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Development of an Innovative Pocket Ampoule Cutter to Improve Nurses' Self-Protection

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Abstract: Nurses are the healthcare professionals who most frequently handle injectable medications packaged in glass ampoules. The conventional method of opening ampoules manually using fingers poses a risk of occupational injury, particularly cuts caused by sharp glass fragments. Therefore, innovation is needed to enhance nurses' self-protection during the ampoule-opening procedure. This study aims to develop an innovative device called the Pocket Ampoule Cutter (PAC) to improve nurses' self-protection. This research employed a Research and Development (R&D) method using the ADDIE model, which consists of the stages of Analysis, Design, Development, Implementation, and Evaluation. The validation process involved three nursing experts and one occupational health and safety (OHS) expert, while the implementation stage involved ten nurses at RST Wijaya Kusuma Purwokerto. Data were collected using validation sheets and user evaluation questionnaires based on a Likert scale to assess aspects of safety, ease of use, comfort, design, material quality, maintenance, hygiene, and overall feasibility of the device. The validation results showed that the PAC achieved an average feasibility score of 95.83%, which falls into the "very feasible" category. Meanwhile, the implementation results based on nurses' assessments showed an average score of 93.33%, also categorized as "very feasible." These findings indicate that the PAC effectively improves nurses' protection by minimizing direct hand contact with broken ampoule glass and facilitating a safer ampoule-opening procedure. In conclusion, the Pocket Ampoule Cutter (PAC) is considered a feasible, practical, and safe device that can enhance nurses' self-protection during the ampoule-opening process.
Keywords: Ampoule cutter, occupational safety, nurses, self-protection, medical device innovation.

INTRODUCTION

Nurses constitute the largest group of healthcare professionals in hospitals and play an important role in healthcare services, including preparing and administering injectable medications to patients [1], [2]. Injectable preparations are generally in the form of drug solutions stored in ampoule packaging. Ampoules are typically made of borosilicate glass, which has good chemical stability and hermetic sealing to protect the medication from air, moisture, and microorganisms, thereby maintaining sterility during storage [3], [4]. In general, an ampoule consists of three main parts: the head, neck, and body [5]. In clinical practice, the manual technique for opening an ampoule is performed by snapping the neck of the ampoule using the thumb [6].

However, the manual process of opening ampoules has the potential to cause occupational injuries to healthcare workers, particularly nurses. Several studies have shown that sharp fragments of broken ampoule glass can cause cuts or puncture wounds to nurses' hands during the ampoule-opening process. Such injuries may disrupt nurses' work activities and potentially lead to infection if the wounds are not treated properly and promptly [7], [8], [9]. Although most glass ampoules are equipped with a marking, typically a dot on the neck indicating the breaking point, the risk of injury from glass fragments can still occur during the snapping process [7].

Several previous studies have compared manual ampoule-opening techniques with the use of ampoule-opening devices. The results indicate that the use of ampoule openers can help simplify the ampoule-opening process and reduce the risk of hand injuries caused by broken glass [7], [6]. Therefore, the use of an ampoule-opening device can serve as a form of risk control to improve occupational health and safety for healthcare workers, particularly nurses [9].

In the context of occupational safety, self-protection for nurses refers to preventive measures taken to protect the hands from potential cuts or puncture wounds caused by shards or fragments of ampoule glass during the preparation of injectable medications. These protective efforts aim to minimize the risk of occupational accidents and enhance the safety of healthcare workers while performing clinical procedures [10], [11].

Although several ampoule-opening devices have been developed previously, innovations that feature a portable design, a closed system, and the ability to accommodate various ampoule sizes (1–10 ml) in hospital nursing practice remain limited. This condition indicates the need to develop a more practical, safe, and ergonomic ampoule-opening device to enhance nurses' hand protection when opening ampoules.

Based on this background, this study aims to develop an innovative ampoule-opening device called the Pocket Ampoule Cutter (PAC) to improve nurses' self-protection at RST Wijaya Kusuma Purwokerto through stages of needs analysis, design development, product feasibility testing, implementation of device use, and evaluation of the product development outcomes.

RESEARCHMETHOD

This study was conducted at RST Wijaya Kusuma Purwokerto in December 2025 using the Research and Development (R&D) method. The Research and Development method is a systematic process or set of steps used to develop new products or improve existing products [12].

The development of the innovative ampoule-opening device in this study employed the ADDIE development model. The ADDIE model is a systematic development approach used to produce an effective and functional product. It consists of five main stages: Analysis, Design, Development, Implementation, and Evaluation [13].

The subjects of this study consisted of two groups, namely validation subjects and trial subjects. The validation subjects included three nursing experts—one nursing lecturer and two practicing nurses—as well as one Occupational Health and Safety (OHS) expert from the OHS installation unit at RST Wijaya Kusuma Purwokerto. These validators were responsible for assessing the feasibility of the developed ampoule-opening device.

Meanwhile, the trial subjects in this study were nurses at RST Wijaya Kusuma Purwokerto who were involved in testing the practicality of the developed ampoule-opening device.

The data collection instrument used in this study was a validation sheet provided to the validators to obtain data regarding the feasibility level of the product. The assessment was conducted using a Likert scale, which is commonly used to measure attitudes, opinions, and perceptions of individuals or groups toward a particular social phenomenon [14].

To determine the feasibility level of the developed ampoule-opening device, the following percentage formula was used:

$$P = \frac{f}{N} \times 100\backslash\%$$

where P represents the percentage score, f represents the total score obtained, and N represents the maximum possible score.

The results of the validation assessment were then interpreted according to the product feasibility criteria shown in Table 1.

Table 1. Interpretation of Product Feasibility

Percentage Score (%)	Interpretasi
0% - 20%	Very unworthy
21% - 40%	Less worthy
41% - 60%	Quite feasible
61% - 80%	Worthy
81% - 100%	Highly feasible

The following are the stages of the ADDIE development method applied in this study:

1. Analysis
   At this stage, the researchers conducted observations to analyze occupational accident incidents experienced by nurses due to glass fragments or shards while opening ampoules at RST Wijaya Kusuma Purwokerto. In addition, the researchers analyzed nurses' needs regarding an assistive device in the form of an ampoule opener that could optimize nurses' self-protection.
2. Design
   The design stage was carried out to determine the technical specifications of the device by developing a two-dimensional (2D) design as an initial visualization and selecting the appropriate material for the ampoule-opening device to be developed.
3. Development
   The development stage aimed to produce the final product. This stage began with creating a prototype to transform the 2D design sketch into a physical form. The developed ampoule-opening device was then validated by nursing experts and occupational health and safety (OHS) experts from the hospital.
4. Implementation
   The implementation stage involved testing the developed ampoule-opening device in real clinical settings by allowing nurses to use the device.
5. Evaluation
   The evaluation stage aimed to assess the quality of the developed ampoule-opening device by analyzing the data obtained from the field trial results involving the nurses.

RESULTS AND DISCUSSION

Results

1. Analysis Stage
   Based on the preliminary study conducted in December 2025 at RST Wijaya Kusuma Purwokerto, it was found that 9 out of 10 nurses (90%) reported having experienced occupational injuries in the form of scratches or puncture wounds caused by broken ampoule glass during the manual ampoule-opening process. In addition, 10 out of 10 nurses (100%) stated that they required an assistive device in the form of an ampoule opener to prevent injuries caused by ampoule fragments. This indicates that the conventional method currently used does not provide optimal protection, thus requiring the development of an innovative ampoule-opening device capable of improving nurses' self-protection.

   After analyzing the problems and needs, the researchers examined the characteristics of the ampoules used at RST Wijaya Kusuma Purwokerto. The hospital uses ampoules with varying volumes, including 1 ml, 2 ml, 5 ml, and 10 ml sizes. These variations result in differences in the diameter of the ampoule head and the pressure required to break the ampoule neck. Therefore, the developed ampoule opener was designed with multiple diameter sizes to accommodate these variations while maintaining the safety of the user's hands from sharp glass fragments.

2. Design Stage
   Based on the results of the analysis, the design stage was carried out to determine the technical specifications of the device. The steps at this stage included prototype design and material selection.

   The researchers developed a visual design in the form of a two-dimensional (2D) model, which included the dimensions of the device, the ampoule-breaking mechanism, and the storage

compartment for the broken ampoule head. This 2D design served as the primary guideline in the fabrication or assembly process to ensure dimensional precision.

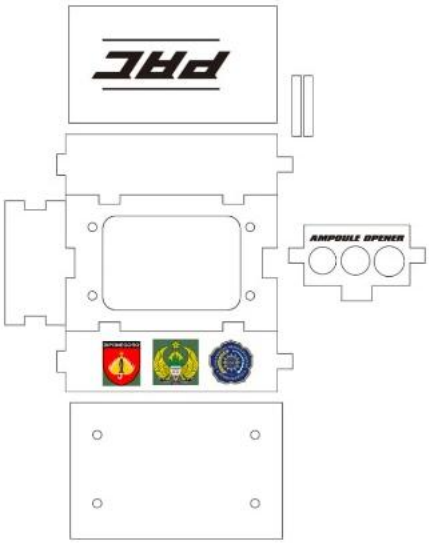

Figure 1. 2D Prototype Design of PAC (Pocket Ampoule Cutter)

After completing the prototype design using the 2D model, the researchers selected acrylic or PMMA (Polymethyl Methacrylate) as the main material for the device. Acrylic (PMMA) is a thermoplastic polymer known for its clarity, ease of shaping, easy cleaning properties, and resistance to weather and light impact. Acrylic has strong and rigid characteristics while remaining flexible for fabrication processes [14]. PMMA is widely used in applications requiring high transparency and durability, such as optical lenses and protective coatings in various fields including medical devices [10]. Additionally, PMMA is frequently used in architectural and biomedical applications due to its consistency, rigidity, transparency, and strength [2].

3. Development Stage

The purpose of the development stage was to produce the final product in the form of the Pocket Ampoule Cutter (PAC). This stage began by transforming the 2D design sketch into a physical prototype using acrylic material with thicknesses of 3 mm and 5 mm.

The fabrication process involved cutting each component using laser cutting technology, which ensured high precision in the dimensions of each part. The assembly process involved joining each component using cyanoacrylate adhesive, forming a unified structure.

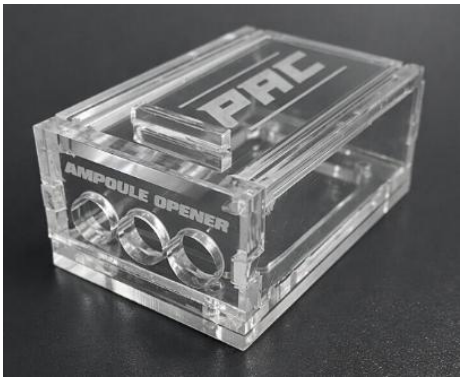

Figure 2. PAC Ampoule Opener Prototype

After the prototype was completed, the researchers conducted a validation test based on expert judgment involving several validators: three nursing experts and one Occupational Health and Safety (OHS) expert from RST Wijaya Kusuma Purwokerto. The validators evaluated the device in terms of

functionality, safety, ease of use, comfort, design, material quality, maintenance, hygiene, and overall feasibility to ensure that the device could minimize occupational injury risks such as cuts or exposure to broken glass during the ampoule-opening procedure.

Table 2. Validator Assessment of PAC Feasibility

No	Validator	Final Score (%)	Interpretasi
1	Nurse Practitioner	93,59%	Highly feasible
2	Hospital OHS Expert	98,07%	Highly feasible
Average		95,83%	Highly feasible

Based on the validation results conducted by three nursing experts (one nursing lecturer and two clinical nurses), a total score of 146 out of the maximum ideal score of 156 was obtained. The calculated percentage resulted in 93.59%. Meanwhile, validation from the hospital OHS expert yielded a score of 98.07%, confirming that the device design meets occupational safety standards by eliminating direct contact between nurses' hands and broken ampoule glass.

Overall, the average validation percentage was 95.83%, which falls within the "Very Feasible" category according to the product feasibility criteria [16]. This indicates that the developed ampoule-opening device is functionally effective and safe for implementation in nursing procedures.

4. Implementation Stage

During the implementation stage, the innovative ampoule-opening device that had been validated by experts was tested in real clinical settings. The purpose of this stage was to evaluate the functionality of the device in minimizing injury risks caused by broken ampoule glass.

The trial involved 10 clinical nurses at RST Wijaya Kusuma Purwokerto selected using probability sampling with a random sampling technique. Sampling is an important step used to select a subset of a population for research purposes, aiming to generate accurate inferences about the overall population [7]. Random sampling is a sampling technique in which members of the population are selected randomly without considering the population strata [8]. The subjects were selected based on the criterion that they routinely perform ampoule-opening procedures.

The implementation process began with a demonstration by the researchers, explaining the functions, working mechanism, and usage procedures of the PAC device. The nurses then practiced opening ampoules using PAC with various ampoule sizes (1 ml, 2 ml, 5 ml, and 10 ml). This variation was intended to evaluate whether PAC could accommodate different ampoule neck diameters while providing precise pressure to break the ampoule safely without producing dangerous glass fragments. During the implementation process, the researchers conducted direct observations and asked respondents to complete an evaluation questionnaire. The primary focus of this stage was to ensure that the device could enhance nurses' self-protection and improve the conventional ampoule-opening method, which previously provided inadequate protection.

Figure 3. PAC Usage by Nurses

After completing the procedure, nurses evaluated the device based on functionality, safety, ease of use, comfort, design, material quality, maintenance, hygiene, and overall feasibility.

Table 3. Nurses' Evaluation of PAC

No	Validator	Final Score (%)	Interpretation
1	10 Field Nurse	88,46% - 98,07%	Very Feasible
Average		93,33%	Very Feasible

Based on these percentages, the results were interpreted according to feasibility criteria [16], where a product is categorized as "Very Feasible" if it achieves a score between 81% and 100%.

The nurses' evaluation showed positive responses toward PAC usage. All respondents (100%) stated that PAC provided protection and a sense of safety, successfully preventing scratches or puncture injuries that had previously been experienced by 90% of nurses when using conventional techniques.

Additionally, PAC proved capable of accommodating different ampoule neck diameters from various ampoule sizes (1 ml, 2 ml, 5 ml, and 10 ml), allowing nurses to apply precise pressure when breaking the ampoule. Nurses also reported that the closed design of PAC minimizes direct contact between hands and sharp glass fragments, which is a major issue in conventional techniques.

This implementation stage demonstrates that the PAC device meets nurses' needs for an assistive tool that enhances self-protection during ampoule-opening procedures. These results are consistent with the validator assessments from nursing experts and OHS experts, which previously reported an average validation score of 95.83%, categorized as "Very Feasible."

5. Evaluation Stage
   Based on the implementation results involving 10 nurses at RST Wijaya Kusuma Purwokerto, the evaluation showed that the PAC device successfully improved nurses' self-protection. The occupational injury risk in the form of scratches or puncture wounds, which previously reached 90% using manual techniques, was effectively prevented during the use of PAC.

   Nurses' responses indicated that the device not only enhances self-protection but also provides comfort and convenience during ampoule-opening procedures.

Discussion

Based on the evaluations from nursing experts, OHS experts, and practical responses from nurses in the field, the developed ampoule-opening device meets the standards of a tool capable of protecting nurses from sharp ampoule glass fragments, providing ergonomic usability, and improving occupational safety standards in nursing practice.

The Pocket Ampoule Cutter (PAC) represents an innovative development based on previous studies on ampoule-opening devices. PAC utilizes acrylic material, which offers high transparency. The use of transparent acrylic provides better visibility, allowing nurses to clearly observe the ampoule breaking point and detect when the storage compartment for broken ampoule heads is full. Additionally, the strong acrylic structure can withstand the pressure applied when breaking the ampoule. The acrylic material also facilitates easy disinfection to eliminate microorganisms, thereby supporting patient and nurse safety.

The PAC design is adapted to the anatomy of the hand, enabling nurses to open ampoules more easily, safely, and comfortably. These findings are consistent with research conducted by [15], which states that ampoule-opening devices help simplify the ampoule-opening process. With its ergonomic design, PAC can be stored in a pocket, placed on a table, held by hand, or connected to a safety box.

PAC consists of several components. The front section contains three holes of different sizes (9 mm, 9.5 mm, and 10 mm) to accommodate various ampoule sizes (1 ml, 2 ml, 5 ml, and 10 ml). The top section can be opened and closed by sliding it backward, allowing PAC to be connected to a safety box as a pathway for disposing of sharp medical waste such as needles. The bottom section contains magnets on

both sides, allowing it to be detachable. When removed, an opening appears that enables PAC to be connected to a safety box so that broken ampoule heads fall directly into the container. When attached, the bottom section functions as a storage compartment for broken ampoule heads when PAC is used on a table or handheld.

PAC is designed as a closed device to minimize direct contact between the skin and broken glass fragments, thereby reducing the risk of occupational injuries during ampoule-opening procedures. This finding aligns with previous research [13], which states that ampoule-opening devices are safer than conventional methods because they are specifically designed to contain ampoule fragments and protect the user's hands.

Other studies also indicate that ampoule openers are safer for nurses compared to manual techniques, as they significantly reduce the risk of cuts caused by glass fragments during ampoule opening [15]. Similarly, [20] reported that ampoule-opening devices improve safety for nurses by reducing the risk of hand injuries caused by broken glass.

Overall, the results of this study indicate that the PAC ampoule-opening device enhances nurses' protection by shielding their hands from sharp glass fragments, improving usability through an ergonomic design, and increasing work efficiency by allowing nurses to open ampoules more quickly compared to manual methods.

CONCLUSION

Based on the results of the Research and Development (R&D) study using the ADDIE model, the conclusions of this research are as follows:

1. Needs Analysis
   The study identified a high risk of occupational accidents at RST Wijaya Kusuma Purwokerto, where 9 out of 10 nurses (90%) had experienced scratches or puncture wounds caused by broken ampoule glass while opening ampoules using manual techniques. This phenomenon indicates the need for an assistive device in the form of an ampoule opener that can provide self-protection for nurses.
2. Design Development
   The researchers developed a two-dimensional (2D) design as the initial visualization of the proposed concept and used PMMA acrylic (Polymethyl Methacrylate) as the primary material for the development of the innovative ampoule-opening device.
3. Product Feasibility
   The innovative ampoule-opening device was declared "Very Feasible" by experts, including the Occupational Health and Safety (OHS) expert from RST Wijaya Kusuma Purwokerto and three nursing experts, with an overall average score of 95.83%. This assessment included aspects of functionality, safety, ergonomics, and ease of maintenance.
4. Product Implementation
   The trial results involving 10 respondents showed that the Pocket Ampoule Cutter (PAC) effectively accommodates various ampoule volume variations (1 ml, 2 ml, 5 ml, and 10 ml) and successfully protects nurses' hands from the risk of sharp ampoule glass fragments.
5. Final Product Outcome
   Through the evaluation stage, the final product met the criteria of an assistive device that is safe, ergonomic, and capable of optimally enhancing nurses' self-protection, in accordance with the objectives of the product development.

Overall, the Pocket Ampoule Cutter (PAC) can serve as a practical assistive device to protect nurses and prevent occupational injuries during ampoule-opening procedures.
This study is expected to serve as a foundation for future research on the development of innovative ampoule-opening devices using materials with higher strength, such as stainless steel, and incorporating more ergonomic designs to further improve user comfort and safety.

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