Development and Evaluation of Desktop and Web-Based Applications for Nutritional Intake Monitoring in Intensive Care Units: Usability and Workflow Efficiency

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Nutrition is an important factor in the recovery of critically ill patients and should be monitored to ensure optimal intake. Different types of applications can be used to assist in monitoring. The aim of this study was to evaluate the usefulness and implications on working practice of different types of applications for monitoring the nutrient intake of patients in hospitals. For this purpose, a desktop and a web application for nutrient intake monitoring were developed and deployed in a hospital at different points in time. The desktop application has been in use for a longer period, while the web application is still in the testing phase. A comparative observational study was conducted, in which ICU staff monitored nutrient intake using traditional non-assisted methods, the desktop application, and the web application. Task completion times, user satisfaction, and perceived effects on patient outcomes were recorded. Time-on-task data were collected by direct observation, while user feedback was obtained through structured surveys assessing acceptability, usability, and workflow integration. There were 8 respondents for the desktop and three for the web application. Both applications were well received by staff. The most important measurable result was a 25% reduction in task completion time with the desktop application compared to non-assisted monitoring, and an additional 6.6% reduction when using the web application compared to the desktop version. Users reported no perceived impact on treatment outcomes. Both applications simplified nutrient intake management and proved useful in the ICU context, with the primary benefit being time efficiency rather than changes in patient recovery indicators.

Povzetek:

1 Introduction

In recent few decades, computer have had a major impact in numerous areas. Medical care at home or in hospitals, where various devices and supporting applications are used extensively, is no exception. One aspect is the also treatment of critically ill patients in the intensive care unit (ICU). Various devices using different techniques such as wireless EEG monitoring devices [1], or smartphones for pupil and iris identification [2] are already part of regular clinical practice or are being considered to support monitoring and recovery of critically ill patients. Adequate dietary care also plays an important role in recovery [3, 4]. Adequate nutrition during and after ICU stay is essential for efficient recovery [5]. Observational studies suggest that negative energy balance may have adverse effects [6, 7]. Recent studies also suggest that malnutrition of a patient may affect the length of stay after procedure [8], whereas adequate nutrition of the patient can help to improve outcome, promote recovery and reduce the rate of complications after surgery [9, 10, 11, 12, 13]. Some studies also suggest that higher nutritional intake may be associated with lower mortality in critically ill patients [14] and with longer survival and faster physical recovery up to 3 months after discharge [15]. Higher caloric intake was also associated with lower mortality in critically ill [16], whereas early high protein intake was associated with lower mortality in critically ill patients with low skeletal muscle area [17]. Improvement in protein intake during hospitalization was also associated with reduced mortality odds in the 3 months after discharge [18]. An observational study reported that increased energy and protein intake may improve clinical outcomes [3], and several studies suggest that meeting recommended intakes early in ICU stay may benefit septic patients [19]. Yet evidence is mixed, as a systematic review found no association between target energy intake and mortality [20]. This uncertainty underscores the importance of reliable monitoring tools, even if mortality benefits remain inconclusive.

In critically ill patients enteral nutrition is often inadequate, so supplemental parenteral nutrition may also be administered. According to ESPEN guidelines [21], supplemental parenteral nutrition should be initiated if enteral intake does not meet target intake within three days of admission. One study suggested supplemental parenteral nutrition after four days in the ICU [22]. SCCM/A.S.P.E.N. guidelines [23] also recommend supplemental parenteral nutrition after seven to 10 days for patients at high or low nutritional risk. In most cases, early parenteral nutrition has been recommended [24], although one study [25] reported increased morbidity associated with parenteral nutrition. In contrast, two observational studies [26, 27] found no differences between the different modalities of nutrition. Supplemental parenteral nutrition is often beneficial to the patient but timing, amount, and composition remain to be determined [28]. The effects of enteral nutrition are easier to manage, but parenteral nutrition is easier to administer and often necessary, so a combination of the two modalities may be more appropriate in critically ill patients [29], with computer-assisted tools facilitating optimal delivery.

Various tools are needed to assess the nutritional status of critically ill patients [30] and to monitor nutrient intake. The using of nutrient delivery monitoring system can improve nutrient delivery and enhance quality of care [31]. The use of available eHealth technologies, allows for easier management of each patient's nutrient intake. Such systems could also help to ensure compliance with nutritional recommendations, which are not always strictly followed in ICU [32, 33, 34, 35]. Since malnutrition prevalence may be even higher at ICU discharge than at admission [36], computerized tools and applications could help mitigate this problem. At the same time, advances in IoT-enabled healthcare systems have demonstrated the potential of remote monitoring solutions, particularly during the pandemic era, where deep learning and edge analytics have been applied to improve diagnostics and continuity of care [37]. These developments highlight the growing importance of integrating sophisticated technologies into healthcare applications.

New technologies enable the development of diverse applications. Beyond desktop software, smartphone applications are increasingly evaluated for healthcare tasks, such as body length estimation in children [38] or optical blood pressure monitoring [39]. Computerization has also shown performance benefits in other fields, such as construction management [40]. In healthcare, handheld devices can improve information seeking and clinical decision-making [41], though suitability depends on the task.

Usability has been emphasized across domains: in tourism, the LOCUS mobile application demonstrated high effectiveness and efficiency [42]; in surgery, gesture-based systems enabled sterile, touchless image navigation [43]; and in accessibility, deep learning–based applications have supported visually impaired users in healthcare management tasks [44]. Together, these examples highlight that the success of computerized systems depends not only on technical functionality, but also on usability, accessibility, and the organizational context in which they are deployed.

Several studies also evaluated the usability of different systems to support diet tracking and clinical decisions. Table 1 shows summary of the usability studies.

This article presents and compares two forms of applications for managing patient nutrient intake: a desktop application and a newer web application. For clarity, we refer to the two tools consistently as the desktop application and the web application. The latter was primarily accessed on mobile devices, but the term web application is used throughout the manuscript to avoid ambiguity. It also presents usability statistics, user responses, and the impact of both applications on ICU work and treatment outcomes. Both applications were developed in collaboration with Jesenice General Hospital, Anesthesiology and reanimation department, which is responsible for the ICU.

2 Methods

The primary aim of this study was to evaluate the usability, task efficiency, and perceived impact on patient treatment outcomes of two applications for nutrient intake monitoring in the ICU: a desktop application and a responsive web application. Both applications were developed and deployed within the same hospital environment at different time points. We hypothesized that:

– Both applications would demonstrate higher usability ratings compared to non-assisted nutrient intake monitoring.

– Use of the applications would reduce average task completion time, with the web application providing additional time savings over the desktop version.

– Neither application would negatively affect the perceived impact on patient treatment outcomes as reported by clinical staff.

The study was conducted among ICU staff involved in monitoring nutrient intake during the application of the treatments. The Institutional Ethics Committee (No. 860-7/2022/2) determined that formal approval was not required but mandated that informed verbal consent be obtained from all participants. Accordingly, consent was obtained verbally prior to participation, in line with the minimal-risk, survey-based nature of the study. Participation was voluntary, responses were anonymized, and staff were assured that declining or withdrawing would have no consequences. These safeguards were implemented to minimize the influence of hierarchical power dynamics within the ICU.

To support nutrition intake monitoring two applications were designed: a desktop application, which was developed first, and a responsive web application, developed later. The development process began with a requirements elicitation process in which both functional and non-functional requirements were identified through interviews with the intended users. Paper prototypes were created and iteratively refined based on user feedback to improve usability.

The applications implemented an established nutritional logic based on clinical guidelines for calculating nutrient requirements. These included the Harris-Benedict equation [50], adjustments for clinical conditions [51] and specific modifications for patients with amputations [52, 53].

Table 1: Overview of usability studies evaluating nutrition monitoring, clinical decision support, and diet-tracking systems. The table summarizes study populations, methods, evaluation metrics, and key findings for comparison with the present work.

Study	Design	Settings	Metrics	Key findings (selected)
Kong [45]	Field usability study; mixed methods (logging & M-MAUQ)	30 participants	M-MAUQ; qualitative feedback; task logging	M-MAUQ = 5.13 (7); Small-sample real-world test; task-entry reduction claimed.
Ferrara [46]	Review of diet-tracking apps	Consumer apps across multiple studies	Usability metrics (SUS, engagement), accuracy comparisons	Apps report good usability; metrics heterogeneous across studies.
Molloy [47]	Usability evaluation (SUS + think-aloud; task timing)	ICU clinicians children's hospital;	SUS n=51; think-aloud n=10	SUS median = 87.5 (IQR 80–95); task times observed: 2–92 s (role-stratified means reported in paper).
de Watteville [48]	Usability study (bedside trials; semi-structured interviews)	Adult ICU caregivers; 55 caregivers; 20 interviewed	*Perceived* metrics	70% rated tool convenient; 85% believed it would improve guideline adherence; 80% of nurses considered it time-saving. Reported downsides: manual data entry, IT integration.
Bakhoum [49]	Observational and systematic time-motion studies	Nurses and clinicians across hospitals	% shift spent in EHR; mean task durations; documentation burden	Substantial fraction of shift time interacting with EHRs (20%+); task durations vary widely across workflows.

In terms of technical architecture, the desktop application was developed in Java and connected to a PostgreSQL database via the hospital's intranet, while the web application was designed as a single-page application using Angular with the same PostgreSQL backend. Both applications followed a client-server model and included modules for authentication, nutrient tracking and reporting. To ensure data security, role-based access control, TLS encryption and database-level restrictions were implemented.

Finally, both the desktop[1] and web[2] applications are available through Git repositories, allowing for transparency and potential reuse. Figures 1 and 2 illustrate the final user interfaces of the desktop and web applications, respectively.

To evaluate the applications, all ten ICU staff members, that were using the applications, were invited to participate (9 female and one mail ICU staff members; 9 physicians, one nutritionist). Eight provided responses for the desktop application, and three of these also provided responses for the web application. All participants were employed in the same ICU and used the applications in the context of daily patient care. Demographic information (e.g., years of experience, profession of the participants) was not systematically recorded.

The evaluation consisted of two complementary approaches. Firstly, usability was assessed using a self-administered questionnaire with 16 items, based on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). The questions related to ease of use, task efficiency and perceived impact on patient care. Secondly, extensive pilot testing was carried out during development, allowing the research team to verify functionality and ensure smooth integration into ICU workflows

The responses to the survey were analysed descriptively (mean values, standard deviations, medians, interquartile ranges). For the three participants who completed the questionnaire for both the desktop and web application, responses were compared using the Wilcoxon signed-rank test to explore differences in perceived ease of use and efficiency. Due to the small sample size, the results are interpreted as exploratory.

The desktop application was already routinely in use in the ICU at the time of the evaluation, which made it familiar to staff and facilitated the integration into the ICU workflows. In contrast, the web application was still being trialled and was only in limited use. Consequently, comparisons between the two applications should be interpreted primarily in terms of user perception and usability rather than long-term operational results.

To provide a clear overview of the research process, a structured workflow of the study design is shown in Figure 3. The diagram illustrates the sequential steps, starting with the collection of requirements through interviews and paper prototypes, followed by the development and pilot testing of the desktop and web applications. Participants

[1]https://gitlab.com/slarty/Nutrition-Desktop
[2]https://gitlab.com/slarty/Nutrition-Web

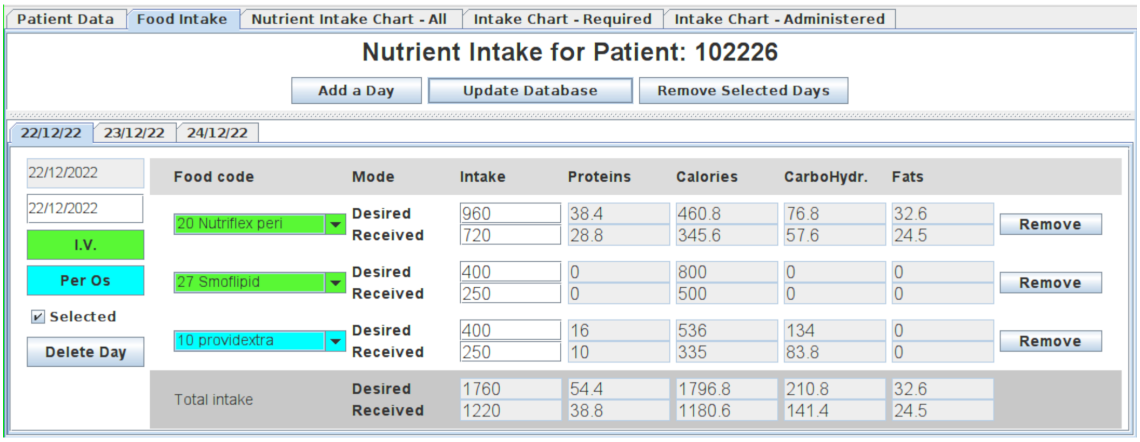

Figure 1: Screenshot of the desktop application interface showing the computerized nutrition form for a selected ICU patient on a specific day. The interface allows staff to enter and review daily nutrient intake, with navigation across days provided in the lower section.

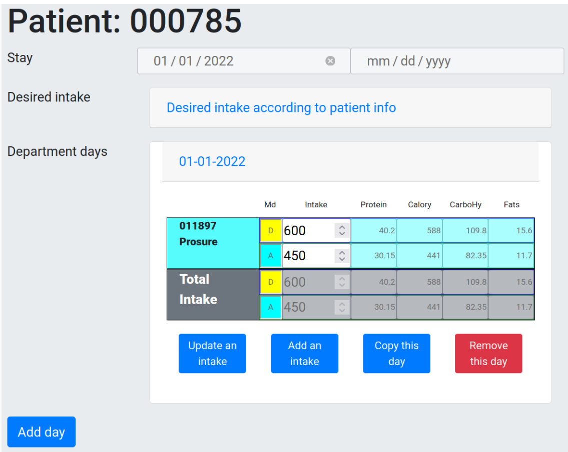

Figure 2: Screenshot of the web application interface in mobile mode for managing the nutrition intake of a selected ICU patient. The application enables quick entry and review of daily nutritional data via a smartphone or tablet.

were then recruited from the ICU staff and usability data were collected using a 16-item questionnaire. Finally, descriptive and inferential analyses, including the Wilcoxon signed-rank test, were conducted to interpret usability, task efficiency and perceived clinical impact.

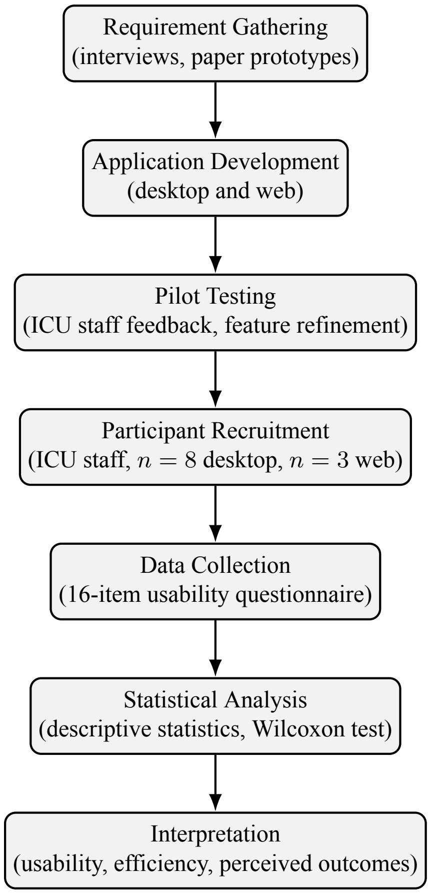

Figure 3: Workflow of study methodology, from requirement gathering and application development to evaluation and analysis.

3 Results

In order to obtain users perceptions of the application and its potential impact on ICU work, a questionnaire was developed with questions about different aspects of usability [54] of interest. The questionnaire consisted of statements for which users could select the level of agreement. The Likert scale [55] with five response levels was used: strongly disagree, disagree, undecided, agree and strongly agree. For the middle point the value "undecided" was used because there are negligible differences when "undecided" or "neutral" is used [56], but it was assumed that the value "undecided" would be less ambiguous. For the analysis values from 1 to 5 were assigned for response levels ranging from

”strongly disagree” to ”strongly agree”, with possibility of not answering a given question. The questionnaire was presented to application users at that time. Unfortunately, several factors affected this study and the number of participants involved. The first factor was that the department (the ICU) in which the study was conducted, was relatively small, which limited the number of possible participants. The other factor is the very demanding work in the ICU, which affects the staff turnover. Only a relatively small number of people work in the ICU for an extended period of time. Ten ICU staff members were invited to participate in the study. Of these, eight completed the questionnaire regarding the desktop application, and three completed it for the web application. No formal inclusion or exclusion criteria were applied; all ICU staff members involved in nutrient intake monitoring at the time of deployment were eligible to participate. The questionnaire was administered online via a secure web-based survey tool. Participants were able to complete the survey at a time convenient to them, no identifying information was collected, and they could also not answer a question. The questionnaire consisted of items assessing usability, efficiency, and perceived impact on patient treatment outcomes, primarily using a five-point Likert scale. The questionnaire was developed for this study and was not formally validated or pilot tested prior to deployment.

The survey results for the desktop application ($n = 8$) are shown in the table 2 (the second column shows the number of responses, the third gives the average of the responses with standard deviations, while the fourth gives the median with interquartile range) and visually represented in the Figure 4. Users liked the appearance (mean = 4.1 ± 1.3; median = 4.5), the color and widget selection (4.4 ± 1.1; 5) and the size of widgets and fonts (4.4 ± 1.1; 5). Users were less likely to agree that the application was pleasant to use (3.9 ± 1.1; 4), but felt that the application was learnable (4.5 ± 1.1; 5) and easy to use once learned (4.6 ± 0.5; 5), with good error prevention and recovery mechanisms (4.9 ± 0.4; 5).

Users were less satisfied with the number of clicks required to complete a given task (3.0 ± 1.3; 3) but felt that it allowed easy task completion (4.8 ± 0.5; 5), simplified the user’s task (4.9 ± 0.4; 5), and reduced the time required to complete a given task (4.3 ± 0.5: 4). Users were also satisfied with the nutrient intake calculations (4.5 ± 0.8; 5), intake monitoring over time (5.0 ± 0.0; 5) and data acquisition (4.5 ± 0.8; 5). While participants agreed the application improved task efficiency (average reported time savings = 25%, SD = 29.5%, median = 30%), they did not perceive a direct effect on treatment outcomes (2.1 ± 0.9; 2). Users also felt, that such application is desirable on mobile device (4.3 ± 1.0; 5).

The same questionnaire was adapted and used to test the web application. Due to a understaffed ICU only a very limited number of users ($n = 3$) actually used this application, making the following responses less representative. Although based on a smaller sample, responses indicated

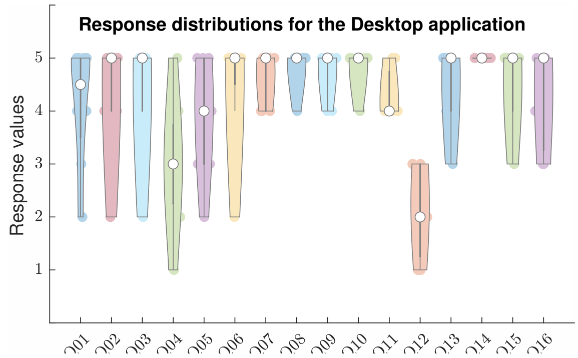

Figure 4: Violin plots of user responses to the first 16 questionnaire items (see Table 2) for the desktop application. The plots display the distribution of Likert-scale ratings (1 = strongly disagree to 5 = strongly agree) for each question.

high usability and feasibility (Table 2, the fifth column show number of responses, the sixth gives the average of responses with standard deviations, and seventh gives median value with interquartile range; and Figure 5). Users reported favorable ratings for appearance, color and widget selection, and font selection (all 4.3 ± 1.2; 5). They also felt, that it is pleasant to use, learnable, easy to use and allows good error prevention and recovery (all 4.0 ± 1.4; 4). Users were not too satisfied with required number of clicks (2.7 ± 1.2; 3), but felt, that it allows easy task execution (4.3 ± 1.2; 5), simplifies tasks, reduces time for task execution, simplifies nutritional intake calculations and monitoring over time, and allows for simple data recording (all 4.0 ± 1.0; 4). They also reported an average additional 6.6% reduction in task time compared with the desktop application (SD = 13.2%, median = 0). Similar to the desktop application, users did not report perceived effects on treatment outcomes (2.3 ± 1.2; 3). Users also felt, that such application is desirable on mobile device (4.3 ± 1.2; 5). For the three participants who evaluated both applications, mean questionnaire scores were 4.69, 3.88, and 4.44 for the desktop application, and 4.36, 4.58, and 3.00 for the web application. A Wilcoxon signed-rank test showed no statistically significant difference between the two ($W = 2.0$, $p = 0.75$).

Users could also answer several questions in free-form. Qualitative feedback ($n = 6$ desktop, $n = 2$ web) highlighted advantages such as more accurate intake assessment, easier monitoring over time, and direct bedside access (for the web version). The most frequent frustrations were the number of clicks required and interface and navigation issues, such as dissatisfaction with the interface and with the nutrient selection, and also insufficient chart comments.

User ratings indicated high acceptability and usability for both applications. No significant differences in perceived impact on treatment outcomes were reported between application types or compared with non-assisted monitoring. Given the small sample sizes, the findings should be con-

Table 2: Summary of questionnaire items and average response values. For each application, the table reports the number of responses, mean with standard deviation, and median with interquartile range: columns 2–4 correspond to the desktop application, and columns 5–7 to the web application.

Question	N	Avg ± SD	M(IQR)	N	Avg ± SD	M(IQR)
I like the appearance of the application	8	4.1 ± 1.3	4.5 (3)	3	4.3 ± 1.2	5 (2)
Selection of color and widgets is suitable	8	4.4 ± 1.1	5 (3)	3	4.3 ± 1.2	5 (2)
Size of widgets and fonts is suitable	8	4.4 ± 1.1	5 (3)	3	4.3 ± 1.2	5 (2)
Application is pleasant to use	8	3.9 ± 1.1	4 (3)	2	4.0 ± 1.4	4 (2)
Application is learnable	8	4.5 ± 1.1	5 (3)	2	4.0 ± 1.4	4 (2)
Application is easy to use when learned	8	4.6 ± 0.5	5 (1)	2	4.0 ± 1.4	4 (2)
Application allows error prevention and recovery	8	4.9 ± 0.4	5 (1)	2	4.0 ± 1.4	4 (2)
Too many clicks to perform a task are required	7	3.0 ± 1.3	3 (4)	3	2.7 ± 1.2	3 (3)
Application allows easy task execution	8	4.8 ± 0.5	5 (1)	3	4.3 ± 1.2	5 (2)
Application simplifies my tasks	7	4.9 ± 0.4	5 (1)	2	4.0 ± 1.4	4 (2)
Application reduces time required for a task	7	4.3 ± 0.5	4 (1)	2	4.0 ± 1.2	4 (2)
Application simplifies nutritional intake calculation	8	4.5 ± 0.8	5 (2)	3	4.0 ± 1.0	4 (2)
Application allows intake monitoring over time	7	5.0 ± 0.0	5 (0)	3	4.0 ± 1.0	4 (2)
Recording patient information and data is simple	8	4.5 ± 0.8	5 (2)	3	4.0 ± 1.0	4 (2)
Use of application influences treatment outcome	7	2.1 ± 0.9	2 (2)	3	2.3 ± 1.2	3 (2)
The application on mobile platforms is desirable	7	4.3 ± 1.0	5 (2)	3	4.3 ± 1.2	5 (2)
Time change for task completion (in %)	6	-25.0 ± 29.5	-30 (80)	3	-6.6* ± 13.2	0 (30)
*compared to the desktop application						

sidered exploratory and interpreted with caution.

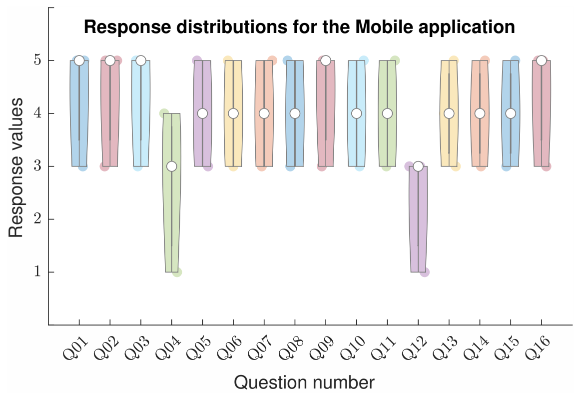

Figure 5: Violin plots of user responses to the first 16 questionnaire items (see Table 2) for the web application. The plots show the distribution of Likert-scale ratings (1 = strongly disagree to 5 = strongly agree) for each question.

4 Discussion

The patient's nutrition is one of the causes that can affect recovery and influence the length of hospital stay. Monitoring of nutrient intake is necessary for appropriate dietary management. A desktop and a responsive web application were developed to monitor patients' nutrient intake. Both applications were used in a clinical setting. The desktop application was well received and has been in use for some time. The web application was designed to be used on any type of device but was designed for an optimal user experience on handheld devices. Although the web application is still in the testing phase, both applications were compared using a user questionnaire that included questions about general usability issues and issues related to task execution. Given the very small sample sizes, these findings should be considered exploratory and interpreted with caution. In addition, due to the very small number of participants who evaluated both tools ($n = 3$), the statistical analysis regarding the differences between the apps was quite limited and did not reveal significant differences in perceived usability. This lack of significance should be interpreted with caution, as the study was underpowered to detect meaningful effects.

A series of questions was aimed at assessing user satisfaction, which relates to acceptance of the information system [57], representing users' willingness to use the applications. Responses indicated overall satisfaction with both applications, suggesting acceptance of both. Users also reported satisfaction with error prevention and recovery mechanisms, although some indicated that certain tasks required too many clicks. To improve the interaction, users should be involved as much as possible in the interface design. In our study, this approach allowed us to slightly enhance the usability of the web application.

Despite the questionnaire including an item on perceived impact on treatment outcomes, the study was not designed to evaluate actual clinical effects. Responses to this item, therefore, reflect subjective perceptions only, and no causal inferences regarding patient recovery or health improvements can be made. Any potential impact of these tools on treatment outcomes would need to be investigated in a controlled or longitudinal study using appropriate clinical metrics. The responses indicated that treatment outcomes were not perceived to be significantly affected by the use of either application, which contrasts with a previous study [31]. This discrepancy is likely due to the study design: we did not directly measure or compare patient outcomes with and without application use. Instead, the results reflect the experiences of ICU staff providing nutrient intake. Given the relatively small ICU, obtaining comparable patient groups for such a comparison would have been impractical. User responses suggest that staff generally followed the established nutrition protocol, which the applications do not alter. Rather, the applications streamline the process by making all relevant data immediately available, facilitating more efficient execution of required tasks. As such, while these systems may improve the management of nutritional intake, they are unlikely to directly affect patient treatment outcomes. The perceived ease of managing nutrition was further supported by responses to usability questions.

An important issue was also the change in time needed to perform the required tasks related to the management of patients' nutritional intake. The manual time measurement was not feasible due to the work process in the ICU. Therefore, the users were asked to estimate how much more or less time it took them to perform the required task with the application compared to without the application. Users estimated that using the desktop application could noticeably reduce the time needed to perform a particular task related to monitoring patient nutrient intake. The application allows for faster calculation of required intake and monitoring over multiple days, with the visual representation of data providing an easier overview of intake over a period of time. The responsive web application also enables the use of mobile devices. This further reduces the time required for a given task, increasing work efficiency. However, the main advantage of using the web application is the mobile aspect. The ubiquity of smartphones ensures that the application is always where it is needed, so little time is required to use it. In addition, the development of a responsive web application ensures consistent operation on different platforms (operating systems and devices) if standard technologies are used. This then allows the same type of user interaction even on different platforms.

Our usability results — a 25% reduction in task completion time using the desktop application compared with non-assisted monitoring, and an additional 6.6% reduction with the web application — are consistent with previous reports (see Table 1 that clinician-facing decision support or monitoring tools can yield measurable time savings and high usability ratings. Prior ICU CDS usability studies report high system usability scores (e.g., median SUS = 87.5) and short task durations for core interactions, suggesting that well-designed interfaces can both be efficient and acceptable to critical-care staff. Similarly, ICU nutrition/glycemic tools (e.g., Glucosafe 2) were perceived by the majority of users as time-saving and helpful for guideline adherence (70–85% agreement). In contrast to consumer diet-tracking apps, which mainly report user satisfaction and variable accuracy, our study demonstrates clinically meaningful time savings in a high-acuity setting. These time reductions can translate into measurable workflow improvements, though we did not detect statistically significant differences in immediate treatment outcomes.

A key limitation of this study is the very small sample size ($n = 8$ for desktop, $n = 3$ for web), which limits the generalizability of the findings and precludes robust inferential statistical analysis. No hypothesis testing was performed; instead, results are presented descriptively using means, medians and ranges to account for the small n. While the observed reductions in task completion time are consistent with expected workflow efficiencies, these findings should be regarded as preliminary. Future research with larger, more diverse samples and the use of inferential statistics is necessary to confirm these trends. The small number of respondents is primarily due to the relatively small ICU, the demanding nature of ICU work, and staff turnover, which limits the number of personnel familiar with the protocols, equipment, and tools. Additionally, the recent SARS-CoV-2 pandemic increased workloads, further reducing staff availability and willingness to participate. Another important limitation is that the desktop application had been in active use for some time, whereas the web application was still in the testing phase. Consequently, observed differences in usability statistics, user responses, and perceived impact on ICU work and treatment outcomes may reflect differences in deployment maturity rather than inherent characteristics of desktop versus web applications. Therefore, comparisons between the two applications should be interpreted cautiously, with the focus on user perceptions within the specific deployment context rather than on generalizable conclusions about application types. The findings should also be interpreted with caution given potential self-report and social desirability biases, the limited internal validity of an unvalidated questionnaire, and the restricted external validity of conducting the study in a single ICU.

This study focused on usability and task efficiency in daily ICU work. We showed that both applications reduced task time and were rated as highly usable. These findings are important because they demonstrate practical benefits in a real ICU setting. However, we did not assess clinical outcomes such as mortality or recovery. The study was not designed to test such effects. Our tools instead provide a solid base for future research. They can support more advanced methods, including AI-driven prediction or clinical decision support. In this way, the present work serves as a foundation for studies that link usability with patient outcomes.

5 Conclusions

The nutritional intake monitoring applications were well received, with users reporting that they are practical tools for calculating and managing nutritional intake in critically ill patients. This positive perception was reflected not only in survey responses but also in requests from additional hospital departments following their introduction in the ICU. According to users, the primary benefit of both applications lies in reducing the time required to complete routine tasks, rather than in direct effects on treatment outcomes. The desktop application has already been successfully adopted in practice, while the web application remains in the testing phase. Although functionally comparable, the web version offers additional flexibility by supporting mobile devices, where it demonstrated an average 6.6% reduction in task completion time relative to the desktop version. However, given the small sample size (n = 3) and high variability (SD = 13.2%), this result should be interpreted with caution. Overall, both applications are suitable for their intended purpose, enabling more efficient task execution, with the choice between desktop and web interfaces depending on user preference and device availability. While the present study does not demonstrate statistically significant effects on patient outcomes, its novelty lies in systematically evaluating the usability and efficiency of two complementary application types within a real ICU context—an environment where workflow integration is often a decisive factor in adoption. Future work should focus on expanding the evaluation to multiple ICUs with larger and more diverse participant groups, while also exploring integration with decision-support systems or predictive analytics (e.g., AI-based nutritional risk assessment). Such extensions could enhance the clinical impact and advance the field beyond efficiency gains, toward demonstrable improvements in patient outcomes.

Declarations

Competing interests The authors have no relevant financial or non-financial interests to disclose.
Ethics approval and consent to participate The local Ethics committee issued a statement No: 860-7/2022/2 stating that assessment and opinion of the Committee for medical ethics is not required. It also states that informed verbal consent of each individual, included in the study, should be obtained. The informed verbal consent of the participants of this study was obtained prior to data collection.

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