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# Participatory Development of a Tool for Recording the Hydroelectrolytic Balance of Critical Patients

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**Abstract:**

***Background:*** The use of assistive technology as a tool for recording the hydroelectrolytic balance of critical patients in Intensive Care Units has broadened the scope of health technologies, contributing to the quality of care provided and aiding in evaluating the hydrological balance of patients.

***Objective:*** This study aimed to describe the stages of participatory development of a printed instrument for recording the electrolyte balance of critical patients.

***Methods:*** A methodological study was conducted between August and October, 2023, at a public oncology referral hospital in Belém, Pará. Four nurses, 21 nursing technicians, and 2 physicians participated in the production of the instrument, following five stages using the problematization methodology. In data analysis, the cores of significance, frequencies, percentages, and response patterns were considered.

***Results:*** From stages 1 and 2, two cores of significance emerged; from stages 3 and 4, based on professional participation, the instrument was organized. The proposed design for the front part was divided into four items, and for the back, 3 columns were inserted. In stage 5, the evaluation of satisfaction and agreement attributes was considered satisfactory.

***Conclusion:*** The instrument was considered satisfactory for use by professionals in recording the electrolyte balance of critical patients.

**Keywords:** Water-electrolyte balance, Intensive care units, Nursing, Nursing records, Nursing assessment, Water balance.



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## 1. INTRODUCTION

Hydroelectrolytic balance is necessary when there is a simultaneous supply of liquids according to the metabolic needs of the organism, coupled with the proper functioning of the cardiovascular, pulmonary, digestive, and renal systems, which can be measured by the Electrolyte Balance (BH) [1-3].

The BH allows for significant evaluation of fluid gain and loss, being a widely used record in Intensive Care

Units (ICUs), which integrates the care routine of the ICU healthcare team with the perspective of rigorously controlling the fluid volume of critical patients [4]. Thus, the use of the BH proves to be relevant as it contributes to the resolution of care, especially by the nursing team, since the records of fluid gain and loss are carried out by nurses and nursing technicians [5, 6].

In this context, there is a need to enhance the BH records, which can be done through health technologies [7]. Health technologies are established processes that combine empirical healthcare experience with research to develop strategies aimed at applying knowledge and understanding processes and practices with a focus on redefining empirical approaches into scientific ones. The integration of health technologies into healthcare encourages the use of new strategies to enhance health practices and processes [7]. Among the modalities of technology, assistive technologies (AT) stand out, characterized as assistive devices aimed at enhancing care and providing qualified assistance, and are also used to implement the care plan of multidisciplinary healthcare teams [8].

In this perspective, recording instruments are considered. They can improve the quality of care, especially nursing care for critical patients in ICUs, as they facilitate the mediation of operationalized and systematized care practices, providing comprehensiveness, resolution, and quality of care to patients [8].

The use of an AS as a tool for recording the electrolyte balance of critical patients in ICUs expands the scope of health technology, contributing to the quality of care provided and aiding in the fluid balance of patients. In this study, the objective is to describe the stages of participatory development of a printed instrument for recording the electrolyte balance of critical patients.

## 2. MATERIALS AND METHODS

### 2.1. Type of Study

A methodological study was conducted on the development of assistive technology through participatory development [9, 10]. The assistive technology is a printed instrument for recording the electrolyte balance of critical patients, targeting the healthcare team working in the ICUs of a public oncology referral hospital in Belém, Pará.

The study occurred between August and October, 2023. An assistive technology in the form of a printed instrument is considered due to the ease of access and the low cost of development. The participatory development was guided by the problematization methodology by applying the Charles Maguerez Arc in order to understand the purpose of the study and propose a technology that helps solve existing problems. To do so, five (5) stages were followed: 1) observation of reality (problem), 2) definition of key points, 3) theorization, 4) solution hypothesis, and 5) application to reality [11].

### 2.2. Population

The sample was of the non-probabilistic type. Thirty-two professionals were invited, of whom 27 accepted the proposal: 4 nurses, 21 nursing technicians, and 2 doctors in stages 1 and 2, and in stage 3, only 22 agreed to continue. Participation in this study was voluntary, following a personal and in-person invitation from the resident researcher who was on duty in the five ICUs of the hospital in question. The signing of the Informed Consent Form (ICF) was done manually after the aforementioned acceptance. The inclusion criteria were nursing professionals and doctors in the morning and afternoon shifts, working in one of the ICUs of the aforementioned hospital, with at least one (1) year of professional experience in the care of critical patients. Professionals who were absent from work during the data collection period were excluded.

### 2.3. Data Collection

In Stage 1, observation of reality, an on-site visit to the ICUs was conducted to carry out a situational diagnosis regarding the recording of the BH (items to be accounted for, elimination devices, among other aspects) in order to identify strengths and weaknesses. Observations were recorded in a field diary. In Stage 2, for the definition of key points, a brainstorming session was held with the participants regarding the BH, and the following questions were asked: What do you understand by BH? What are the major difficulties and/or problems experienced that affect the recording of the BH? The responses were recorded in the field diary. In Stage 3, which is theorization, evidence synthesis was used, obtained from an Integrative Review [12] (protocol registered and available on the figshare repository at https://doi.org/10.6084/m9.figshare.24750054.v1) [13]. In Stage 4, solution hypotheses, starting from the initial version of the instrument, suggestions for adjustments regarding the format and content of the TA were formulated. In Stage 5, application to reality, the second version of the TA, structured based on the received suggestions, was evaluated by the participants regarding satisfaction, agreement, and importance using a form. It is emphasized that consent was obtained from the participants for data collection.

### 2.4. Analysis and Treatment of Data

For the analysis of the data obtained in stages 1 and 2, the technique of constructing cores of meaning [14, 15] was used. The analysis began with a floating reading of the records from stages 1 and 2 in order to identify terms with broad meanings that were repeated and defined as pre-indicators [14]. Then, agglomeration by complementarity and similarity was performed [15]. Next, the pre-indicators were separated into indicators so that the central cores could take shape and be named, thus obtaining the main themes, called cores of meaning, based on the frequency and relevance listed. For the analysis of the data obtained in stage 5, frequency and percentage were used for the manifestations, and the pattern of responses obtained from Cronbach's alpha coefficient was considered.

### 2.5. Ethical Aspects of the Research

This research was submitted and assessed by the Ethics and Research Committee of the aforementioned hospital, obtaining approval through opinion number 6127275 and Certificate of Presentation of Ethical Appreciation (CAEE): 68677323.7.0000.5550.

## 3. RESULT

From stage 1, five pre-indicators were selected, and from stage 2, eight (Table **1**). After reading, six indicators linked to two cores of meaning were selected. The first core of meaning, named "BH as a tool for intensive prognosis," had two indicators: 1) "continuity of care" and 2) "intensive monitoring." The second core of meaning, named "the importance of good practices regarding the recording of BH," had four indicators: 1) "standardization of practices," 2) "communication and identification," 3) "adequate recording," and 4) "integrated work." Stage 1 occurred in the five ICUs of the hospital. In stage 2, two meetings were held on alternate days according to the participants' schedules (one in the morning shift and another in the afternoon), and everyone was able to attend. It lasted an average of 40 minutes and occurred at the nursing station in the ICU.

In stage 3 of theorization, the synthesis of evidence obtained from an Integrative Review was used as a reference to select the type of technology to be produced. Initially, the results of the review were presented; then, a discussion occurred about which TA (Technological Artifact) would best meet the reality in question, namely, improving the recording of the BH of critical patients. After the discussion, three options for production were considered: 1) a booklet (1 indication), 2) a printed BH recording form (24 indications), and 3) a manual of norms and routines (2 indications). Considering the option with the highest number of indications, the printed BH recording form was chosen by common agreement. In this stage, meetings were held on alternate days and in different shifts, and everyone was able to attend. It lasted an average of 20 minutes and occurred at the nursing station in the ICU.

In stage 4 of the solution hypothesis, initially, the first version of the instrument, elaborated by the resident researcher based on two Standard Operating Procedures (SOPs), was presented. Then, the participants reviewed the instrument and provided suggestions for adjustments regarding the format and content of the AT (Table **2**). Once again, two more meetings were held in different shifts, and everyone was able to attend. It lasted an average of 30 minutes and occurred at the nursing station in the ICU.

In stage 5 of application to reality, initially, the second version of the TA was reviewed, highlighting that all suggestions received were incorporated. In a second moment, participants mentioned that there was no need for further adjustments as the version met their suggestions. Subsequently, the version was evaluated by the participants based on a form regarding satisfaction, agreement, and importance (Tables **1**-**3**). In this stage, the last two meetings occurred in their respective shifts, but only 22 participants were present as five of the professionals could not participate. The meetings occurred at the same locations as before and lasted about 30 minutes each. At the end, the resident researcher thanked everyone for their collaboration.

**Table 1. Pre-indicators selected from stages 1 and 2 (Belém, PA, Brazil, 2023).**

| Stages | Leading Indicators | Interpretation |
|---|---|---|
| Observation of reality (situational diagnosis) | Device identification | Inadequate description of the items to be accounted for in the BH, and lack of identification of elimination devices as well as of water loss in gastric or enteral probes and loss in surgical drain and intestinal ostomies. |
| | Record | Lack of ethical and professional rigor in the execution of records in the BH. |
| | Physiological eliminations | Failure to observe deficits in accounting for physiological loss of diuresis and evacuation. |
| | Erasures | Non-conformities were evidenced regarding the use of corrections, the presence of adjusted numerical writings, and handwriting that is difficult to comprehend. |
| | Hemodialysis | Inaccuracy of records of fluid elimination through diuresis, combined with episodes of failure to record actual losses in the BH after hemodialysis sessions. |
| Definition of key points - 'Brainstorming' about BH | The form used | Considered by the participants as the main cause of the failures. |
| | Everything that is infused and everything that is eliminated. | Considered a fundamental principle of BH*. |
| | Medical therapeutic approach | Understanding that BH aims to provide information about the patient for therapeutic decision-making. |
| | Continuity of care | Recognized as essential, when well-established, for guiding shared work among morning, afternoon, and night teams. |
| | Integrated work | Recognition of the flaws that compromise the continuity of care, aiming at the need for standardization of routines among professionals. |
| | Standardization of practices | Identified the need by participants for greater rigor in the collective construction of BH records. |
| | Intensive monitoring | One of the applications of BH is to provide an overview of the critical patient's health status. |
| | Communication and identification | Lack of effective communication among the multiprofessional team regarding continuity of care during shift handover and difficulty in identifying drainage and hydration infusion devices. |

**Note:** *BH – Hydroelectrolyte balance.

**Table 2. Suggestions for the BH recording instrument (Belém, PA, Brazil, 2023).**

| Items | Suggestion |
|---|---|
| Technology Front: I) First upper horizontal table; II) Second upper horizontal table | Reduce the header space to increase the other recording spaces. |
| Technology Front: IV) Fluid Control | Remove the titles of gains and loss items. Let them be registered according to what device the patient has.<br>Increase the size of the space to record the values."<br>"Remove one column from loss and add it to gain, as patients mostly receive more fluid than they eliminate. |
| Technology Back: I) Left Column | Decrease the size of assessment scales.<br>Use acronyms for device names.<br>Reduce size to increase space for nursing notes. |
| Technology Back: II) Central Column | Reduce the size of assessment scales to increase space for nursing notes. |
| Technology Back: II) Right Column | Increase space for nursing notes. |

**Table 3. Frequency distribution and percentage of manifestations regarding satisfaction, agreement, and importance (Belém, PA, Brazil, 2023).**

| Value | Degree | Frequency | %* |
|---|---|---|---|
| 1 | Very satisfied | 1 | 4,5 |
| 2 | Dissatisfied | 0 | 0 |
| 3 | Neutral | 0 | 0 |
| 4 | Satisfied | 9 | 40,9 |
| 5 | Very satisfied | 12 | 54,5 |
| | **TOTAL** | **22** | **100** |
| **Value** | **Degree** | **Frequency** | **%*** |
| 1 | I totally disagree | 1 | 4,5 |
| 2 | Disagree | 0 | 0 |
| 3 | Neutral | 0 | 0 |
| 4 | Agree | 9 | 40,9 |
| 5 | Strongly agree | 12 | 54,5 |
| | **TOTAL** | **22** | **100** |
| **Value** | **Degree** | **Frequency** | **%*** |
| 1 | Not important | 0 | 0 |
| 2 | Sometimes important | 0 | 0 |
| 3 | Moderate | 0 | 0 |
| 4 | Important | 6 | 27,3 |
| 5 | Very important | 16 | 72,7 |
| | **TOTAL** | **22** | **100** |

**Note:** *Percentage.

When obtaining an α value far from the ideal postulated value of 1, it becomes necessary to initiate purification processes. Upon conducting the first questionnaire purification by eliminating the item with the highest variance, namely, item A_1, a decrease in Cronbach's alpha coefficient to α: 0.168 was observed, indicating the relevance of item A_1 to the research results, and thus it should be retained. Upon conducting the second purification by eliminating the second item with the highest variance, *i.e.*, item A_2, a decrease in the Cronbach's alpha coefficient to α: 0.168 was also observed, indicating the relevance of item A_2 to the research results, and thus it should be retained. Upon conducting the third purification by eliminating the third item with the highest variance, *i.e.*, item A_3, there was an increase of 0.3 in the Cronbach's alpha coefficient to α: 0.904, indicating an increase in the reliability and overall consistency of the test upon excluding the third statement, thereby expanding the alpha value closer to 1. The use of Cronbach's alpha coefficient statistically considered only the satisfaction and agreement criteria (Alpha: 0.904) valid upon excluding the importance criterion. Thus, the evaluation results allow for evaluating the relevant TA, considering the satisfaction and agreement criteria expressed by the research participants.

Regarding the format of the TA, structuring, organization, layout, language, design, and cultural adequacy pertinent to the target audience were performed. The TA was produced in landscape format, with an A4 sheet size of 21 x 29.7 cm, without predetermined spacing and Calibri fonts throughout the document. The final version of the TA is available in the Figshare repository at https://doi.org/10.6084/m9.figshare.24803277.v1 [16].

**Table 4. Distribution of responses, mean, variance, and Cronbach's alpha value (Belém, PA, Brazil, 2023).**

| Evaluators | Statements | | | | |
|---|---|---|---|---|---|
| | A_1 | A_2 | A_3 | Average | Variance |
| *P1 | 5 | 5 | 5 | 5 | 0 |
| *P2 | 5 | 5 | 4 | 5 | 0,333333333 |
| *P3 | 2 | 2 | 5 | 2 | 3 |
| *P4 | 4 | 4 | 4 | 4 | 0 |
| *P5 | 4 | 4 | 4 | 4 | 0 |
| *P6 | 5 | 5 | 5 | 5 | 0 |
| *P7 | 5 | 4 | 5 | 5 | 0,333333333 |
| *P8 | 4 | 4 | 5 | 4 | 0,333333333 |
| *P9 | 5 | 4 | 4 | 4 | 0,333333333 |
| *P10 | 5 | 5 | 5 | 5 | 0 |
| *P11 | 5 | 5 | 5 | 5 | 0 |
| *P12 | 5 | 5 | 5 | 5 | 0 |
| *P13 | 5 | 5 | 5 | 5 | 0 |
| *P14 | 4 | 4 | 5 | 4 | 0,333333333 |
| *P15 | 4 | 5 | 5 | 5 | 0,333333333 |
| *P16 | 4 | 4 | 5 | 4 | 0,333333333 |
| *P17 | 5 | 5 | 5 | 5 | 0 |
| *P18 | 4 | 4 | 5 | 4 | 0,333333333 |
| *P19 | 5 | 5 | 5 | 5 | 0 |
| *P20 | 4 | 5 | 4 | 4 | 0,333333333 |
| *P21 | 5 | 5 | 5 | 5 | 0 |
| *P22 | 4 | 4 | 4 | 4 | 0 |
| MÉDIA | 5 | 5 | 5 | - | - |
| VARIANCE | 0,545455 | 0,545455 | 0,207792 | - | - |

**Note:** Cronbach's Alpha coefficient: 0,667.
*P – Evaluators; **A – Statements.

The proposed design for the front was divided into I) the first horizontal table header containing the institution's identification; II) the second horizontal table header with patient identification, containing elements, such as name, hospital registration, date of birth, age, bed, ICU admission date, current date, diagnosis, allergies, and type of precaution; III) the left column intended for hemodynamic control, containing items, such as vital signs (temperature, heart and respiratory rate, blood pressure and mean arterial pressure, peripheral oxygen saturation, and capillary blood glucose) to be recorded every two hours or every hour depending on patient idiosyncrasies; IV) the right column intended for fluid balance, subdivided into gains, containing items to be recorded: sedation, analgesia, blood, plasma, platelets, venous hydration, diet, water, others 1, and others 2; and losses, containing urine output, bowel movements, hemodialysis, drain 1, drain 2, others 1, and others 2. Additionally, an item related to the previous day's BH was added. The spaces designated for partial and total horizontal and vertical balances were highlighted with shading, and for each shift of the day, a blank space was added for the signature of the technical nursing professional of the respective shift.

Regarding the back side, it was initially divided into 3 columns and subdivided into I) the left column dedicated to pain assessment scales, adapting the visual analog scale with the numeric scale to assist in assessing conscious patient pain, and the Behavioral Pain Scale (BPS) aimed at assisting in pain assessment in sedation analgesia and mechanically ventilated patients, in addition to a daily control chart of device insertions and exchanges/removals. II), Central column dedicated to consciousness level scales, containing summarized values and scores of the Glasgow Coma Scale, aimed at assessing the consciousness level of conscious patients, and the Richmond Agitation-Sedation Scale (RASS), intended for assessing the consciousness level of sedated patients. III) The right column was dedicated to nursing notes. The developed instrument was in a printed format for recording the electrolyte balance of critical patients (Table **4**).

## 4. DISCUSSION

### 4.1. Fluid Balance as an Intensive Prognostic Tool

The human body's water balance is a physiological mechanism controlled by a complex neuroendocrine regulator whose objective is to maintain the levels of fluids and electrolytes present in the body, which are necessary for the proper functioning of cells [3]. Hospitalized individuals will utilize, in addition to physiological means, complementary mechanisms that allow the measurement of fluid intake, such as intravenous solutions through venous access, liquid diet *via* nasogastric or nasoenteric

tubes, and as fluid output, drains through which secretion flow, and urinary catheters for urine drainage [3, 17].

The physiological regulation of fluid balance can be affected by certain pathological processes, such as acute kidney injury, leading to decreased urinary output; neuroendocrine tumors cause the oversecretion of hormones that stimulate diuresis, among many others [1, 18]. Thus, certain diseases alter the patient's fluid and electrolyte balance, requiring more specific healthcare interventions to enable monitoring of the resulting BH [17, 19]. In this context, to ensure the monitoring of individuals with this fluid imbalance, the implementation of the BH procedure is necessary, conceptualized as a precise record of the individual's fluid homeostasis, characterized by the difference between fluids administered or ingested *via* intravenous or oral routes, and fluids eliminated *via* urinary and gastrointestinal routes over 24 hours [17, 20].

The BH allows for accurate quantification and accounting of the patient's losses and gains, operationalized by the nursing team. At the end of 24 hours, the total value will be obtained, which can be recorded as a negative value, indicating that the patient is losing more fluid than gaining, as a positive value, when the patient presents significant fluid retention, and neutral, indicating an ideal fluid balance state [3, 21]. Given the context of ICUs, the importance and routine of FB are emphasized, as it is a highly complex sector with critically ill patients, who present deficits in self-regulation mechanisms, necessitating continuous monitoring as well as specialized and effective care [22].

Considering this, the use of BH allows for continuous monitoring of the patient's fluid balance and, through its results, guides and indicates the best therapeutic possibilities for critically ill patients, as well as acting as strong indicators of clinical outcomes related to the survival and mortality of critically ill patients with shock and sepsis [23].

The opportunity to participate in the development of the TA allowed the research participants to express their technical and scientific knowledge about BH, as they revealed through their opinions that one of its main characteristics is its ability to allow intensive monitoring and control of the patient's hemodynamic capacity. This understanding considers the individuality of each patient as well as their critical intensive state, emphasizing the continuity of the process, which is considered an essential factor to ensure greater fidelity in records and safety in results [24].

Inconsistencies were identified in the completion of the BH, indicating the difficulty faced by the teams in this context, which can lead to conflicts among the multidisciplinary team regarding the lack of proper BH completion [25]. In this sense, participation provided an opportunity for reflection on the work process of the team involved in the development of the TA, allowing participants to identify service demands considered urgent for the improvement of nursing care for critically ill patients in the ICU regarding BH recording and communication among healthcare professionals and team members. The team emphasized the importance of structural improvement projects and institutional ones regarding protocols and standard SOPs. Additionally, they highlighted the need for ongoing in-service education cycles as minimization strategies for failures aimed at improving the BH process, as well as for defining and building best practices regarding BH records [19].

### 4.2. The Importance of Best Practices regarding Fluid Balance Recording

Theoretical framework, through literature review, allows for the expansion of knowledge through evidence produced by researchers on, for example, the systematization of care and facilitates a better understanding of the observed reality [14]. Nursing care systematization (NCS) guides the nurse's actions towards an organized, systematized, and continuous practice in accordance with Resolution No. 736/2024 of the Federal Nursing Council, present at all levels of health care [26]. Among the main practical examples is BH, a tool that allows for the daily assessment of patients within the hospital environment, being applied more frequently within the ICU [8, 17].

In a study that investigated and analyzed BH records of patients admitted to an ICU, errors and inadequacies were identified in 49% of the BH sheets. The main occurrences were manifested as calculation errors and incomplete records in different shifts, highlighting the lack of knowledge, updating, and collective construction of nursing teams, which directly interferes with the daily assessment of patients, as well as future therapeutic actions [19].

Furthermore, another study highlighted that the non-adherence to practices considered indispensable for BH accounting, such as weighing on a proper scale or accounting performed using the crossing system (+), the presence of erasures found in 68.5% of the analyzed forms, and calculation errors in partial (12h) and total (24h) balances in 65.7% of the investigated balances. Such shortcomings in the BH context have the ability to cause harm and interfere negatively with the patient's care continuity, both at an assistance level and at a managerial level [6].

When performing a technical analysis of 220 BH forms from an ICU, by focusing on the proper completion of the forms, several issues were raised, with inadequacies, such as erasures, illegible letters, use of improper pens, calculation/sum errors, and values recorded in incorrect locations on the form being the most frequent [5]. From the counting and analysis of inconsistencies, it was concluded that there is a 40.7% chance of obtaining a correct and completed BH, meaning that the presence of these factors causes this increasing deficit in BH accuracy [5]. Thus, these inadequacies affect the fidelity of the procedure, patient safety, and the quality of care provided and violate the nursing code of ethics regarding the authenticity of nursing records [5].

The absence of a clear and objective SOP to guide the

nursing team through the steps ranging from collecting information and filling out the form to partial and total summation performed by nurses is emphasized. In this interim, the implementation of educational assistance technologies focused on work organization and assistance planning is a viable alternative to gradually and continuously mitigate the inadequacies present in the BH procedure [5].

Researchers from a hospital in Singapore [24] analyzed, through a retrospective review, approximately 2199 BH records from the electronic medical records of a reference hospital. The researchers highlighted the need to improve the completion of BH values. The analysis showed satisfactory levels of accuracy in nursing records (77%) regarding BH; however, attention is drawn to the high rate of inadequacies in patient loss records (93.3%), corroborating the findings of the Brazilian [19] research when observing inaccuracies in loss quantities.

A study conducted in England [27] aimed to implement an intervention project focused on improving the completion of BH records in a reference hospital through PDSA cycles, Plan - Do - Study - Act. The initial analysis of BHs showed that only 25% of the medical records were properly filled out, as well as their partial and total calculations, and 75% had discrepancies, such as erasures, calculation errors, and incomplete and/or neglected records, as also observed in the Singaporean research [24].

These studies point again to the importance given to permanent education processes, as well as their frequency of implementation to become routine in their respective work environments, in order to ensure the maintenance and updating of theoretical and practical knowledge, which directly affect the quality of care provided [27].

The evidence in the literature aligns with the results presented here regarding the failures in BH records. In this context, the presence of inadequacies observed in reality, corroborated in the literature, and the difficulties reported by research participants reveal a demand for educational assistance aimed at compliance with best practices regarding BH records [24, 25]. Furthermore, it is emphasized that instrumental interventions through strategies guided by the PDSA cycle and training in permanent education programs are considered effective and essential for the service [5, 27].

The use of a TA to improve care proved more attractive and relevant to research participants, which motivated the production of the institution's BH form [8]. The use of the problematization methodology mediating the production process through the Maguerez arc promoted a more interactive and collaborative approach among research participants. This strategy allowed considering the reality of participants, focusing on improving practices with a view to compliance with best practices [28]. The participatory construction process of a TA is based on the alliance between technical and scientific knowledge derived from theory and scientific literature, together with the experiences lived by professionals faced with problems [7, 8].

In this research, two SOPs were used for the construction of technology, which characterize the guiding of conduct and processes towards better organization and quality of service execution. In addition to this, the gap in the literature regarding validated materials aimed at guiding the production of TA focused on BH recording is highlighted [25]. In the nursing field, the increasingly frequent presence of technologies ensures significant increases in quality improvement indicators, in addition to the ability to offer greater patient safety and better communication among the health team, fostering and strengthening compliance with patient safety goals [7].

Finally, the potential for application of the produced TA and the need to establish the solution generated, conduct an overall evaluation of its use, and understand its limits with a view to developing new problematization cycles are highlighted [28].

This study has limitations. The first concern is the turnover of professionals working in the ICU of the hospital where the study was conducted. The second refers to the development of a TA with participants from a federative state of Brazil, as it may have highlighted more particular aspects of the context. Regarding this second limitation, it is noted that despite the particularity of the context, the TA can serve as a viable example to other intensive environments that serve critical patients.

## CONCLUSION

The instrument is considered satisfactory for use by professionals in recording the fluid and electrolyte balance of critical patients. It has the potential for application considering the reduction in inadequacies regarding the fluid balance record and for contributing to improved communication among the multidisciplinary team in the context of critical patients.

The TA was constructed based on the observed needs and reflected on the work process in response to the nursing care demands of critical patients in the ICU regarding fluid balance records by research participants. It provides essential elements for fluid and hemodynamic control through an intuitive design. Thus, it is suitable for use in the ICU environment with the aim of improving the systematization of care, especially by the nursing team.

## AUTHORS' CONTRIBUTION

It is hereby acknowledged that all authors have accepted responsibility for the manuscript's content and consented to its submission. They have meticulously reviewed all results and unanimously approved the final version of the manuscript.

## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| BH | = | Electrolyte Balance |
| ICU | = | Intensive Care Units |
| AT | = | Assistive Technology |
| ICF | = | Informed Consent Form |
| TA | = | Technological Artifact |

| | | |
|---|---|---|
| SOP | = | Standard Operating Procedures |
| BPS | = | Behavioral Pain Scale |
| RASS | = | Richmond Agitation-Sedation Scale |
| NCS | = | Nursing care systematization |

## ETHICAL STATEMENT

The fundamental ethical and scientific requirements for research involving human beings were met, according to Resolution 466/12 of the Brazilian National Health Council and approved by the ethics and research committee of Ophir Loyola Hospital under opinion number 6127275 and Certificate of Presentation of Ethical Appreciation (CAEE): 68677323.7.0000.5550.

## CONSENT FOR PUBLICATION

All participants signed an Informed Consent Form (ICF).

## AVAILABILITY OF DATA AND MATERIALS

The data and supportive information are available within the article.

## FUNDING

None.

## CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Declared none.

## REFERENCES

[1] Lacey J, Corbett J, Forni L, *et al*. A multidisciplinary consensus on dehydration: Definitions, diagnostic methods and clinical implications. Ann Med 2019; 51(3-4): 232-51. http://dx.doi.org/10.1080/07853890.2019.1628352 PMID: 31204514

[2] Perez Nieto OR, Wong A, Lopez Fermin J, *et al*. Aiming for zero fluid accumulation: First, do no harm. Anaesthesiol Intensive Ther 2021; 53(2): 162-78. http://dx.doi.org/10.5114/ait.2021.105252 PMID: 34006046

[3] Potter PA, Perry AG. Fundamentals of Nursing. 2017.

[4] Davies H, Leslie G, Jacob E, Morgan D. Estimation of body fluid status by fluid balance and body weight in critically ill adult patients: A systematic review. Worldviews Evid Based Nurs 2019; 16(6): 470-7. http://dx.doi.org/10.1111/wvn.12394 PMID: 31811748

[5] Figueiredo MAG, Nazareth CAL, Souza LA, *et al*. Water balance in an intensive care unit. R Enferm Cent O Min 2021; 11. http://dx.doi.org/10.19175/recom.v11i0.4286.

[6] Forte ECN, Pires DEP, Martins MMFPDS, Padilha MICS, Ghizoni Schneider D, Trindade LL. Work process: A basis for understanding nursing errors. Rev Esc Enferm USP 2019; 53: e03489. http://dx.doi.org/10.1590/s1980-220x2018001803489 PMID: 31433019

[7] Gonçalves GAA, da Silva KVLG, dos Santos RL, Machado MFAS, Rebouças CBA, Silva VM. Facilitators' perceptions about health technologies used in educational workshops with adolescents. Reme Minas Gerais Nursing Magazine 2020; 24: e1273. http://dx.doi.org/10.5935/1415-2762.20200002

[8] Figueiredo AR, Cabral ABS, Carneiro DRC, Parente JS, Ribeiro MA. Construction of an assistive technology to help patients with post-surgical vocal impairment: An experience report. REAS 2022; 15(1): e9188. http://dx.doi.org/10.25248/reas.e9188.2022

[9] Polit DF, Beck CT. Book-Fundamentals of nursing research: Assessment of evidence for nursing practice. 2011.

[10] Teixeira E, Palmeira IP, Rodrigues ILA, Brasil G de B, Carvalho DS, Machado TDP. Participative development of educational technology in the HIV/AIDS context. Reme Minas Gerais Nurs Magazine 2019. http://dx.doi.org/10.5935/1415-2762.20190084

[11] Fontoura dos Santos E, Lindemann RH. Training in the nursing area: Discussion regarding methodological approaches *via* arco de maguerez. Vivências 2022; 18(35): 41-54. http://dx.doi.org/10.31512/vivencias.v18i35.613

[12] Souza MT, Silva MD, Carvalho R. Integrative review: What is it? How to do it? Einstein (Sao Paulo) 2010; 8(1): 102-6. http://dx.doi.org/10.1590/s1679-45082010rw1134 PMID: 26761761

[13] Costa MEF, Nascimento MHM, Mendes CP, Gomes RS, Lima FC, Guimarães RS, *et al*. Integrative review protocol. Figshare 2023.

[14] Aguiar WMJ, Ozella S. The meaning core as an instrument for the understanding of the sense constitution. Psicologia (Cons Fed Psicol) 2006; 26(2): 222-45. http://dx.doi.org/10.1590/S1414-98932006000200006

[15] Freitas M, Pereira ER. The field diary and its possibilities. Psychology Notebooks; Bellaterra 2018; 20(3): 235. http://dx.doi.org/10.5565/rev/qpsicologia.1461

[16] Costa MEF, Nascimento MHM, Mendes CP, *et al*. Fluid and hemodynamic control form for patients in the ICU. Figshare 2023.

[17] Gomes PPS, Lima FET, Araújo PR, *et al*. Water balance in pediatric nephrology: Construction of a standard operating procedure. Rev Bras Enferm 2018; 71 (Suppl. 3): 1404-11. http://dx.doi.org/10.1590/0034-7167-2017-0045 PMID: 29972541

[18] Tigabu BM, Davari M, Kebriaeezadeh A, Mojtahedzadeh M. Fluid volume, fluid balance and patient outcome in severe sepsis and septic shock: A systematic review. J Crit Care 2018; 48(48): 153-9. http://dx.doi.org/10.1016/j.jcrc.2018.08.018 PMID: 30199843

[19] Gums LS, Souza JS, Souza LP. Mapping of fluid balance records in a public intensive care unit in the southern region of the Legal Amazon. REAS 2021; 13(2): e6279. http://dx.doi.org/10.25248/reas.e6279.2021

[20] Santos PA, Ribas A, Quadros TCC, Blattner CN, Boniatti MM. Postextubation fluid balance is associated with extubation failure: A cohort study. Rev Bras Ter Intensiva 2021; 33(3): 422-7. http://dx.doi.org/10.5935/0103-507X.20210057 PMID: 35107553

[21] Oliveira CCA, Rabelo JMMF, Nascimento MJL, Macedo WM. Development of a standard operating procedure to guide the nursing team in monitoring the patient's water balance and vital signs. Federal University of Tocantins 2022.

[22] Ruivo BARA, Bastos JPC, Júnior AMF, *et al*. Nursing assistance in patient safety at ICU: An integrative literature review. REAEnf 2020; 5: e5221. http://dx.doi.org/10.25248/reaenf.e5221.2020

[23] Dhondup T, Tien JCC, Marquez A, Kennedy CC, Gajic O, Kashani KB. Association of negative fluid balance during the de-escalation phase of sepsis management with mortality: A cohort study. J Crit Care 2020; 55: 16-21. http://dx.doi.org/10.1016/j.jcrc.2019.09.025 PMID: 31670149

[24] Lim SH, Lim ML, Aloweni FAB, Ang SY. Audit of the appropriateness and accuracy of fluid intake and output monitoring: Experience in a tertiary hospital. Br J Nurs 2021; 30(11): 660-4. http://dx.doi.org/10.12968/bjon.2021.30.11.660 PMID: 34109822

[25] Sales CB, Bernardes A, Gabriel CS, Brito MFP, Moura AA, Zanetti ACB. Standard operational protocols in professional nursing practice: Use, weaknesses and potentialities. Rev Bras Enferm 2018; 71(1): 126-34. http://dx.doi.org/10.1590/0034-7167-2016-0621 PMID: 29324954

[26] Cofen resolution Nº 736 of january 17, 2024. 2024. Available from: https://www.cofen.gov.br/resolucao-cofen-no-736-de-17-de-janeiro-de-2024/

[27] Madu A, Asogan H, Raoof A. Education and training as key drivers for improving the quality of fluid balance charts: Findings from a quality improvement project. BMJ Open Qual 2021; 10(3): e001137-7. http://dx.doi.org/10.1136/bmjoq-2020-001137 PMID: 34417269

[28] Sousa JDN, Fernandes CS, Ximenes MAM, Caetano JÁ, Galindo Neto NM, Barros LM. Effectiveness of the Maguerez Arch in nursing teaching on vesical catheterism: An almost experimental study. Rev Gaúcha Enferm 2021; 42: e20200105. http://dx.doi.org/10.1590/1983-1447.2021.20200105 PMID: 34287596