.

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Introduction

According to Indonesia's Ministry of Health regulation number 24, all healthcare facilities must switch from paper-based medical records to electronic by the year 2022. Singapore, Canada, the United States, and a number of other countries have adopted government-centralized electronic medical records. (Salmi et al., 2020; Klecun et al., 2019; Dornan et al., 2019). One health data was the final purpose of the National goals in Indonesia to gather big data of health, but it may take several times to reach that (Adnyana et al., 2023). During the process of technology adoption, hospitals used to develop a healthcare management system to record and monitor patients' health.

In this digital area, the user interface (UI) has a major impact on amplifying the user experience and efficiency in the usage of the system in healthcare facilities (Chen et al., 2021). User interface plays a main role in facilitating interaction between patients, medical records, and healthcare information systems (Rane, 2023). UI's healthcare facilities are built to facilitate the different needs of stakeholders, such as patients and health staff. Interfaces are critical for communication and control for successful interventions and outcomes in digital health scenarios (Gatrio et al., n.d.). Interface design, for instance, is easy to use and intuitive as a key to users getting easy interaction with the system, convenient and effective for recording patients' data (Kang et al., 2020). In order to assess the ease of use and satisfaction of users with the system, a number of usability and user interface evaluation surveys are necessary (Zardari et al., 2021). Moreover, usability and heuristic evaluation were utilized in the evaluation of the user interface, and these parameters need to be adjusted in order to assess the performance of the healthcare system.

In Indonesia, each hospital has its own healthcare management system that may differ from that of another hospital. As a result, each hospital management system might have a different user interface so that health workers feel difficulties operating the system. Recently, hospitals have developed an outpatient registration system to record patients' social and medical data. However, the outpatient registration system used to be improved due to the difficulties in the adoption of the user interface system. It leads to developing UI evaluation in the healthcare management system so that all healthcare workers can easily adopt the system. User interface question for healthcare system (UIQHS) could reflect the view of the user on the user interface of the outpatient registration system in a hospital. In this sense, the development of tools that help measure and develop system user interface also helps improve the efficiency of healthcare system performance.

Methods

Theory

A system's user interface (UI) is a component that serves as a go-between for users and other systems, enabling effective user-system interaction. When utilizing the system, end users interact with the user interface physically, perceptually, and intellectually (Pratama & Cahyadi, 2020). Moreover, there are several aspects that need to be focused on in UI's healthcare facilities based on usability testing, such as satisfaction, efficiency, memorability, learnability, and error (Sharfina & Santoso, 2017; Brooke, 2020). This framework makes it possible to stabilize usability around five main dimensions that are widely used in the field of eHealth (Chaniaud et al., 2020). Heuristic evaluation also used to be evaluation of user interface with ten aspect i.e visibility of system status; match between system and the real world; user control and freedom; consistency and standards; error prevention; recognition rather than call; flexibility and efficiency of use; aesthetic and minimalize design; help users recognize, diagnose, and recover from errors; help and documentation (Nielsen, 2005). The UI aspect was modified from the usability and heuristic aspects to establish the fit aspect for the healthcare system. As a result, user interface evaluation consists of ten aspects such as visibility of system status; match between system and the real world; user control and freedom; consistency and standards; error prevention; flexibility and efficiency of use; help users recognize, diagnose, and recover from errors; eye-catching; privacy and security; documentation. UI has ten aspects spread in 25 questions, then respondents answered these questions using a Likert scale consisting of five values (1–5) from strongly disagree (1) to strongly agree (5). This allowed for a more exploratory quantitative analysis of the data.

Research setting and design

The research was conducted in nineteen hospitals located in Semarang City/ District, Central Java Province of Indonesia, whereas Semarang is an urban city and can therefore represent the characteristics

of Indonesia's healthcare facilities. Three phases made up this study: instrument development in the first, pretest studies in the second, and questionnaire field testing in the third. Stage 1, Academic experts and practitioners in the fields of health and ICT were given access to a questionnaire (UIQHS ver.0) as part of this project. At this point, ten expert responses have been received by the study. UIQHS ver. 1 was produced as a result of the expert evaluation, and this version would be tested in the following phase. Two pilot investigations were conducted by Stage 2, each employing an offline questionnaire given to health workers. UIQHS ver.2 was created after UIQHS ver. 1 was given to a random health worker in the first pilot study, and this version was evaluated in Pilot Study 2. Health workers received UIQHS version 2 from the second pilot project, which also produced UIQHS version 3 for distribution in the subsequent phase. The personnel who handle medical records participated in the third step.

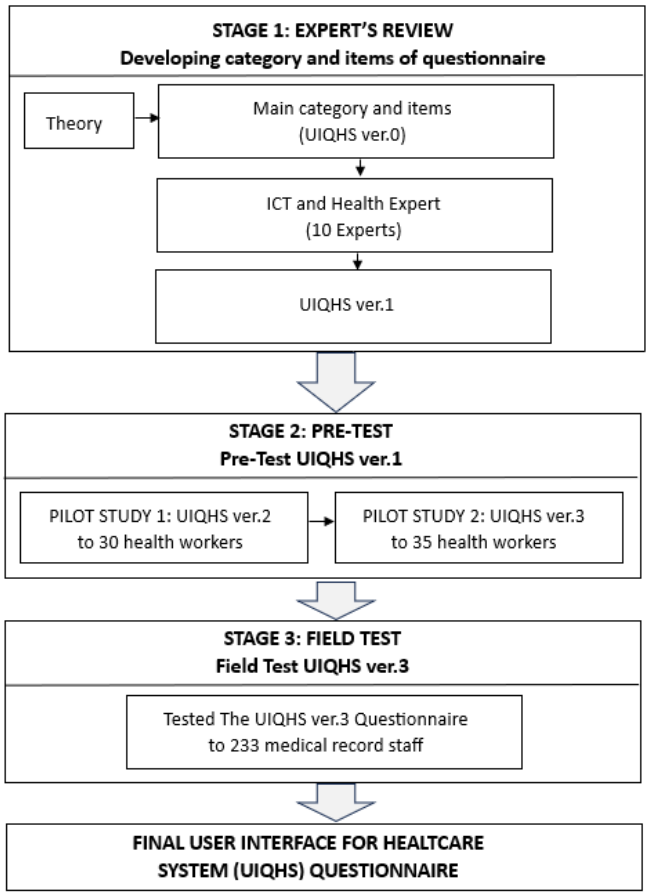

Figure 1. The stages of developing a user interface Quality questionnaire for healthcare system (UIQHS)

Data Analysis

Two stages of data processing were used in this investigation. The UIQHS questionnaire was initially validated using a statistical technique. Internal consistency was assessed using Pearson's product-moment correlation, and Cronbach's alpha was calculated for each item within the scale. The dependability of the instrument is deemed adequate based on the Cronbach's alpha coefficient. The Statistical Package for the Social Sciences (SPSS) was used to conduct the statistical analysis (Bryman & Cramer, 2004).

Results

This literature review stage generated UIQHS ver.0, which consists of 10 indicators with 25 questions that experts will check in the following steps.

Expert review

The first stage consists of literature and an expert review. This study engaged ten experts to review the initial UIQHS questionnaire. The experts consist of three males and seven females. Two of them have Doctoral Education backgrounds, and the rest are experts with Master's Education backgrounds in Informatics and Health Majors. The experts are working as academics and private employees. This stage has the purpose of testing content validity. The experts reviewed the UIQHS ver.0 and judged the importance of each question through Likert Scale responses ranging from strongly unimportant (score one) to strongly important (score 5). The cut-off point at which item questions could be accepted in the items of the questionnaire is using a mean cut-off value of 3.75. This study also used the content validity coefficient (Aiken's V) to quantify the relevance of items based on expert judgment, often requiring values higher than 0.70 for evidence of high validity. (Aiken, L. R.,1980) Table 1 shows that two questions had a score mean below 3.75 and a coefficient below 0.70, so these questions were categorized as invalid in the following form questionnaire. This expert's stage judgment generated UIQHS ver.1 with 25 questions.

Table 1. Reduction of the questionnaire by an expert panel

Question	Statements UIQHS ver.0	Mean	Aiken's V	Valid
UI-1	Everything the system displays can be understood clearly	4,67	0.93	valid
UI-2	The system always displays indicators in the form of progress bars or other things, if there are changes	4,22	0.83	valid
UI-3	The system is designed so that users can easily identify the function of each available control/icon	4,44	0.88	valid
UI-4	The most frequently used functions are found at the top/main system	3,89	0.75	valid
UI-5	The system uses Indonesian which is easy to understand	4,22	0.83	valid
UI-6	The sequence of data in the system has been arranged logically	4,11	0.80	valid
UI-7	Similar items/data become one	4,11	0.80	valid
UI-8	The system provides a button to return to the main menu on each input screen	4,67	0.93	valid
UI-9	The system provides buttons to undo and redo actions that have been performed	4,44	0.88	valid
UI-10	The system provides a warning when leaving the input page	4,22	0.83	valid
UI-11	All saved actions/input can be accessed at any time	4,11	0.80	valid
UI-12	The naming of control buttons/icons on the system is made consistently	4,33	0.85	valid
UI-13	The system is designed to be familiar because it is made in accordance with general system standards	4,33	0.85	valid
UI-14	The system never experiences problems or errors during use	4,00	0.78	valid
UI-15	The system display, both in the form of images and links, functions properly	4,67	0.93	valid
UI-16	The system is able to display or hide the required information	3,89	0.75	valid
UI-17	The system always notifies the location of the error and provides appropriate input suggestions if the user makes an input error	4,67	0.93	valid
UI-18	The system provides a help button when the user does not know how to input data	4,56	0.90	valid

Question	Statements UIQHS ver.0	Mean	Aiken's V	Valid
UI-19	The system uses colors and text that attract attention to convey information	3,67	0.68	Not valid
UI-20	The system has the ability to expand the work area	3,78	0.70	valid
UI-21	The system provides a warning in the form of a sound or vibration whose volume and frequency can be adjusted	3,44	0.63	Not valid
UI-22	Each user has a username and password	4,89	0.98	valid
UI-23	The system provides an exit feature automatically if the time limit has been exceeded (timeout feature)	4,56	0.90	valid
UI-24	All required documents can be accessed	4,44	0.88	valid
UI-25	Area fills in questions as needed	3,78	0.73	valid

Pilot Test

The pilot test stage has two steps; this study randomly distributed an online questionnaire to the health workers and got 30 responses in the first step; later, the questionnaire was distributed to 29 health workers. The UIQHS ver.0 has 25 questions related to the UI'S healthcare system with a range of responses: Very Not Agree (1), Not Agree (2), Neutral (3), Agree (4), Very Agree (5). The first pilot test involved 26,6% males and 73,3% females, with a mean of 3.97 ± 0.92. The second pilot test consists of 34.2% males and 65.7% females (4.18 ± 0.80). Table 3 shows that two of the 25 questions in pilot test 1 and one of the 25 questions in pilot 3 should be excluded because they are invalid. The question numbers 19, 21, and 23. In this stage, the activity resulted in UIQHS ver.3.

Table 2. Reduction the question by pilot test

Question	Statements UIQHS ver.1	Pilot 1 (0.361)	Cronba alpha (0.951)	Pilot 2 (0.367)	Cronba alpha (0.929)
UI-1	Everything the system displays can be understood clearly	.911**	0.946	.714**	0.925
UI-2	The system always displays indicators in the form of progress bars or other things, if there are changes	.863**	0.947	.639**	0.926
UI-3	The system is designed so that users can easily identify the function of each available control/icon	.606**	0.951	.802**	0.923
UI-4	The most frequently used functions are found at the top/main system	.562**	0.951	0.266	0.932
UI-5	The system uses Indonesian which is easy to understand	.416*	0.953	.657**	0.925
UI-6	The sequence of data in the system has been arranged logically	.895**	0.946	.744**	0.924
UI-7	Similar items/data become one	.720**	0.949	.718**	0.924
UI-8	The system provides a button to return to the main menu on each input screen	.763**	0.949	.731**	0.924
UI-9	The system provides buttons to undo and redo actions that have been performed	.697**	0.950	.487**	0.928
UI-10	The system provides a warning when leaving the input page	.502**	0.952	.409*	0.930
UI-11	All saved actions/input can be accessed at any time	.940**	0.946	.672**	0.926

Question	Statements UIQHS ver.1	Pilot 1 (0.361)	Cronba alpha (0.951)	Pilot 2 (0.367)	Cronba alpha (0.929)
UI-12	The naming of control buttons/icons on the system is made consistently	.846**	0.948	.788**	0.924
UI-13	The system is designed to be familiar because it is made in accordance with general system standards	.587**	0.951	.801**	0.922
UI-14	The system never experiences problems or errors during use	.606**	0.952	.489**	0.929
UI-15	The system display, both in the form of images and links, functions properly	.824**	0.947	.758**	0.924
UI-16	The system is able to display or hide the required information	.825**	0.948	.819**	0.922
UI-17	The system always notifies the location of the error and provides appropriate input suggestions if the user makes an input error	.795**	0.948	.732**	0.924
UI-18	The system provides a help button when the user does not know how to input data	.802**	0.949	.567**	0.929
UI-19	The system uses colors and text that attract attention to convey information				
UI-20	The system has the ability to expand the work area	.936**	0.946	.818**	0.922
UI-21	The system provides a warning in the form of a sound or vibration whose volume and frequency can be adjusted				
UI-22	Each user has a username and password	.438*	0.954	.379*	0.930
UI-23	The system provides an exit feature automatically if the time limit has been exceeded (timeout feature)	0.139			
UI-24	All required documents can be accessed	.666**	0.621	.549**	0.927
UI-25	Area fills in questions as needed	.718**	0.707	.769**	0.923

Field Test

In this field stage, UIQHS v.3 was validated by 233 respondents through an offline survey conducted among medical record staff in nineteen hospitals in Semarang City/ District. Table 4 shows that most respondents (66%) are female and graduated from a Diploma (57%), and only 23% ever received higher education. The age range of respondents was predominantly around 21-30 years old. Most respondents had used a mobile phone for an estimated 11-20 years and had never received computer training.

Table 3. The Characteristics of Respondents in the Field Test

Characteristic	f	%
Gender		
Male	99	34%
Female	189	66%
Education		
Senior High School	59	20%
Diploma	163	57%
Bachelor	66	23%

Characteristic	f	%
Age		
< 20 years	4	1%
21- 30 years	163	57%
31- 40 years	92	32%
41- 50 years	25	9%
> 50 years	4	1%
Using computer		
< 5 years	44	15%
5-10 years	84	29%
11-20 years	130	45%
> 20 years	30	10%
Using mobile phone		
< 5 years	10	3%
5-10 years	62	22%
11-20 years	193	67%
> 20 years	23	8%
Ever computer training		
Yes	136	47%
No	152	53%

This study conducted Exploratory Factor Analysis (EFA) with the Principal Component Analysis (PCA) extraction method and Varimax rotation in the field test.

Table 4. Exploratory Factor Analysis (EFA) with the Principal Component Analysis (PCA)

	1	2	3	4
UI-4	0.781			
UI-6	0.759			
UI-15	0.681			
UI-13	0.619	0.481		
UI-2	0.610			
UI-7	0.606	0.535		
UI-1	0.529			0.400
UI-12	0.525	0.471		
UI-16	0.523			
UI-24	0.494			
UI-10	0.461			
UI-5		0.831		
UI-9		0.813		
UI-8	0.402	0.751		
UI-3		0.715		
UI-11		0.663		
UI-25		0.474		
UI-18			0.832	
UI-17			0.823	
UI-22				0.681
UI-14			0.413	0.484
UI-20				0.432

The analysis aimed to confirm the scale's underlying dimensions using data from 233 respondents.

Factor Structure and Loadings

The rotated component matrix revealed a four-factor structure, with most items exhibiting strong factor loadings above the recommended threshold of 0.40 (Hair et al., 2018). The distribution of the items is as follows:

Factor 1: Consists of 11 items (UI-4, UI-6, UI-15, UI-13, UI-2, UI-7, UI-1, UI-12, UI-16, UI-24, and UI-10) with loadings ranging from .461 to .781. This factor represents the instrument's primary dimension.

Factor 2: Comprises 6 items (UI-5, UI-9, UI-8, UI-3, UI-11, and UI-25) with loadings between .474 and .831.

Factor 3: Includes 2 items (UI-18 and UI-17) with high loadings of .832 and .823, respectively.

Factor 4: Contains 3 items (UI-22, UI-14, and UI-20) with loadings ranging from .432 to .681.

Data Refinement and Cross-Loadings

The analysis identified several instances of cross-loading, in which items loaded significantly (>0.40) on more than one component. Specifically, items UI-13, UI-7, and UI-12 showed substantial loadings on both Factor 1 and Factor 2. Similarly, item UI-14 cross-loaded onto Factors 3 and 4.

To achieve a simple structure and ensure high discriminant validity, these cross-loading items were scrutinized. Items with a low discrepancy between loadings (less than 0.20 difference) were considered for elimination to maintain the purity of each dimension. Any items not appearing in the matrix were excluded due to factor loadings falling below the 0.40 cut-off point.

The final EFA results indicate that the instrument possesses solid construct validity. The high factor loadings and the emergence of distinct components suggest that the items effectively measure their intended theoretical constructs.

Table 5 shows that the final UIQHS questionnaire has 10 main indicators with 22 questions. Two indicators, such as privacy and security, are catching only one question.

Table 5. Distribution of main indicators, indicators during validation of the user interface question for the healthcare system (UIQHS)

Question	Statements UIQHS	Expert	Pilot 1	Pilot 2	Field Test
Visibility of system status					
UI-1	Everything the system displays can be understood clearly	valid	Valid	valid	valid
UI-2	The system always displays indicators in the form of progress bars or other things, if there are changes	valid	Valid	valid	valid
UI-3	The system is designed so that users can easily identify the function of each available control/icon	valid	Valid	valid	valid
UI-4	The most frequently used functions are found at the top/main system	valid	valid	valid	valid
Match between system and real world					
UI-5	The system uses Indonesian which is easy to understand	valid	Valid	valid	valid
UI-6	The sequence of data in the system has been arranged logically	valid	Valid	valid	valid
UI-7	Similar items/data become one	valid	valid	valid	valid
User control and freedom					
UI-8	The system provides a button to return to the main menu on each input screen	valid	valid	valid	valid
UI-9	The system provides buttons to undo and redo actions that have been performed	valid	valid	valid	valid

Question	Statements UIQHS	Expert	Pilot 1	Pilot 2	Field Test
UI-10	The system provides a warning when leaving the input page	valid	valid	valid	valid
UI-11	All saved actions/input can be accessed at any time	valid	valid	valid	valid
Consistency and standars					
UI-12	The naming of control buttons/icons on the system is made consistently	valid	valid	valid	valid
UI-13	The system is designed to be familiar because it is made in accordance with general system standards	valid	valid	valid	valid
Error prevention					
UI-14	The system never experiences problems or errors during use	valid	valid	valid	valid
UI-15	The system display, both in the form of images and links, functions properly	valid	valid	valid	valid
Flexibility and efficiency of use					
UI-16	The system is able to display or hide the required information	valid	valid	valid	valid
Help users recognize,diagnose, and recover from errors					
UI-17	The system always notifies the location of the error and provides appropriate input suggestions if the user makes an input error	valid	valid	valid	valid
UI-18	The system provides a help button when the user does not know how to input data	valid	valid	valid	valid
Eye catching					
UI-19	The system uses colors and text that attract attention to convey information	Not valid	delete	delete	delete
UI-20	The system has the ability to expand the work area	valid	valid	valid	valid
UI-21	The system provides a warning in the form of a sound or vibration whose volume and frequency can be adjusted	Not valid	delete	delete	delete
Privacy and Security					
UI-22	Each user has a username and password	valid	valid	valid	valid
UI-23	The system provides an exit feature automatically if the time limit has been exceeded (timeout feature)	valid	Not valid	delete	delete
Document					
UI-24	All required documents can be accessed	valid	valid	valid	valid
UI-25	Area fills in questions as needed	valid	valid	valid	valid

Discussion

Indonesia government used to One Health program to build centralized healthcare data because of healthcare system in Indonesia is not centralized in national system (Hariyati et al., 2020). Moreover, each healthcare system has different user interface that could distress health worker during recording patient's data. In the previous studies, it's known that digital literacy of Indonesian health worker categorized as medium competencies and the remains was high and low competence (Rachmani et al., 2020). Low digital literacy of health worker may cause difficulties to operate system and may going worse if the user interface was bad (Bergson-Shilcock, 2020). To improve the efficiency system, user interface of healthcare system needs to be improved. Result studies in healthcare using usability and heuristic evaluation found that

healthcare system is categorized as good system but still need to improved for several aspect (Kaya et al., 2019; Tang et al., 2006; Ssemugabi & De Villiers, 2010). The evaluation of user interface should emphasize interface aspect such as eye catching and error prevention which is not include in heuristic or usability aspect. This study developed a tool to measure user interface of healthcare system.

The evaluation in user interface of healthcare system may leads health worker to improved working time and enjoyable using system during recording patient's data. Mostly, health worker hadn't gotten computer training before they used the system. As a result, they uncomfortable and find difficulty to operate the system. It would impact the speed of worker to do their jobs. By changing the user interface more familiar than before, worker more likely enjoy and easier using the healthcare system. Recently user interface questionnaire was using heuristic and usability testing, but doesn't measure eye caching aspect in the system. The heuristic framework has ten aspects to evaluate system (Paramitha et al., 2018). This UIQHS adopt the ten aspect and adding three aspects related to user interface so that the 17 questions was valid and reliable to evaluate UI's system. The field test reveals all error prevention and eye catching should be improve in the future development system. Consistently, Indonesian healthcare system is still on processing transfer from paper-based to electronic-based (Ministry of Health Indonesia, 2022). It indicated that the healthcare system in Indonesia should be develop and constantly upgrading to reconcile the Government mandatory.

Conclussion

This study developed UIQHS to measure user interface for healthcare system in hospital, further studies of the previous tool in usability and heuristic questionnaire specially for user interface system evaluation. UIQHS has been proven valid and reliable in measuring user interface of healthcare system. This study reveals that user interface of healthcare system needs to be improved in aspect of eye catching and error prevention. Elevating user interface of healthcare system among medical record staff is urgent to get easy interaction with system, convenient and improve efficiency of healthcare system. Future studies need to conduct to test the validity and reliability of UIQHS in various setting of healthcare management system.

Patents

This questionnaire will be submit as the copy right and publish in https://www. sicerdik.dinus.ac.id.

Authors Contribution

Conceptualization, EW. and ER.; methodology, ER.; software, EW.; validation, EW., ER. and YP.; formal analysis, YP.; investigation, EW. and ER.; resources, AS.; data curation, ZW.; writing—original draft preparation, EW.; writing—review and editing, ER.; visualization, AS.; supervision, ZW.; project administration, AS.;. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of Univesitas Dian Nuswantoro (protocol code 328 and 25 November 2022)." for studies involving humans.

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Conflicts of Interest:

The authors declare no conflict of interest.

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