

DIGITAL COGNITIVE OVERLOAD IN THE EMERGENCY DEPARTMENT: IMPACT ON CLINICAL PERFORMANCE AND PATIENT SAFETY

DIGITALNA KOGNITIVNA PREOPTEREĆENOST U HITNOM BOLNIČKOM PRIJAMU: UTJECAJ NA KLINIČKU IZVEDBU I SIGURNOST BOLESNIKA

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Abstract

The digitalization of healthcare systems has significantly transformed clinical work in emergency departments. Electronic documentation, patient monitoring systems, alarm systems, digital notifications and parallel team communication enable faster access to information, but simultaneously increase the cognitive burden on healthcare professionals. In emergency settings, where decisions must be made rapidly, often under conditions of uncertainty and incomplete information, an excessive number of digital stimuli may impair attention, slow down decision making and increase the risk of errors.

Digital cognitive overload refers to a state in which the volume of information, the number of concurrent tasks and frequent interruptions exceed an individual's capacity for effective information processing. This narrative review presents current knowledge on digital cognitive overload in emergency care, with a particular focus on its impact on clinical performance, patient safety and work organization. Special attention is given to the sources of digital burden, its effects on clinical decision making, the role of alarms and interruptions, and potential strategies for reducing cognitive load in everyday clinical practice.

Keywords: clinical decision making; digital cognitive overload; emergency department; interruptions; patient safety

Sažetak

Digitalizacija zdravstvenog sustava značajno je promijenila rad u hitnoj službi. Elektronička dokumentacija, monitori, alarmni sustavi, digitalne obavijesti i paralelna komunikacija unutar tima omogućuju brži pristup informacijama, ali istodobno povećavaju kognitivno opterećenje zdravstvenih djelatnika. U hitnoj službi, gdje se odluke donose brzo, često uz nepotpune informacije i visok stupanj nepredvidivosti, prevelik broj digitalnih podražaja može narušiti održavanje pažnje, usporiti donošenje odluka i povećati rizik pogrešaka. Digitalna kognitivna preopterećenost označava stanje u kojem količina informacija, broj istodobnih zadataka i učestalost prekida rada nadilaze sposobnost pojedinca da ih učinkovito obradi. Ovaj narativni pregled prikazuje suvremene spoznaje o digitalnoj kognitivnoj preopterećenosti u hitnoj službi, s naglaskom na njezin utjecaj na kliničku izvedbu, sigurnost bolesnika i organizaciju rada. Posebna pozornost posvećena je izvorima digitalnog opterećenja, posljedicama za donošenje odluka, ulozi alarma i prekida rada te mogućim strategijama smanjenja opterećenja u svakodnevnoj kliničkoj praksi.

Glavne riječi: digitalna kognitivna preopterećenost; hitna služba; kliničko odlučivanje; prekidi rada; sigurnost bolesnika.

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Introduction

The emergency department (ED) is one of the most dynamic and demanding clinical environments within the healthcare system. Clinical work is performed under conditions of time pressure, unpredictable patient inflow, varying levels of illness severity, and the need for rapid decision-making (1). In this setting, healthcare professionals simultaneously assess patients, prioritize care, perform diagnostic and therapeutic interventions, communicate with team members, and document clinical activities (2). Such complexity requires a high level of concentration, rapid information processing, and the ability to manage multiple tasks concurrently (1,3).

The development of digital technologies has substantially transformed workflow organization in emergency medicine. Electronic health records, continuous patient monitoring systems, laboratory and radiology information systems, and various digital communication platforms enable faster access to clinical data, improved coordination of care, and greater availability of real-time information (4). These advances have the potential to facilitate timely clinical decision-making and improve patient outcomes. However, alongside these advantages, digitalization has introduced new demands that may increase the cognitive burden on healthcare professionals, particularly in environments where decisions must be made under significant time pressure (5).

Digital cognitive overload occurs when the volume of information, concurrent tasks, and interruptions exceeds clinicians' capacity to efficiently process information and make safe decisions.

In routine clinical practice, healthcare professionals in the ED are frequently required to simultaneously process information from multiple sources. These include continuous monitoring of vital signs, electronic documentation, interpretation of laboratory and radiological findings, communication with team members, and responses to alarms and other notifications (6). In addition, workflow is often interrupted by telephone calls, requests for consultation, or the arrival of new patients. When these demands occur continuously and overlap, they place increasing strain on attention and working memory, potentially compromising the quality of clinical decision-making (1,5).

Within this context, the concept of digital cognitive overload has gained increasing attention. It refers to a state in which the volume of information, the number of concurrent tasks, and the frequency of workflow interruptions exceed an individual's capacity to efficiently process and integrate information for decision-making (3). Importantly, digital cognitive overload represents more than a subjective perception of mental fatigue; it is associated with measurable reductions in

information-processing efficiency, an increased risk of errors, and impaired ability to sustain attention.

The consequences of excessive cognitive load are particularly pronounced in the emergency department. Even brief lapses in attention may result in delayed recognition of patient deterioration, inaccurate prioritization, or failures in communication within the clinical team (2). These factors increase the risk of patient safety incidents, particularly in situations requiring rapid and precise coordination among multiple healthcare professionals. Furthermore, chronic exposure to excessive cognitive demands may contribute to mental fatigue, reduced work performance, and professional burnout (7).

The aim of this review is to examine the role of digital cognitive overload in the emergency department, with particular emphasis on its impact on clinical performance, decision-making, and patient safety. In addition, the review seeks to identify the principal sources of digital cognitive burden and to highlight potential strategies for reducing cognitive load and improving the alignment of digital systems with the needs of contemporary clinical practice.

Methodology

This study was designed as a narrative review of recent scientific and professional literature with the aim of synthesizing current knowledge on digital cognitive overload in the emergency department. A narrative review approach was selected because it allows the integration of heterogeneous sources, including studies from emergency medicine, nursing, health informatics, ergonomics, and human factors, which provide complementary perspectives on this topic.

The literature search was conducted using the PubMed, Scopus, and Web of Science databases. Publications from 2015 onwards were considered, with particular emphasis on recent studies reflecting contemporary trends in healthcare digitalization. The search strategy included keywords related to cognitive workload, digital health systems, workflow interruptions, alarm systems, electronic health records, and patient safety in acute clinical settings.

The review included original research articles, systematic and narrative reviews, and relevant professional publications examining the impact of digital technologies on the work of healthcare professionals in emergency departments, intensive care units, and other acute care settings. Particular attention was given to studies investigating the relationship between cognitive workload, clinical performance, and patient safety outcomes.

Studies focusing exclusively on the technical development of software solutions without clinical application, investigations conducted in non-clinical settings, and publications without a clear relevance to clinical practice or patient safety were excluded. This approach ensured that the review included literature directly applicable to the emergency department setting.

Table 1. Main Sources of Digital Cognitive Overload in the Emergency Department

Source	Description	Consequence
Electronic medical records (6,8)	Multiple data entries and complex system navigation	Fragmentation of attention and prolonged information-processing time
Alarm systems and monitors (9,10,27)	Large number of auditory and visual alerts, often with low clinical relevance	Alarm fatigue and reduced sensitivity to important signals
Work interruptions (1,11,17,22,23)	Telephone calls, questions from team members, and arrival of new patients	Loss of focus and increased risk of errors
Parallel use of multiple systems (6,12,13)	Insufficient integration of laboratory, radiology, and documentation systems	Increased mental workload and impaired navigation
Continuous data interpretation (2,6,12)	Large volume of information requiring rapid assessment	Impaired decision-making and selective information processing

Source: Prepared by the author based on a synthesis of the literature (1–3,6,8–13,17,22,23,27).

This study did not involve human participants or the processing of personal data; therefore, ethics committee approval was not required.

Discussion

Sources of Digital Cognitive Overload in the Emergency Department

The cognitive demands of the digital environment in the emergency department arise from the combination of multiple interrelated factors that operate simultaneously and cumulatively burden healthcare professionals' attention and working memory (3). Rather than resulting from a single source, digital cognitive overload reflects the interaction of numerous technological, organizational, and human factors that collectively create substantial challenges in everyday clinical practice.

One of the principal contributors to digital cognitive overload is the electronic health record (EHR). Although EHR systems improve data standardization and accessibility, their use often requires repeated data entry, navigation through complex interfaces, and frequent switching between different modules (8). Workflows characterized by repetitive documentation, complex navigation, and continuous transitions between system interfaces may fragment attention and prolong the time required to process clinical information, particularly in situations that demand rapid decision-making.

Patient monitoring systems and clinical alarm systems represent another major source of cognitive burden. Patients in the ED are frequently connected to multiple monitoring devices that generate large numbers of audible and visual alerts (2,9). A high frequency of alarms, particularly those lacking clinical relevance, may contribute to alarm fatigue and reduce clinicians' ability to recognize alerts requiring immediate intervention (10). Consequently, an environment characterized by continuous auditory and visual stimuli requires constant redistribution of attention and increases mental workload.

Frequent workflow interruptions further intensify cognitive demands. In the emergency department, interruptions are an integral part of routine clinical practice and include telephone

calls, questions from team members, the arrival of new patients, and additional documentation requests (11). Such interruptions increase the risk of clinical errors and reduce work efficiency.

The concurrent use of multiple digital systems further increases workflow complexity. Healthcare professionals often interact simultaneously with electronic documentation systems, laboratory information systems, radiology platforms, and digital communication tools (8,12). Insufficient interoperability between these systems may result in duplicated information, inefficient navigation, and increased cognitive workload. Rather than simplifying clinical practice, technology may, under such circumstances, become an additional source of complexity (12).

An important but often overlooked contributor to cognitive overload is the continuous need to interpret large volumes of clinical data. The increasing availability of patient information requires rapid assessment and integration into clinical decision-making (2). Under conditions of significant time pressure, these cognitive demands may exceed an individual's capacity for efficient information processing.

In addition to these technological and organizational factors, individual characteristics also play an important role. Professional experience, level of training, and the ability to manage attention all influence susceptibility to cognitive overload (13). Less experienced healthcare professionals may be particularly vulnerable because they require greater cognitive effort to process clinical information, whereas experienced clinicians, despite greater routine and expertise, may be exposed to chronic cognitive burden resulting from prolonged work in a highly demanding environment (14).

Digital cognitive overload in the emergency department results from the cumulative interaction of technological, organizational, and human factors rather than from a single source.

Overall, digital cognitive overload in the emergency department is not attributable to a single cause but rather reflects the complex interaction of technological, organizational, and human factors. Understanding these contributing factors represents an essential step toward developing strategies aimed at reducing cognitive burden and improving patient safety.

Impact of Digital Cognitive Overload on Clinical Performance

Excessive digital demands have a direct and measurable impact on the clinical performance of healthcare professionals working in the emergency department (ED). In an environment where decisions must be made rapidly and often on the basis of incomplete information, any disruption in information processing or sustained attention may have significant consequences for patient management (15).

One of the most important aspects of clinical performance affected by cognitive overload is decision-making. Under conditions of increased digital workload, working memory capacity is reduced and the integration of information from multiple sources becomes more difficult (2,13). As a result, healthcare professionals may make decisions based on incomplete or selectively processed information, increasing the risk of diagnostic errors and suboptimal therapeutic interventions (16). These challenges are particularly pronounced in the emergency department, where patients' clinical conditions may change rapidly. Furthermore, the complexity of digital systems and the need to use multiple platforms simultaneously may slow workflow, fragment attention, and reduce the overall efficiency of healthcare professionals (17).

Another critical component of clinical performance is the ability to maintain situational awareness (18). In the emergency department, situational awareness involves continuous monitoring of patient status, understanding the clinical context, and anticipating potential complications. The large volume of information and continuous stream of digital stimuli may compromise this ability by making it more difficult to distinguish clinically relevant information from less important data (12). Consequently, deterioration in a patient's condition may be recognized later, and early signs of complications may be overlooked.

Team communication is also highly susceptible to the effects of cognitive overload. Under conditions of increased mental workload, healthcare professionals may shorten or simplify communication, thereby increasing the risk of misunderstandings (19). Workflow interruptions and digital distractions further impair information exchange among team members, particularly during critical phases of patient care (20). Communication failures may directly affect care coordination and compromise patient safety.

Digital cognitive overload is also associated with increased mental fatigue, which develops following prolonged exposure to high information-processing demands. Mental fatigue reduces concentration, slows reaction time, and increases

susceptibility to errors (21). In the emergency department, where sustained attention is essential, these effects may significantly compromise the quality of patient care.

The consequences of excessive cognitive workload often manifest as a gradual decline in performance over the course of a work shift (2). As cognitive demands accumulate, the ability to maintain a consistently high level of clinical performance progressively decreases, leading to an increased likelihood of errors, particularly during the later stages of the shift (22). Collectively, these factors adversely affect key components of clinical performance, including clinical decision-making, workflow efficiency, situational awareness, and communication within the healthcare team.

Impact of Digital Cognitive Overload on Patient Safety

Patient safety is a fundamental indicator of healthcare quality, particularly in the emergency department, where clinical decisions are made rapidly and often under conditions of considerable uncertainty (23). In such an environment, excessive digital cognitive workload is not merely an individual challenge for healthcare professionals but also a systemic risk that may directly affect patient safety outcomes.

One of the primary mechanisms through which cognitive overload compromises patient safety is by increasing the likelihood of clinical errors. Under conditions of excessive demands on attention and working memory, healthcare professionals may overlook critical information, misinterpret clinical findings, or make decisions based on incomplete data (22). Importantly, these errors are not necessarily the result of insufficient knowledge or experience but frequently reflect the limitations of human cognitive capacity under conditions of high workload.

Workflow interruptions and digital distractions represent another important threat to patient safety. Healthcare professionals in the ED are continuously exposed to multiple simultaneous stimuli, including monitor alarms, notifications from electronic information systems, and communication with other members of the clinical team (20). Each interruption increases the risk of losing focus and forgetting previously initiated tasks. During medication administration, clinical documentation, or patient monitoring, such interruptions may lead to delays in intervention or errors in task execution (17).

Digital cognitive overload is a systemic patient-safety risk that can delay recognition of clinical deterioration, increase errors, and impair communication and timely clinical responses.

Excessive digital demands may also impair the timeliness of clinical responses. When healthcare professionals must

Table 2. Strategies for Reducing Digital Cognitive Overload in the Emergency Department

Level	Strategy	Clinical effect
Technological	Simplification of user interfaces (29,30)	Reduced information-processing time
Technological	Filtering and prioritization of alarms (27,31)	Reduced distractions and alarm fatigue
Technological	Integration of digital systems (6,12,29)	Easier access to information and reduced mental workload
Organizational	Standardization of protocols (32)	Reduced need for continuous decision-making
Organizational	Clear distribution of responsibilities (32,33)	Improved coordination and patient safety
Organizational	Limiting interruptions during critical tasks (17,32,33)	Preservation of focus and reduction of errors
Individual	Education on cognitive workload (2,3,34)	Improved decision-making
Individual	Training in prioritization and time management (2,17)	Increased work efficiency
Individual	Simulation-based training (35)	Better preparation for high-workload situations

Source: Prepared by the author based on a synthesis of the literature (2,3,6,12,17,27,29–35).

simultaneously process large volumes of information, the time required to recognize clinically significant changes may be prolonged (22). Delayed recognition of patient deterioration may have serious consequences, particularly in acute conditions requiring immediate intervention (24).

Reliable communication within the healthcare team is another essential component of patient safety. Increased cognitive workload may lead to simplified or incomplete communication, thereby increasing the risk of misunderstandings (25). Ambiguous or insufficiently precise information exchange may result in misinterpretation of clinical instructions, delays in treatment, or duplication of interventions (26).

Although digital systems are designed to enhance patient safety, they may under certain circumstances introduce additional risks. The large number of electronic alerts and notifications may lead to reduced responsiveness to clinically important warnings, a phenomenon commonly referred to as alert fatigue (27). When healthcare professionals are exposed to excessive numbers of digital alerts, important notifications are more likely to be ignored or their response delayed.

The cumulative effects of prolonged cognitive workload become particularly evident during extended work shifts. As mental fatigue increases, the ability to maintain sustained attention and accuracy progressively declines, further increasing the likelihood of errors (28). Consequently, even routine and standardized clinical tasks may be performed with greater variability and a higher risk of safety incidents.

Patient safety incidents rarely result from a single contributing factor. Instead, they typically arise from the interaction of multiple elements, including organizational processes, technological systems, and human factors. Digital cognitive overload acts as an intermediary mechanism that amplifies the effects of these risks and reduces healthcare professionals' ability to respond promptly to changes in the clinical environment (17,22).

Overall, digital cognitive overload represents a significant but still underrecognized risk factor for patient safety in the emergency department. A better understanding of its effects is

essential for developing effective strategies aimed at reducing clinical errors, improving working conditions, and enhancing the overall quality and safety of patient care.

Strategies to Reduce Digital Cognitive Overload in the Emergency Department

Reducing digital cognitive overload in the emergency department (ED) requires a systematic, multilevel approach that encompasses organizational changes, optimization of digital technologies, and the development of individual competencies among healthcare professionals (17). Because digital cognitive overload arises from the complex interaction between humans, technology, and the work environment, effective interventions must address all of these domains.

One of the key strategies involves optimizing digital systems. Clinical information systems should be designed to support, rather than burden, the work of healthcare professionals (8,29). This includes simplifying user interfaces, reducing unnecessary data entry steps, and presenting clinical information in accordance with users' priorities. Systems requiring repeated entry of identical information or presenting data in complex and poorly organized formats substantially increase cognitive workload and reduce work efficiency (30).

Particular attention should also be paid to the management of digital notifications and alarm systems. A large number of alerts, especially those of limited clinical relevance, may lead to alert fatigue and reduced responsiveness to important warnings (30). Prioritizing notifications, filtering non-essential alerts, and adjusting alarm thresholds according to the clinical context can substantially reduce unnecessary workflow interruptions (31). Such measures enable healthcare professionals to focus their attention on clinically relevant information and support more effective decision-making.

Work organization also plays an important role in reducing cognitive workload. Clearly defined team responsibilities, standardized clinical workflows, and structured protocols can reduce the need for repeated decision-making in routine situations (32). By minimizing routine cognitive demands, workflow interruptions, and the need to process multiple

information streams simultaneously, healthcare professionals can devote greater attention to clinically critical tasks, such as assessing unstable patients and making timely therapeutic decisions (33).

In the emergency department, where interruptions are frequent, specific organizational measures may further reduce distractions and the risk of errors. These include limiting non-urgent communication during critical procedures, establishing interruption-free zones during medication administration, and using visual indicators to signal that high-risk tasks are being performed.

Reducing digital cognitive overload requires a multilevel approach that combines better-designed digital systems, smarter alarm management, optimized workflows, and targeted staff education

Education of healthcare professionals represents another essential component of reducing cognitive overload. Understanding the concept of cognitive workload and its effects on clinical performance may help clinicians recognize high-risk situations and adapt their work practices accordingly (34). Educational initiatives may include training in time management, task prioritization, and effective team communication. In this context, simulation-based training may be particularly valuable, as it enables healthcare professionals to practice working under conditions of high cognitive demand without compromising patient safety (35).

The role of nurses in mitigating cognitive overload is particularly important. As healthcare professionals who remain continuously present at the patient's bedside, nurses play a central role in workflow organization, prioritization of care, and coordination of clinical activities. Their experience and ability to identify clinically relevant information in complex environments constitute important protective factors for maintaining patient safety (2,17). Furthermore, actively involving nurses in the design and adaptation of digital systems may contribute to the development of solutions that are better aligned with the realities of clinical practice (34).

Technological innovations may also contribute to reducing cognitive workload, provided they are implemented appropriately (17). Automation of routine tasks, integration of multiple information systems, and the use of intelligent clinical decision support systems may reduce the need for manual data entry and facilitate rapid access to relevant clinical information (6). However, it is essential to ensure that these technologies do not introduce additional cognitive burden through unnecessarily complex or non-transparent functionalities.

At the organizational level, it is important to recognize cognitive workload associated with digital systems as a

significant occupational challenge (2). Systematic assessment of cognitive workload, analysis of clinical workflows, and active involvement of healthcare professionals in decisions regarding the implementation of new technologies may contribute to creating a safer and more efficient work environment. Measures promoting adequate rest, task rotation, and balanced work schedules may further reduce the cumulative effects of cognitive overload during clinical shifts (36).

Healthcare professionals should be actively involved in the design and implementation of digital systems to ensure that technology supports clinical work rather than adding to cognitive burden.

The overarching goal of these strategies is to achieve an appropriate balance between technological capabilities and human cognitive capacity. Only an integrated approach that acknowledges the complexity of emergency department practice can effectively reduce digital cognitive overload and improve patient safety.

Conclusion

Digital cognitive overload represents an increasingly important, yet still underrecognized, challenge in everyday emergency department (ED) practice. In an environment characterized by time pressure, unpredictability, and the need to manage multiple concurrent tasks, continuous exposure to digital information, notifications, and workflow interruptions may exceed the cognitive capacity of healthcare professionals. Consequently, the risk of clinical errors, delayed responses, and communication failures increases, directly affecting patient safety.

Current evidence suggests that excessive digital demands are not solely a consequence of the growing use of technology, but rather of the way digital systems are integrated into clinical workflows. Systems that are not aligned with the practical needs of emergency care may increase workflow complexity and impair clinical decision-making. Conversely, well-designed and optimized digital tools have the potential to improve workflow efficiency, support clinical decision-making, and enhance the quality and safety of patient care.

Reducing the cognitive demands imposed by digital systems requires coordinated interventions at multiple levels, including optimization of digital technologies, improvements in workflow organization, and continuous education of healthcare professionals. Nurses play a particularly important role in this process, as their continuous presence at the patient's bedside and responsibility for coordinating clinical activities contribute substantially to maintaining patient safety in a complex healthcare environment.

Ultimately, recognizing and proactively addressing digital cognitive overload represents an important step toward improving patient safety and the overall quality of emergency care. Future research should further elucidate the mechanisms underlying digital cognitive overload and evaluate the effectiveness of targeted interventions aimed at reducing cognitive burden and optimizing digital workflows in clinical practice.

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