


ИНФОРМАЦИОННЫЕ ТЕХНОЛОГИИ

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QUALITY OF EXPERIENCE (QOE) METRICS IN COMPUTER-AIDED HEALTHCARE SYSTEMS: A REVIEW

Abstract. This review aims to highlight the current metrics of quality of experience (QoE) related to healthcare ecosystems. Understanding of the current situation and suggesting future directions by examining the landscape of QoE metrics within healthcare ecosystems. In addition, this review paper refers to the subjective metrics including metrics related to the patient itself, and other metrics called objective that are related to the system and network environment. Taking into account the constraints that may exist in the healthcare environment, the analysis takes into account both subjective and objective measures. this study also partitions the case study QoE metrics by determining and integrating to reach better optimization of healthcare ecosystem metrics. Furthermore, future directions for improving QoE evaluation in healthcare include integrating AI, continuous monitoring, and real-time feedback loop metrics should be considered. The results of this study show how to improve patient experiences and guide future investigations in this developing area.

Keywords: QoE metrics, healthcare systems, patient experience metrics, Computer-aided systems.

1. Introduction

Quality of experience (QoE) is defined as “the overall acceptability of an application or service, as perceived subjectively by the end-user. The recommendation also includes the complete end-to-end information about client, terminal, and network infrastructure; and may be influenced by the client context”. Hence, measuring a subjective QoE may differ from one client to another, it is

usually estimated using objective parameters [1, p. 723-734]. The relationship between QoE and QoS is non-trivial and we have to analyze if additional factors can influence the perception of quality for the delivery of multimedia content especially in cloud computing environments and SDN networks. figure 1 shows factors contributing to QoE [2, p. 308-318].

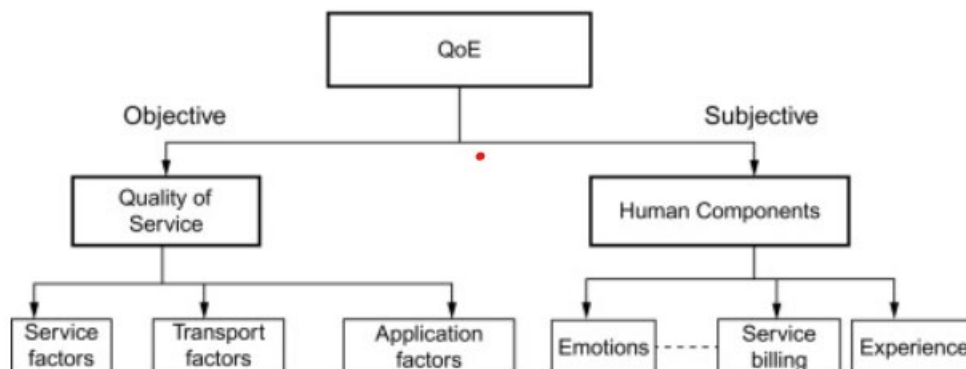


Fig. shows factors contributing to QoE

QoE in healthcare systems reflects overall satisfaction of users with the network system and

services [3, p. 92718-92730]. For personalized and remote healthcare services, and for monitoring

patient conditions QoE is essential. QoE in healthcare systems has become an important dimension in delivering contemporary health services in addition to this. Clinical outcomes solely used to measure the effectiveness of healthcare traditionally, but the new paradigm shift is evolving which recognizes the importance of patient-centered care and places its focus on the overall experience of an individual within the ecosystem of healthcare. In healthcare, QoE represents both subjective and qualitative dimensions related to a patient while coming into contact with clinical efficacy's aspects as well as those other factors contributing towards satisfaction, involvement, and wellness altogether. With years passing by, technology merging along with increased patient-centered care has raised importance towards QoE in Healthcare [4, p. 1-6]. It covers a wide range of issues— usability of healthcare applications, effective communication between patients and providers, seamless integration of technology into workflows, and satisfaction with the healthcare journey [5, p. 102779]. Elements like reaction times, availability of medical records, and compassionate treatment all play a major role in the overall experience quality. The patient experience is expanding with the introduction of telehealth services, health applications, and electronic health records [6, p. 865-876]. One of the most important things is to have these technologies that not only fulfill clinical standards but also improve patient's overall well-being. QoE factors are particularly important in areas such as telemedicine, where the success of remote consultations depends heavily on how easy it is to use, reliable and emotionally connected technology can be [7, p. 3083].

The main point of this argument is that the author wants to understand what QoE in healthcare really involves. The first statement also highlights the fact that there is a systematic review through which the study synthesized past literature. This second statement, on the other hand, says that even if this has been looked at at many angles over time, little remains known about it and hence a new perspective is needed.

2. Contribution of this work

This systematic review's aim is to develop insights and trends from current research work. It is rather based on aggregating different studies therefore being seen as a blue print for future works on quality of care improvement in health. Meaningful insights can be obtained by including only those metrics that are most likely to have an impact on medical care delivery. These

include CES or Customer Effort Score and NPS or Net Promoter Score which are specific metrics used by businesses in the healthcare industry. In addition, its concise tabular format enhances readability making it an excellent resource for understanding and applying QoE measures in various scenarios.

3. Types of qos measurement in healthcare system

QoE metrics [8, p. 8387-8408] The QoE is employed to evaluate a product or service's overall user satisfaction and usefulness. These metrics explore the subjective experience in addition to technical performance [9, p. 1-6]. Typical QoE measures consist of:

3.1 Subjective Metrics:

Mean Opinion Score (MOS): Quantifying the overall quality of a system or service, MOS is commonly used. The users are required to grade their experience on a numerical scale which majorly ranges from 1-5 with five being the highest score [10, p. 2505-2519].

User Satisfaction Surveys: These surveys seek opinions and views of users concerning different aspects of experience. One may ask about usability, content quality and perceived performance among others [11, p. 716-724].

Qualitative Feedback: Users' comments and qualitative feedback can be useful for identifying specific problems, preferences, or areas to work on.

Focus Groups: When done in a well organized manner, Focus groups can provide detailed insights into experiences of users and bring out common threads.

3.2 Objective Metrics:

Bitrate: For video streaming applications, Higher bitrates often offer better quality. However it is vital to balance between quality and bandwidth restrictions [9, p. 1-6].

Frame Rate: The higher frame rates contribute to smoother video playback and improved user experience.

Latency: This is measured as latency where there is delay between action and corresponding response. It therefore implies that low latency is important in real time applications like online gaming and video conferencing [12, p. 2290].

Packet Loss: The network performance would be degraded due to packet loss. Thus lower packet loss usually implies better performance.

Jitter: What is Jitter? It is a variation in the arrival of data packets. For smoother experiences, packets must be delivered consistently.

Resolution: What does resolution mean? Higher resolutions result into better quality of the video and image applications.

Start-up Time: What's it called when the time for an application or service to start is long enough? User satisfaction depends on how long an app or services takes to start.

Error Rates: How often do errors occur? Error rates are measured by glitches or mistakes in userinterface and content delivery.

3.3 Key Metrics for Measuring Patient Experience

Measuring patient experience involves looking at both subjective as well as objective metrics that collectively reveal different aspects of patient satisfaction and wellness within healthcare industry [13, p. 6243-6269]. Here are some of the metrics are used for assessing Patient QoE:

Net Promoter Score (NPS): NPS is one of the most valuable KPIs in healthcare because it gives real-time feedback regarding customer satisfaction and loyalty. The focus must be on promoters,

while detractors should ideally be converted into promoters; thus NPS cannot be used to identify likes and dislikes specifically. Thus, low NPS means there is a high chance that patients will leave their doctor or hospital therefore hospitals have to conduct root cause analysis as well as improve their services in order not to lose any customers due churns.

Customer Effort Score (CES): CES is considered as a driver of loyalty hence can easily be measured using one question only. This score helps measure how many patients found their interaction easy compared with all those who answered.

Customer Satisfaction (CSAT): CSAT help to understand how patient providing specific contact made at the hospital. It calculated by considering the satisfied-responses divided by total-responses.

Number of Open Issues: it help to observing how many issues are still in unresolved state for a specific patient or over a period of time.

Quality Metrics: used to assess how service is given match the patient needs.

Table 1

Shows the summarization of these metrics

Category	Metric	Description
Subjective Metrics	MOS	users rate their experience on a scale of 1 to 5.
	User Satisfaction Surveys	Gathering opinions using surveys.
	Qualitative Feedback	qualitative feed back from user.
	Focus Groups	Structured discussions with a group of user.
Objective Metrics	Bitrate	balancing quality, bandwidth.
	Frame Rate (Fr)	Higher Fr contribute smoother video.
	Latency	Measures the delay between sender and receiver in a time
	Packet Loss	Refers to packet lost, used for asses the network.
	Jitter	Vibration in time of packet delay
	Resolution	Used in video streaming, refers to the quality of the transmitted video.
	Start-up Time	measuring time take for an application or service to start.
	Error Rates	Frequency of error in user application or content delivery.
Patient Experience Metrics	NPS	Indicates patient satisfaction and loyalty, to improve service.
	CES	Measures ease of patient interactions
	CSAT	Assesses how patient perceive specific service at hospital.
	Number of Open Issues	Observe the unresolve issue for a patient over time period.
	Quality Metrics	Evaluate the service match patient needs.

4. Literature Survey of QoE in Healthcare Systems

Several studies discuss the significance of QoE in healthcare systems are illustrated in this survey, highlight the main contributions. Furthermore, the summarization of these studies is presented in table 2.

- In [14, p. 844-856], The authors identify 22 main categorie, 51 sub-categorie that underlie the experience quality concept in healthcare and present them in a classification framework that suggest relationship between experience quality and satisfaction.

- In this paper [15, p. 54-70], the effect of service quality on health-services experience was asses with help of Smart software package, and data was combined via the questionnaire survey.
- In this paper [16, p. 137-140], the authors investigate factors like (technical and non-technical) to evaluate the patients and doctor using the sevice with video consultations (teleconsultations).
- In [17, p. 2483-2500] the authors proposed overview of metrics of assessing quality of medical images, discuss the performance metrics in QoE-oriented resource allocation for health monitors, and provide a taxonomy of different metrics employed to evaluate medical image.
- They proposed in [18, p. 723-734], a novel adaptive QoS computation algorithm (AQCA) for efficient monitoring of system performance indicator, i.e, transmission power,duty cycle, and route selection via medical data processing.
- The main contribution of this research [19] is they develop and work on QoE-driven data communication frame-work for tele-healthcare in Android. The framework introduces a QoE-driven congestion controller (QCC) and a QoE-driven multi-path transmission control protocol (MPTCP) scheduler (QMS). These component

- worked together to enhance data transmission throughput and robust in telehealthcare system.
- The study [20, p. 1195-1214] provide view and perceptions of patient toward the quality of healthcare services. The healthcare service quality dimensions i.e, physical environment, customer-friendly, responsive, communication and privacy. Hospital healthcare service quality was examined in order to find out its effect on patients satisfaction.
- The main Contribution of this study [21] refers to emphasizing its complexity and its close association of patient satisfaction. It highlight the evolving significance of patient experience metric in context of healthcare reimbursement and performance policies.
- The study refers to [22, p. 19-28] qualitative investigated relationship between overall user satisfaction and five key aspect of clinical information system, namely, key functionalitie; efficiency of use; intuitive of graphical user interface, communication, collaboration and information exchange.
- In this paper [23], the authors describe a framework of three short generic measures cover patient experience, result, and integration, used individual or in combination in all levels of the healthcare application providers.

Table 2

The summarization of the literature review

Ref.	Methodology	Main Contributions
[14]	Classification Framework	Identifie 22 main, 51 sub-categories metrics. Suggests a relationship between experience quality and satisfaction.
[15]	SmartSoftware & Questionnaire Survey	Assesses the mediating effect of service quality on health services innovation and outpatient experience. Utilizes SmartPLS for analysis.
[16]	Investigation of Technical and Non-Technical Factors	Investigates factors influence patient and doctor quality of experience
[17]	Overview of Metrics & QoE-Oriented Resource Allocation	Proposes overviews of metrics for assessing medical images.
[18]	Proposal of AQCA Algorithm	Propose an adaptive QoS computation algorithm for efficient monitoring data processing in healthcare applications.
[19]	Development of QoE-Driven Framework	Introduce QoE-driven data communication framework for tele-healthcare using Android device.
[20]	Assessment of Healthcare Service Quality Dimensions	Assesse healthcare service quality dimension and their impact on patient satisfaction and loyalty.
[21]	Exploration of Patient Experience Metrics	Highlight the significance of patient experience metrics in healthcare application and system performance.
[22]	Qualitative Investigation	Investigates the relationship between user satisfaction and key aspect of clinical information system.
[23]	Description of Measures	Describes a framework of three measures covers Patient Experience, Satisfaction Result, and Service Integration for healthcare provider.

5. Conclusions

the review highlight on the main roles of QoE metrics in assessing user satisfaction and across healthcare system. The presented table 1 shows the set of subjective and objective metrics, offering a valuable reference for practitioners and researchers. In addition, covering challenges including subjective in assessment and trying to diverse content, emphasize the need for ongoing studies in QoE methodologies. Addressing issues in the real-time applications and ensures healthcare data security remain critical considerations.

6. Recommendation, Challenges, and Future direction:

Moving forward, future endeavors in QoE in healthcare systems assess should focus on enhancing subjective metrics by develop more robust methods for effective subjective metrics across different users, considering individual perceptions and preferences. Privacy and data security research approach most be considered in future directions to ensure healthcare data security while collecting valuable patient experience data, aligned with stringent privacy regulations. Furthermore, investigates real time optimization strategy to address challenges in latency, ensuring a consistently high-quality user experience in dynamic network conditions. By addressing these future directions, the field can progress toward more standardized, adaptive, and efficiently.

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