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Managing Spaghetti Syndrome with a Prototype IV Pole Hook: A Nursing Perspective

Jhonee F. Balmeo, MAN, RN
Instructor 1, College of Nursing, Nueva Ecija University of Science and Technology, Cabanatuan City, Nueva Ecija, Philippines

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Email of Corresponding Author: balmeojhoneef@gmail.com

Abstract

This study evaluated the perceived effectiveness and usability of the Prototype IV Pole Hook in managing IV-related Spaghetti Syndrome among nurses in hospital settings in Cabanatuan City, Nueva Ecija. Guided by Everett Rogers' Five Factors of Diffusion of Innovation Theory and product usability measures, the study used a descriptive correlational research design. The respondents were 114 registered nurses with at least three years of clinical experience and direct involvement in IV line management. After using the prototype for approximately one to two weeks, the nurses assessed its perceived effectiveness in terms of relative advantage, compatibility, complexity, trialability, and observability, and its usability in terms of novelty, technical merit, and system usability. Findings showed that the Prototype IV Pole Hook was rated at a high level across all innovation attributes, indicating that it was perceived as useful, compatible with nursing routines, easy to use, testable, and visibly beneficial in organizing multiple IV lines. It also obtained high ratings in novelty, technical merit, and system usability, suggesting that the device was viewed as innovative, technically sound, and user-friendly. Demographic profile had no significant relationship with perceived effectiveness, while perceived effectiveness had significant positive relationships with usability. The study concluded that the prototype has potential to support safer and more efficient IV line management, although further design improvement, broader testing, and longer trial periods were recommended. The study aligns with SDG 3, SDG 8, and SDG 9 by promoting patient safety, safer nursing work, and practical healthcare innovation. Its sustainability impact lies in supporting public health, institutional improvement, nursing workflow efficiency, and locally relevant medical device development.

Keywords: Cabanatuan City, Diffusion of Innovation Theory, IV Line Management, Nurses, Patient Safety, Product Usability, Prototype IV Pole Hook, Spaghetti Syndrome, System Usability

1. Introduction

This study focused on the perceived effectiveness and usability of the Prototype IV Pole Hook in managing IV-related Spaghetti Syndrome among nurses in hospital settings. Spaghetti Syndrome was defined in the study as the presence of three or more tangled IV lines around the patient's bedside, creating risks such as workflow disruption, restricted staff movement, accidental disconnections, medication errors, and equipment damage. Guided by Everett Rogers' Five Factors of Diffusion of Innovation Theory and product usability measures, the study evaluated whether the prototype could support safer, more organized, and more efficient IV line management among licensed nurses in Cabanatuan City, Nueva Ecija.

1.1 Background of IV-Related Spaghetti Syndrome and the Prototype IV Pole Hook

The continuous advancement of medical technology increased the use of monitoring, diagnostic, and treatment equipment in hospitals, improving care quality and patient outcomes while also creating operational challenges. One major concern was the growing complexity of bedside tubing systems, including IV lines, oxygen tubing, and monitoring cables. When these lines became tangled or disorganized, the condition was referred to as "Spaghetti Syndrome," which described situations where medical lines compromised safety, accessibility, or efficiency of care (Erbaş et al., 2023). In this study, Spaghetti Syndrome specifically referred to three or more tangled IV lines around the patient's bedside, which obstructed nursing workflow, limited movement, and increased risks of accidental disconnections, medication errors, and equipment damage. Globally, tangled IV lines remained a common issue in high-acuity settings such as intensive care units, where patients often required multiple simultaneous infusions. Disorganized tubing delayed nursing interventions and increased the likelihood of adverse events such as line dislodgement and medication errors (Erbaş et al., 2023). Although innovations such as the Beanstalk Pole introduced anti-tangling and child-friendly designs and received recognition through the James Dyson Award in 2020 (James Dyson Award, 2025), such interventions were not yet widely accessible in many settings, including the Philippines. Locally, Filipino nurses continued to encounter challenges related to tangled IV lines, prompting institutions such as St. Luke's Medical Center to strengthen infusion therapy protocols through systematic line labeling, regular assessment of IV connections, and equipment intended to minimize line entanglement (St. Luke's Medical Center,

2021). The Prototype IV Pole Hook was introduced as a practical and cost-efficient device designed to organize and separate multiple IV lines. It aimed to improve nursing workflow, reduce bedside clutter, prevent line tangling, and support patient safety. Through quantitative assessment among nurses, the study evaluated whether the prototype could improve clinical efficiency, reduce IV-related risks, and contribute to safer nursing care.

1.2 Related Literature on IV Pole Design, Line Management, and Nursing Workflow Efficiency

The literature showed that the increasing use of IV therapy required safer and more functional IV pole designs. Existing IV pole hooks often caused tangled lines, difficulty in identifying IV bags, increased medication error risks, and workflow delays. Design improvements such as expanded hook capacity, stronger bases, antimicrobial materials, and ergonomic features were considered important for caregiver efficiency and patient safety (Claflin Medical Equipment Corp, 2024). Studies also noted that unstable, poorly maneuverable, and ergonomically weak IV poles affected patient mobility, nursing comfort, and clinical workflow (Monane et al., 2025; Mebarki et al., 2023; Mistri et al., 2023). Tubing arrangements using hooks, clips, and temporary line supports also increased infection risks, monitoring difficulties, and patient safety concerns (Weaver et al., 2023). Spaghetti Syndrome was described as the tangling of IV lines caused by poor organization or unsecured tubing (Erbaş et al., 2023). Even limited tangling could delay medication delivery, make line identification difficult, increase dislodgement and infection risks, and contribute to medication errors (Erbaş et al., 2023). For this reason, equipment design became central to improving IV line management. Innovations such as smart IV poles, improved hook systems, and line organizers were developed to reduce tangling, improve stability, and support safer medication delivery, although some remained limited by adaptability, durability, clutter, and accessibility (Seddighi et al., 2024; Beata Clasp, 2025; OTen Medical, 2025; PDC Healthcare, 2025; BAILIDA, 2025; UMF Medical, 2025; Provita, 2025; James Dyson Award, 2025). In this context, the Prototype IV Pole Hook was designed as a dual-head, lightweight, stainless steel and rubber device compatible with 25 to 40-mm IV poles and intended to support locally available IV fluids and other hanging solutions (Philippine Medical Supplies, 2025; Philippine Food and Drug Administration, 2025). Its mechanism relied on balance, friction, and gravity to prevent slippage and improve stability (Halliday et al., 2020; Anhui Xinzhitu Technology Development Co. Ltd., 2020). Related studies emphasized that medical equipment innovations improved patient care by enhancing mobility, safety, workflow efficiency, and medication management (Sayed-Kassem et al., 2020; THRIV Coalition, 2024; Monane et al., 2025). However, successful adoption depended not only on technical design but also on nurses' perceived usefulness, work culture, professional development, organizational support, and user involvement (Jedwab et al., 2023; Coffetti et al., 2022; Yan et al., 2022; Cunha et al., 2022; Moisoglou et al., 2024; Ibrahim, 2023). These findings supported the relevance of Diffusion of Innovations theory, which emphasized relative advantage, compatibility, complexity, trialability, and observability in determining whether healthcare workers adopt new tools (Coffetti et al., 2022). Healthcare professionals' perceptions were also important in assessing medical device effectiveness. User-centered design improved usability, satisfaction, and acceptance of medical technologies (Savic & Goetz, 2023), while advanced medical devices were generally viewed as beneficial to patient care (Saad et al., 2023). However, complex devices introduced without sufficient training could create difficulties for ICU nurses and increase risks of device-related errors (Rhagnanan-Kramer, 2020). Studies also showed that IV pole design affected patient safety, workflow efficiency, patient comfort, and nurse interaction with equipment (Hwang et al., 2023; Mistri et al., 2023; Iacono et al., 2023; Claridge & Powell, 2022; Grissim et al., 2020; Li-mei et al., 2021). Barriers to adopting new medical technologies included complexity, poor usability, limited clinician feedback, and weak alignment with existing workflows (Rhagnanan-Kramer & Johnson, 2023; Jesso et al., 2022; Ros & Neuwirth, 2020; Harst et al., 2021). Prototype testing was therefore necessary to identify design issues, improve functionality, and ensure safe integration into clinical settings (Gundi, 2023; Seputra et al., 2024; Cambridge Design Technology, 2022; Jon, 2024). Recent studies further showed that poor infusion line management contributed to misconnections, medication errors, workload-related IV drug administration errors, and tubing strain, supporting the need for practical interventions such as the Prototype IV Pole Hook (Schmid et al., 2019; O'Connell et al., 2023; Gul & Ahmed, 2025; Zeller et al., 2021).

1.3 Local, National, and Global Context of Spaghetti Syndrome in Hospital IV Line Management

At the global level, Spaghetti Syndrome reflected a common bedside safety issue in hospitals, particularly in high-acuity environments where patients required several simultaneous infusions. International studies and innovations showed growing recognition of the need to improve IV pole design, line organization, tubing visibility, and patient safety. Devices such as the Beanstalk IV Pole, Beata Clasp®, iLine IV Line Organizer, IV Port Clips, and other multi-hook pole systems demonstrated the global effort to solve IV line disorganization, although limitations remained in adaptability, durability, clutter control, accessibility, and local implementation (Beata Clasp, 2025; OTen Medical, 2025; PDC Healthcare, 2025; BAILIDA, 2025; UMF Medical, 2025; Provita, 2025; James Dyson Award, 2025). At the national level, the issue remained relevant in Philippine hospitals because nurses managing multiple IV fluids encountered delays, safety hazards, and workflow challenges linked to disorganized IV lines. Existing local responses, such as improved infusion therapy protocols, emphasized line labeling, regular assessment of IV connections, and advanced equipment to reduce entanglement risks (St. Luke's Medical Center, 2021). The prototype was also designed with consideration of locally available IV fluids and hanging solutions commonly used in healthcare settings (Philippine Medical Supplies, 2025; Philippine Food and Drug Administration, 2025). At the local level, the study focused on nurses working in hospitals in Cabanatuan City, Nueva

Ecija. It involved 114 licensed nurses with at least three years of experience and direct involvement in managing patients with three or more IV fluids. Nurses used the Prototype IV Pole Hook during their shifts for approximately two weeks and then assessed its perceived effectiveness and usability. This local context allowed the study to examine whether a simple, locally applicable device could address IV-related Spaghetti Syndrome in actual nursing practice.

1.4 Diffusion of Innovation and Usability Basis of the Prototype IV Pole Hook

The study was guided by Everett Rogers' Five Factors of Diffusion of Innovation Theory, which explains how people decide whether to adopt new technologies, products, or practices. The theory's five factors—relative advantage, compatibility, complexity, trialability, and observability—served as the basis for evaluating nurses' perceptions of the Prototype IV Pole Hook in managing Spaghetti Syndrome. Relative advantage referred to the extent to which the Prototype IV Pole Hook was perceived as better than conventional IV pole hooks. In this study, it involved the device's ability to reduce tangled IV lines, support nursing workflow, improve ease of use, and enhance patient safety. Compatibility referred to how well the prototype aligned with nurses' work habits, values, clinical routines, and patient care protocols. Complexity referred to the perceived ease or difficulty of using the device, particularly whether nurses found it intuitive and manageable during clinical practice. Trialability referred to the opportunity for nurses to test the prototype before full adoption, while observability referred to the visibility of its benefits in improving workflow efficiency and patient safety. The conceptual basis of the study followed an input-process-output structure. The input included nurses' demographic profile in terms of age, sex, and years of experience; the five factors of Diffusion of Innovation Theory; product usability indicators such as novelty, technical merit, and system usability; the problem of Spaghetti Syndrome; and the Prototype IV Pole Hook as the proposed intervention. The process involved using the prototype in clinical practice for around two weeks, followed by structured assessment and statistical analysis through descriptive and correlational methods. The output consisted of findings on the prototype's perceived effectiveness, usability, relationships between demographic profile and perceived effectiveness, relationships between usability and effectiveness, and design recommendations for possible improvement.

1.5 Research Gaps and Rationale for Evaluating the Prototype IV Pole Hook among Nurses

The reviewed literature showed that IV line disorganization created safety risks, workflow delays, infection concerns, medication errors, and equipment-related complications. Although several IV line organizers and improved pole designs had been introduced, limitations remained in adaptability, stability, usability, clutter prevention, and accessibility. Existing innovations also appeared to be less widely available in the Philippine context, despite the continued presence of tangled IV lines in local hospital settings. The study addressed these gaps by evaluating a simple, lightweight, and compatible Prototype IV Pole Hook that could be attached to existing IV poles. Unlike broader discussions of IV pole design, the study specifically focused on IV-related Spaghetti Syndrome, operationally defined as three or more tangled IV lines at the bedside. It also examined nurses' perceptions after actual device use, allowing the study to assess the prototype's relative advantage, compatibility, complexity, trialability, observability, novelty, technical merit, and system usability. The rationale of the study was further strengthened by the need to determine whether nurses' demographic profile influenced perceived effectiveness and whether usability was significantly related to effectiveness. By focusing on licensed nurses with direct experience in managing multiple IV lines, the study generated evidence that could guide design improvements, support possible adoption, and contribute to safer and more efficient IV line management in hospital settings.

1.6 Alignment of the Prototype IV Pole Hook Study with Relevant Sustainable Development Goals

The study aligned most directly with SDG 3 – Good Health and Well-Being because it focused on improving patient safety, reducing IV-related risks, preventing medication errors, minimizing accidental disconnections, and supporting safer nursing care. By addressing a preventable bedside hazard, the study contributed to safer healthcare delivery and improved clinical outcomes. The study also aligned with SDG 9 – Industry, Innovation and Infrastructure because it evaluated a prototype medical device designed to improve healthcare equipment functionality and clinical workflow. The Prototype IV Pole Hook represented a practical healthcare innovation intended to improve the organization of IV lines using a simple, durable, and compatible design. The study was also connected to SDG 8 – Decent Work and Economic Growth in the context of safer and more efficient nursing work. By reducing clutter, improving workflow, and minimizing risks associated with multiple IV lines, the device could support a more organized and safer work environment for nurses. This alignment was limited to the study's focus on workflow efficiency, occupational safety, and professional practice improvement.

1.7 Multidisciplinary Sustainability Relevance of the Prototype IV Pole Hook in Nursing Practice

The study contributed to public health sustainability by addressing patient safety risks associated with tangled IV lines, including medication errors, line dislodgement, infection concerns, and delays in care. Safer IV line management supported more reliable clinical practices and helped reduce preventable harm in hospital settings. It also supported technological and innovation sustainability by evaluating a practical prototype that could improve existing IV pole systems without requiring complex infrastructure. The study emphasized user-centered design, usability, and clinical compatibility, which are important in developing medical devices that healthcare workers can realistically adopt and sustain in practice. The study contributed to institutional and professional sustainability by providing evidence that could help nurses, hospitals, the Philippine Nurses Association, nursing students, and future researchers improve IV line management practices. Its findings

may guide design improvements, support safer nursing workflows, and encourage further innovation in healthcare equipment. Through its focus on patient safety, nursing efficiency, and locally relevant medical device evaluation, the study demonstrated multidisciplinary value across healthcare practice, technology design, institutional improvement, and socio-economic sustainability.

2. Material and methods

2.1 Research Design

The study used a descriptive correlational research design. According to Devi et al. (2023), this non-experimental approach explores relationships between two or more variables without establishing cause and effect. The descriptive component was used to describe the demographic profile of the nurse respondents, the perceived effectiveness of the Prototype IV Pole Hook in terms of relative advantage, compatibility, complexity, trialability, and observability, and its usability in terms of novelty, technical merit, and system usability. The correlational component examined the relationship between respondents' demographic factors and their evaluation of the prototype's perceived effectiveness, as well as the relationship between Rogers' five innovation attributes and the prototype's usability dimensions.

2.2 Locale of the Study

The study was conducted in Cabanatuan City, Nueva Ecija, specifically in five hospitals: Eduardo L. Joson Memorial Hospital, Manuel V. Gallego Medical Center, Premiere Medical Center, Wesleyan University General Hospital, and Immaculate Conception Medical Center.

2.3 Respondents of the Study

The respondents were 114 registered nurses currently employed in hospitals in Cabanatuan City. They were selected because of their direct involvement in intravenous line management and their capacity to provide informed feedback on the Prototype IV Pole Hook. The respondents had at least three years of clinical nursing experience and voluntarily agreed to participate by signing an informed consent form.

2.4 Sample and Sampling Procedure

The study employed purposive non-probability sampling to ensure that the participants were directly relevant to the research objectives. According to Fraenkel et al. (2012), cited in the study of Putra (2017), a minimum sample size of 30 is generally acceptable for correlational studies; however, recent recommendations suggest that larger samples improve statistical power and generalizability (Bujang, 2024). The inclusion criteria required respondents to be registered nurses employed in hospitals within Cabanatuan City, have at least three years of clinical experience, have sufficient exposure to IV line management, and be willing to provide honest feedback on the prototype's effectiveness.

2.5 Research Instrument

The instrument consisted of two main parts. The first was a modified questionnaire based on the Autonomy and Competence in Technology Adoption Questionnaire, adapted from Everett Rogers' Five Factors of Diffusion of Innovations Theory (Lemos, 2022). This section gathered demographic data, including age, sex, and years of nursing experience, and assessed perceptions of the prototype using Rogers' five innovation attributes: relative advantage, compatibility, complexity, trialability, and observability. It used a 4-point Likert scale ranging from 1 = Not at all true to 4 = Completely true. The second part was the Product Usability Scale, adopted from Einfolge's IP Asset Management Services and based on the standard System Usability Scale (Finstad, 2006; Sauro & Lewis, 2016). It assessed the prototype's novelty, technical merit, and system usability using a 5-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree. The researchers obtained formal permission through email correspondence to use and adapt the instruments. The questionnaire was evaluated by five nursing experts for content validity using a 5-point scale. The expert ratings were 4.3, 4.0, 3.8, 4.0, and 4.6, with an overall mean of 4.14, indicating good clarity, relevance, and representativeness. A mean expert rating above 4.0 or a scale-level CVI above 0.80 is considered acceptable evidence of content validity (International Journal of Medical Research, 2023). The instrument was then pilot-tested with 20 nurses, after which revisions were made to improve clarity and reliability. Validity was established through the review of five registered nurses with Master of Arts degrees in Nursing. Validity refers to the accuracy of a research tool in measuring what it intends to measure (Ranganathan et al., 2024). Reliability was tested using Cronbach's alpha among 20 randomly selected nurses from San Antonio District Hospital in Nueva Ecija. Based on Schrepp (2020), alpha values of 0.90 and above are excellent, 0.80 to 0.89 are good, 0.71 to 0.79 are acceptable, and below 0.70 are unacceptable. The Product Usability section obtained $\alpha = 0.825$, Observability obtained $\alpha = 0.865$, Relative Advantage obtained $\alpha = 0.795$, Compatibility obtained $\alpha = 0.738$, Complexity obtained $\alpha = 0.768$, and Trialability obtained $\alpha = 0.715$. The overall reliability score was 0.784, indicating that the questionnaire was generally reliable for the main study.

2.6 Data Gathering Procedure

Before data collection, the researchers secured approval from the Dean of the College of Nursing at Nueva Ecija University of Science and Technology. After approval was granted, authorization letters were sent to the participating hospitals, and the Chief Nurses were contacted to explain the purpose of the study, voluntary participation, and confidentiality measures. Eligible participants were then identified and provided with informed consent forms explaining the study objectives, procedures, rights, and confidentiality protections. After consent was obtained, the researchers demonstrated the proper use of the Prototype IV Pole Hook in managing multiple IV lines. Nurses who were unavailable during the demonstration received printed instructions, the prototype, and a contact number for clarification. Participants used the prototype continuously for approximately one to two weeks. This testing period allowed nurses to incorporate the device into their workflow and evaluate its performance in actual clinical settings. A testing period of ten days to two weeks was supported by Mitomi et al. (2021) and Hansen et al. (2021), who found that such durations allowed prototype evaluation and improvement. After the trial period, the researchers administered the structured questionnaire face-to-face to assess the nurses' perceptions and experiences. This approach allowed clarification of concerns and helped ensure accurate responses. Administering the questionnaire after actual prototype use allowed participants to provide feedback based on real experience rather than assumptions, producing more accurate and useful insights (Dam & Teo, 2023). This timing also supported data validity by aligning with recommended questionnaire evaluation practices (Nirmalan, 2021). The researchers ensured that photographs were used only for the study and that patient identities were blurred in all documentation.

2.7 Data Analysis Techniques

The study used descriptive and inferential statistics to analyze the collected data. Descriptive statistics, including frequency, mean, valid percentage, standard deviation, verbal interpretation, and overall weighted mean, were used to summarize the respondents' demographic profile and evaluate their perceptions of the Prototype IV Pole Hook based on Rogers' five factors: relative advantage, compatibility, complexity, trialability, and observability. The 4-point Likert scale removed a neutral option to encourage respondents to provide definite opinions and reduce midpoint responses (Mariano et al., 2024). Descriptive statistics were also used to analyze the Product Usability Scale, which measured novelty, technical merit, and system usability. The 5-point Likert scale included a neutral midpoint because respondents evaluating novel technologies may not always have strong opinions or sufficient experience to form a firm judgment (Mariano et al., 2024). Mean scores and standard deviations were computed to identify general trends in usability, satisfaction, functionality, and design efficiency. Inferential statistics were used to determine relationships among demographic variables, perceived effectiveness, and usability. Spearman's Rho was used for ordinal or non-normally distributed variables, particularly age-related associations, while Pearson's correlation coefficient was used to examine linear relationships involving continuous variables, including the five innovation attributes and usability dimensions. These statistical techniques were selected to accurately interpret relationships between theoretical constructs and user experiences (Schober et al., 2018). Correlation values were interpreted using established qualitative descriptors (Schober et al., 2018). Correlation analysis helped determine how the innovation related to both theoretical concepts and real user experience (Schober et al., 2018), while significant links between perceptions and innovation attributes supported the study's credibility and identified factors affecting adoption (Greenhalgh et al., 2020). Differences across demographic groups also guided strategies for product improvement, training, and implementation (Dearing & Cox, 2020).

2.8 Ethical Considerations

The study followed ethical protocols established by Nueva Ecija University of Science and Technology. Participation was voluntary, and only respondents who agreed to participate and signed the informed consent form were included. The researchers protected the anonymity and confidentiality of responses and ensured that all information was used solely for ethical academic research. Ethical safeguards included informed consent, respect for participant autonomy, confidentiality, and beneficence throughout the research process.

3. Results and Discussion

3.1 Demographic Profile of the Respondents

3.1.1 Age Distribution of the Respondents

The respondents were mostly younger adults. The largest group was aged 25–29 years, with 53 respondents or 46.5%, followed by 30–34 years with 29 respondents or 25.4%. Nineteen respondents or 16.7% were aged 35–39 years, while eight or 7.0% were aged 40–44 years. Only two respondents or 1.8% belonged to the 45–49 age group, another two or 1.8% were aged 50–54 years, and one respondent or 0.8% belonged to the 55–59 age group. The use of five-year age intervals supported standardized age-disaggregated data and improved comparability across studies and public health contexts (Diaz et al., 2021). The dominance of nurses in their twenties and thirties reflected the growing presence of younger nurses in the workforce, as noted by Flaubert et al. (2021). This was relevant because younger nurses may show greater technical readiness and openness to innovations such as the Prototype IV Pole Hook (Korte & Bohnet-Joschko, 2023). However, the limited representation of older respondents may affect how broadly innovation adoption can be

interpreted, since responses may vary across age cohorts and equal age representation can strengthen survey validity (Federal Reserve, 2025).

3.1.2 Sex Distribution of the Respondents

Most respondents were female, with 74 participants or 64.9%, while 40 respondents or 35.1% were male. This showed that the sample reflected the continued female-dominated nature of the nursing profession. This sex distribution may influence perceptions of the Prototype IV Pole Hook, particularly in terms of ergonomics, user preference, and engagement with new clinical tools. Prior studies noted that age and sex may affect readiness and willingness to adopt healthcare innovations, with younger and male healthcare professionals generally showing higher technical readiness (Korte & Bohnet-Joschko, 2023). However, the predominance of female respondents should be considered in interpreting the findings to ensure that implementation strategies remain inclusive and responsive to workforce needs (Terry et al., 2020). Recent studies also emphasized the importance of gender balance and diversity in nursing, as male participation in the profession continues to increase in some settings (Masibo et al., 2024), while gender stereotypes may still affect female nurses' professional experiences (Aca et al., 2025).

3.1.3 Years of Nursing Experience

The respondents were almost evenly distributed between proficient and expert levels. Fifty nurses or 43.9% had three to four years of experience and were classified as proficient, while 64 nurses or 56.1% had five years and above of experience and were classified as expert. This distribution was consistent with Patricia Benner's Novice to Expert Theory, which explains that nurses generally reach the proficient stage after three to five years of experience and become experts through extended clinical practice beyond five years (Nursology, 2025). The presence of both proficient and expert nurses strengthened the evaluation because years of experience may influence how nurses accept and use new technologies. Less experienced nurses may be more influenced by peer and social factors, while more experienced nurses may rely more on clinical judgment and may require different strategies for innovation acceptance (Barchielli et al., 2021).

3.2 Perceived Effectiveness of the Prototype IV Pole Hook in Managing Spaghetti Syndrome

3.2.1 Relative Advantage of the Prototype IV Pole Hook

The Prototype IV Pole Hook obtained an overall weighted mean of 2.93 for relative advantage, interpreted as High Level. Nurses perceived the device as beneficial compared with current IV pole hooks. The highest-rated item was that the prototype made tasks easier and faster to perform, with a weighted mean of 2.98. This was followed by improved ability to manage multiple IV lines at 2.97 and better IV line organization at 2.96. Improved workflow efficiency and reduced patient safety risks also received high ratings of 2.86 and 2.87, respectively. These findings indicate that nurses viewed the prototype as a useful tool for improving task efficiency, organizing IV lines, and supporting safer workflow. The results align with Velasquez (2022), who emphasized that practical IV line management tools can reduce nurse workload and improve care quality, especially in high-acuity areas. Although patient safety and workflow efficiency had slightly lower ratings, they remained within the high-level category, suggesting that further use, refinement, and institutional support may strengthen the perceived advantages of the prototype.

3.2.2 Compatibility of the Prototype IV Pole Hook

The compatibility of the Prototype IV Pole Hook obtained an overall weighted mean of 2.81, interpreted as High Level. Nurses agreed that the prototype fit smoothly into their current workflow, with a weighted mean of 2.80, and that it aligned with their values as critical care nurses, with a weighted mean of 2.72. The highest score was for consistency with previous experiences in managing Spaghetti Syndrome at 2.88, followed by integration with existing IV equipment at 2.87. Its functionality in critical care settings also received a high rating of 2.80. The high compatibility rating suggests that the prototype can be integrated into current nursing routines without major disruption. Since compatibility is a key factor in Rogers' Five Factors of Diffusion of Innovation Theory, the findings imply that the Prototype IV Pole Hook has strong potential for adoption because it aligns with nurses' existing practices, values, equipment, and clinical needs. Its compatibility may reduce resistance, shorten the learning curve, and support sustained use in actual hospital settings.

3.2.3 Complexity of the Prototype IV Pole Hook

The prototype received an overall weighted mean of 3.06 for complexity, interpreted as High Level. Nurses generally found the device easy to learn, set up, and use. The highest-rated item was that learning how to use the prototype required minimal effort, with a weighted mean of 3.14. This was followed by the device's functionality being easy to figure out at 3.13, ease of setup and use at 3.11, minimal training requirement at 3.05, and intuitive integration into routine tasks at 2.88. These results show that nurses perceived the prototype as simple and user-friendly, which is important in fast-paced clinical environments. However, the slightly lower score for training needs suggests that even easy-to-use medical tools may still require orientation to ensure proper and confident use. This supports Salwei et al. (2021), who emphasized that poor usability and weak integration into clinical workflows can hinder the effectiveness of new technologies, making training and orientation important during implementation.

3.2.4 Trialability of the Prototype IV Pole Hook

The trialability of the Prototype IV Pole Hook obtained an overall weighted mean of 3.06, interpreted as High Level. Nurses reported that they were able to test the prototype under realistic conditions, which received the highest score of 3.23. The trial period allowed them to determine the prototype's effectiveness, with a weighted mean of 3.19, and compare it with current IV pole hooks, with a weighted mean of 3.15. Sufficient time to experiment with the device received a score of 2.92, while confidence in its long-term performance received the lowest score of 2.80. The findings indicate that the trial period helped nurses assess the prototype's practicality and function in actual clinical settings. However, the lower score for long-term confidence suggests the need for extended use or follow-up evaluation to establish durability and reliability. These findings support Everett Rogers' Five Factors of Diffusion of Innovations Theory, where trialability increases the likelihood of adoption because users can test an innovation before full implementation. Healthcare innovations are more likely to be adopted when professionals can evaluate them under realistic conditions and compare their advantages with existing practices (Stoermer et al., 2024). Allowing nurses to trial tools also strengthens evidence-based decision-making and supports smoother integration into clinical routines (Wolters, 2023).

3.2.5 Observability of the Prototype IV Pole Hook

The prototype obtained an overall weighted mean of 2.89 for observability, interpreted as High Level. Nurses perceived the benefits and outcomes of the device as visible in clinical workflow. The highest-rated item was that the outcomes of using the prototype were clearly visible and measurable, with a weighted mean of 2.96. This was followed by observable efficiency gains in clinical settings at 2.95, noticeable benefits in daily workflow at 2.91, colleagues noticing its advantages at 2.84, and observed improvement in patient safety at 2.79. These results suggest that nurses were able to recognize visible improvements associated with the prototype, particularly in workflow efficiency and measurable outcomes. However, the slightly lower score for patient safety improvement may indicate that safety outcomes require longer observation before becoming fully evident. This is consistent with Kearney & McDermott (2023), who acknowledged that some safety benefits and risks become clearer only after prolonged real-world use and extended clinical data evaluation. Overall, the findings show that the prototype's visible benefits may encourage acceptance and sustained use.

3.3 Usability of the Prototype IV Pole Hook

3.3.1 Novelty of the Prototype IV Pole Hook

The Prototype IV Pole Hook obtained an overall weighted mean of 3.72 for novelty, interpreted as High Level. Respondents perceived the product as new, unique, and innovative. The highest-rated statement was that the product was new and previously unknown to the public, with a weighted mean of 3.88. The product's ability to solve a problem in a new way received a score of 3.65, while its non-obvious and inventive features received a score of 3.63. These findings show that nurses recognized the prototype as distinct from existing solutions and potentially valuable in addressing IV line management concerns. According to Dabrowski (2022), novelty and meaningfulness are essential to innovative products because distinctiveness helps attract early adopters and differentiate the product from existing alternatives. The high novelty rating suggests that the prototype has potential for further development, provided that its uniqueness remains aligned with user needs and practical benefits.

3.3.2 Technical Merit of the Prototype IV Pole Hook

The technical merit of the Prototype IV Pole Hook received an overall weighted mean of 3.70, interpreted as High Level. Respondents agreed that the invention appeared innovative, with the highest weighted mean of 3.76. They also rated its technical strength at 3.68 and its ability to solve a problem at 3.67. These results indicate that the device was viewed as technically promising, well-designed, and relevant to its intended clinical purpose. The findings suggest that the prototype has a solid technical foundation and potential for practical application. Coulentianos (2022) emphasized that early stakeholder participation through prototypes improves medical device innovation by helping designers identify usability issues, align features with real-world needs, and improve usefulness. The high technical merit rating therefore supports continued refinement and development of the Prototype IV Pole Hook.

3.3.3 System Usability of the Prototype IV Pole Hook

The prototype obtained an overall weighted mean of 3.80 for system usability, interpreted as High Level. Nurses generally found the device easy to use, intuitive, and confidence-building. The highest-rated item was that most people would learn to use the device very quickly, with a weighted mean of 3.96. Nurses also agreed that they would not need technical support to use the device, with a score of 3.89, and that they felt confident using it, with a score of 3.84. Ease of use received 3.82, lack of awkwardness received 3.81, well-integrated function received 3.75, and willingness to use the device frequently received 3.64. These results show that the prototype was perceived as user-friendly and easy to operate. According to Lewis and Sauro (2021), usability lowers barriers to adoption by making products easier to learn and encouraging users to explore their features. The high usability rating, together with the novelty score of 3.72 and technical merit score of 3.70, produced an overall product usability mean of 3.74, interpreted as high. This suggests that the prototype was perceived as unique, technically sound, and practical for clinical use.

3.4 Relationship Between Demographic Profile and Perceived Effectiveness of the Prototype IV Pole Hook

The findings showed no significant relationship between respondents' demographic profile and their evaluation of the prototype's perceived effectiveness. Age had weak and non-significant correlations with relative advantage, compatibility, complexity, trialability, observability, and overall perceived effectiveness, with the overall value at -0.057 and significance at .546. Sex also showed weak positive but non-significant correlations, with an overall r-value of .163 and significance at .084. Years of experience showed weak negative and non-significant correlations, with an overall r-value of -.090 and significance at .340. Since all significance values were greater than 0.05, the null hypothesis was accepted. These results suggest that age, sex, and years of experience did not meaningfully influence how nurses evaluated the Prototype IV Pole Hook. Although younger professionals may be more open to healthcare innovations, the prototype's practical and low-complexity design may have reduced age-related barriers (Barchielli et al., 2021). The slight positive trend among female respondents was consistent with studies showing that sex may shape technology acceptance patterns (Winterberg et al., 2023), while the slight negative trend among more experienced nurses may reflect adjustment challenges associated with new technologies (Abdelaziz et al., 2024). However, these trends were not statistically significant. Winterberg et al. (2023) also found that demographic characteristics such as age and gender did not significantly affect acceptance of robotic healthcare systems, supporting the present findings. Broader studies with larger and more diverse samples may improve the generalizability of these results (Giannini, 2022).

3.5 Relationship Between Perceived Effectiveness and Usability of the Prototype IV Pole Hook

The findings showed significant positive relationships between perceived effectiveness and usability of the Prototype IV Pole Hook. All correlation coefficients were significant at the $p < 0.01$ level. Overall perceived effectiveness had significant positive correlations with novelty at $r = .528$, technical merit at $r = .716$, system usability at $r = .751$, and overall product usability at $r = .731$. Compatibility showed the strongest relationship with system usability at $r = .764$ and overall usability at $r = .748$. Complexity also showed strong relationships with system usability at $r = .742$ and overall usability at $r = .713$. Relative advantage had strong correlation with technical merit at $r = .706$ and a moderate-to-strong association with system usability at $r = .676$. Observability showed strong relationships with system usability at $r = .733$ and overall usability at $r = .709$. Trialability had the lowest but still significant relationships, including $r = .367$ with novelty and $r = .540$ with overall usability. These findings show that nurses who perceived the prototype as effective also tended to rate it as usable, technically sound, and practical. Correlation values were interpreted using established standards, where 0 to 0.10 indicates negligible correlation, 0.10 to 0.39 weak correlation, 0.40 to 0.69 moderate correlation, 0.70 to 0.89 strong correlation, and 0.90 to 1.00 very strong correlation (Schober et al., 2018). The strongest findings centered on compatibility and system usability, suggesting that the more the prototype fit nurses' routines, equipment, and clinical needs, the more usable it became. This supports Nurhasanah et al. (2023), who found that perceived compatibility improves usefulness and ease of use by aligning technology with prior experiences and familiar practices. The positive relationship between relative advantage and usability also supports Tseng (2025), who concluded that recognized benefits such as time efficiency and usefulness improve adoption attitudes. The strong relationship between complexity and usability shows that intuitive design improves user experience, consistent with MoldStud (2025), which emphasized that simplicity and essential functions enhance usability and satisfaction. Observability also strengthened usability perceptions because visible and measurable benefits help users recognize a system's value (Weichbroth, 2025). Since all relationships between perceived effectiveness and usability were significant, the second null hypothesis was rejected.

3.6 Summary of Hypothesis Testing

The first null hypothesis was accepted because the respondents' demographic profile showed no significant relationship with their evaluation of the Prototype IV Pole Hook's perceived effectiveness. Age, sex, and years of professional experience did not significantly affect ratings across relative advantage, compatibility, complexity, trialability, and observability. Although some slight trends appeared, they were not statistically significant. The second null hypothesis was rejected because perceived effectiveness had significant positive relationships with usability. The results showed that higher ratings of relative advantage, compatibility, complexity, trialability, and observability were associated with higher ratings of novelty, technical merit, system usability, and overall usability. Overall, the findings indicate that the prototype's acceptability is shaped more by its functional compatibility, ease of use, visible benefits, and technical usability than by demographic characteristics.

4. Conclusion & Recommendations

The study concluded that the nurse respondents were mostly young, female, and experienced, making them suitable evaluators of the Prototype IV Pole Hook. The prototype was perceived positively in terms of relative advantage, compatibility, complexity, trialability, and observability, indicating that it was useful, compatible with nursing routines, easy to operate, testable, and visibly beneficial in managing Spaghetti Syndrome. It was also rated highly in novelty, technical merit, and system usability, showing that it was viewed as innovative, technically sound, and user-friendly. Demographic variables had no significant relationship with perceived effectiveness, while perceived effectiveness had a significant positive relationship with usability, confirming that stronger perceptions of innovation attributes were associated

with higher usability ratings.

The researchers recommended that future studies include a more balanced number of respondents across age, sex, and nursing experience levels to better understand how demographic factors influence innovation adoption. The Prototype IV Pole Hook should also undergo continued improvement and testing in broader clinical settings to assess its adaptability and practical value. Suggested design enhancements include adjustable components, improved stability, collapsible or retractable arms, durable medical-grade stainless steel, lightweight high-performance polymers, antimicrobial coatings, and non-slip grips. Future designs should prioritize compatibility with nurses' needs and workflows, while longer trial periods should be provided to allow users to evaluate the device in varied clinical situations and support long-term adoption.

The study was limited by the unequal distribution of respondents across demographic groups, particularly age and sex, which may have restricted the interpretation of how these factors influence innovation adoption. The sample was also limited to nurses from Cabanatuan City, Nueva Ecija, which may affect the generalizability of the findings to other healthcare settings. In addition, the trial period was limited to approximately two weeks, which may not have been sufficient to fully assess the prototype's long-term durability, reliability, and performance in different clinical situations.

Compliance with ethical standards

The study followed ethical protocols established by Nueva Ecija University of Science and Technology. Participation was voluntary, and the researcher protected the anonymity and confidentiality of the respondents' information. All data were used solely for ethical academic research, and patient identities in photographs were blurred in the study documentation.

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