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Original article

Interventions to reduce peripheral intravenous catheter failure: An international e-Delphi consensus on relevance and feasibility of implementation

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ABSTRACT

Background: Around 1 billion peripheral intravenous catheters (PIVC) fail annually worldwide before prescribed intravenous therapy is completed, resulting in avoidable complications, dissatisfaction, and avoidable costs surging to ~€4bn. We aimed to provide an international consensus on relevance and feasibility of clinical practice guideline recommendations to reduce PIVC failure.

Methods: e-Delphi study with three rounds through an online questionnaire from March-September 2020 recruiting a multispecialty panel formed by clinicians, managers, academic researchers, and experts in implementation from seven developed and three developing countries, reflecting on experience in PIVC care and implementation of evidence. Further, we included a panel of chronic patients with previous experience in the insert, maintenance, and management of PIVC and intravenous therapy from Ireland and Spain as public and patient involvement (PPI) panel. All experts and patients scored each item on a 4-point Likert scale to assess the relevance and feasibility. We considered consensus descriptor in which the median was 4 with less than or equal to 1,5 interquartile intervals.

Findings: Over 90% participants (16 experts) completed the questionnaire on all rounds and 100% PPI (5 patients) completed round 1 due to high consensus they achieved. Our Delphi approach included 49 descriptors, which resulted in an agreed 30 across six domains emerged from the related to (i) general asepsis and cutaneous antisepsis (n = 4), (ii) catheter adequacy and insertion (n = 3), (iii) catheter and catheter site care (n = 6), (iv) catheter removal and replacement strategies (n = 4), (v) general principles for catheter management (n = 10), and (vi) organisational environment (n = 3).

Conclusion: We provide an international consensus of relevant recommendations for PIVC, deemed feasible to implement in clinical settings. In addition, this methodological approach included substantial representation from clinical experts, academic experts, patient and public expertise, mitigating uncertainty

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Abbreviations: PIVC, Peripheral intravenous catheters; CRBSI, catheter-related bloodstream infections; CPG, Clinical practice guidelines; PPI, Patient and public involvement; IQR, Interquartile range; ANTT, Aseptic non-touch technique

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during the implementation process with high-value recommendations to prevent PIVC failure based contextual and individual features, and economic resources worldwide.

Background

Peripheral intravenous catheters (PIVC) are used in health care settings for short-term clinical treatment of inpatients, with around 2 billion devices inserted annually worldwide [1,2]. For most patients, a PIVC would be their first invasive vascular access device. These devices are not without complications and failure, which are common, and include phlebitis (owing to extreme pH of infusion), extravasation (tip position and movement in the vein), occlusion, or infectious events [3]. Between 40% and 70% of PIVCs removals in hospitalised patients are premature and unplanned [4,5]. Further, extravasations are one of the most frequent contributors to PIVC failure, leading to dissatisfaction among healthcare professionals, and resulting in a poor care experience for patients [5,6]. Catheter-related bloodstream infections (CRBSI) are, in addition, serious yet preventable adverse events for patients. Specifically, the incidence of PIVC-CRBSI is 0·1% or 0·5 per 1000 catheter-days [7], with a high cost in terms of morbidity and mortality [8–10]. Despite the importance of optimal PIVC care strategies which focus on the different technologies used (for example, device material, dressing, fixation, add-ons, etc), the professional's skills during insertion, use, and care, and intrinsic factors linked to the patient (body's response, activity) [11], PIVC failure remains at unacceptable rates [3,12].

Implementation science promotes the adoption and integration of the best available research results to influence change, improving care quality and cost-effectiveness [13]. To date, healthcare systems benefit from advances in knowledge generated by international research, which can increase interest in implementation science [14]. More recently, studies incorporating multimodal interventions have successfully reduced PIVC failure rates and the incidence of PIVC-related bloodstream infections [13,15,10] These interventions have typically included components such as improved education about device use, feedback and academic detailing, involvement of 'champions' and key behaviour role models, and support from institutional leaders. The implementation of these multimodal interventions has the potential to release up to €3.9 billion in unnecessary costs and resources associated with the treatment of PIVC failures and infections [13].

Clinical practice guidelines (CPG) play a crucial role supporting clinicians who insert, care, and maintain PIVCs, integrating the best available scientific knowledge, clinical expertise, and patient preferences so healthcare professionals and patients make shared decisions about the appropriate care and experience of PIVCs [16,17]. However, healthcare professionals can experience challenges to keep up to date with such niche knowledge due to the high volume and variable quality of evidence generated over the last decades [18,19]. Nevertheless, whilst the availability of CPGs can aid clinical decision-making, the chasm between evidence and practice remains, with one in two effective interventions never adopted by healthcare professionals in practice [20]. The underlying determinants of such limited adoption may include prior experience, intuition, and perceptions shaping clinical judgement and decision-making [21]. Further, both clinicians and policymakers may be uncertain or have divergent beliefs about the feasibility of the interventions and measures to be implemented, or it may be difficult for them to combine perceptions about the impact and feasibility of the recommendations, perhaps engaging in a cognitive appraisal of the impact/feasibility ratio [22,23].

We argue that an ineffective knowledge translation into clinical practice threatens the safety and quality of care. Given the significant use of PIVCs in healthcare, a global perspective on CPGs is necessary. Therefore, this study aims to provide an international consensus-driven decision tool on the relevance of CPG recommendations for the insertion, maintenance, and management of PIVC to reduce catheter failure and infections, together with feasibility for implementation in clinical practice worldwide.

Methods

Design

We conducted e-Delphi consensus with a multispecialty panel of experts from different developing and developed countries to canvass their opinions on recommendations for insertion, maintenance, and management of PIVCs to reduce PIVC failure and infectious complications, ranking measures for their relevance and feasibility of implementation of recommendations from clinical practice guidelines. This method engages in an iterative and systematic process to refine expert views after each round of data collection through shared feedback (24), achieving high reliability through consensus [24,25]. Each round was available for three weeks, with a follow-up message to experts who did not respond to the questionnaire. Between each round, there was an interval of 7 – 14 days. Prior to the first round, the collection of recommendations derived from the review of the CPG related to the prevention of PIVC complications was extracted [26–28]. A further potential benefit of the method is the meeting of geographically dispersed experts on a single panel while maintaining their anonymity [24]. Simultaneously to e-Delphi consensus with a multispecialty panel of clinical and academic experts, we conducted one round with patient and public involvement (PPI) panel members from Ireland and Spain. The panel survey and implementation feasibility of this study were done between March 15 to September 30, 2020. The protocol was approved by Research Ethic Committee of the Universitat de les Illes Balears (146CER20).

Panel recruitment

We used intentional and 'snowball' sampling (non-probability sampling technique) to recruit participants [25]. We included experts from Europe, America, Africa, and Oceania (seven developed and three developing countries), reflecting on their experience in vascular access and implementation of evidence, including knowledge of insertion, maintenance and management of care related to PIVCs from their different cultural, socio-political, and healthcare contexts.

We identified potential clinical panel members with a minimum of ten years of expertise in vascular access and/or previous participation in other similar expert panels. To be eligible, academic experts who were predominantly researchers had to have at least five scientific publications in vascular access. The pool of experts was balanced according to the following profiles: 1) Clinicians (nurses, physicians, vascular access specialist team professionals); 2) Managers or other staff implicated in decision-making; 3) Hospital infection prevention and control professionals; and 4) Academic researchers and experts in implementation science.

We selected members of the expert panel, meeting the established inclusion criteria. These members then proposed potential participants using the snowball technique. All individuals were contacted via email and classified through a self-assessment of professional role. We proposed to recruit 4–5 experts for each category, expecting between 16 and 20 participants, and we finally recruited 17. All participants provided written consent prior to participation and following an email with the relevant information about the study, allowing them to have any questions clarified about the study.

Patient and public involvement (PPI).

This study included PPI representatives who were chronic patients with previous experience in the insert, maintenance, and management of PIVC and intravenous therapy from Ireland and Spain participated in Round 1. On the other hand, we reviewed and provided feedback about our study design, interpretation and write up of results. The study group planned to communicate the research findings to patients and citizens via press releases in suitable language, and health care professionals and researchers via presentations at an international scientific congress on vascular access.

Data collection

First round of the questionnaire

Between January – March 2020, we compiled an initial set of measures through a systematic review [26], the book Vessel Health and Preservation: The Right Approach for Vascular Access [27], and the Infusion Therapy Standard of Practice [28].

In this Delphi first round, we included six domains and 49 descriptors through an online questionnaire, administered with a survey and reporting tool, SurveyMonkey, (Momentive, California). Panellists entered separately using a link and/or QR code sent in the email. Furthermore, we included an open question inviting experts to offer additional suggestions. In parallel with this, we included 5 PPI for completing this first round to provide feedback about the finding interpretations.

Second round of the questionnaire

We analysed the results of the first round and returned them to the panel members for their interpretation and feedback. Descriptors which did not reach meet the minimum threshold of consensus were removed or modified according to the suggestions and recommendations of the experts. We then sent the second round of the questionnaire to the experts, coupled with an open question for their evaluation of any descriptors amended or added.

Additional rounds

After two rounds, we conducted an additional and focused round to clarify the answers of participants to descriptor number two.

Analysis

To ensure the consideration of contextual information and economic resources specific to their country or region in formulating their responses, we instructed the panel members to analyse the relevance and implementation feasibility of each item according to the construct definition of this study, scoring on a 4-point Likert scale, from 1 (little relevance or low feasibility) to 4 (highly relevant or feasible) in reducing PIVC failure. All panel members voted on the relevance of the recommendations and the feasibility of their implementation.

We carried out a descriptive analysis of responses to our descriptors which were performed. We used median and the interquartile ranges to assess the voting of the relevance of recommendation and feasibility for implementation. Moreover, we used interquartile ranges to represent the dissemination of the data and evaluate the level of consensus by descriptor. We considered a significant consensus descriptor in which the median was 4 (i.e., a high level of agreement) with a small (less than or equal to 1,5) interquartile interval. Moreover, we explored qualitative responses using content analysis [29]. Therefore, we eliminated descriptors with a result below three points on the relevance and feasibility and interquartile range more than to 1,5 after each round, being consistent this statistical analysis with previous studies [30–32]. Data were analysed using SPSS IBM Statistics version 25.

Results

Of the 17 expert panel members who agreed to take part, 16 (94.1%) completed the questionnaire on the first round, with 16 (100%) completing rounds two and extra. Simultaneously, the five PPI panel members participated (100%) and completed round 1 survey. The flow of Delphi rounds and participants is presented in Fig. 1. The characteristics of the expert panel are described in Appendix, Table S1.

Round 1 questionnaire results

The 16 expert panel members who responded to round one achieved high levels of agreement on 47 descriptors with score means in the strong range of agreement for relevance, and 44 descriptors for feasibility (3 or 4 on the four-point Likert scale). The strength of agreement related to relevance was high for 45 descriptors (IQR ≤ 1·5), but lower for 4 descriptors; in terms of feasibility, it was high for 30 descriptors (IQR ≤ 1·5), but lower for 19 descriptors (Appendix, table S2).

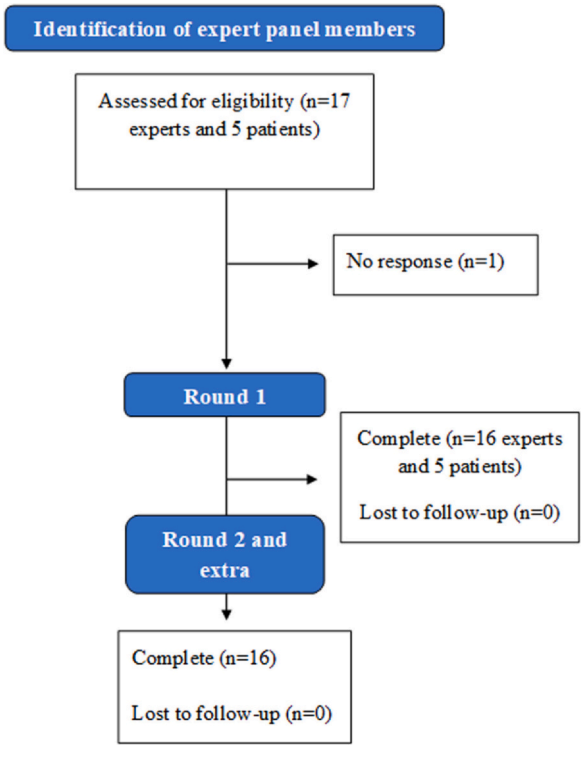

Fig. 1. The flow chart of Delphi rounds and participants.

Qualitative content analysis of open-ended responses identified 7 descriptors, which were removed (Appendix, Table S3). 21 descriptors (including the descriptor above for which the strength of agreement was low) were amended in the light of qualitative feedback (Appendix, Table S3). These amended descriptors were taken forward to the round 2 survey (in total 42).

Round 1 questionnaire results of PPI panel members

Of the five PPI panel members who responded to round 1 of the survey, there were high levels of agreement for all descriptors with means in the strong range of agreement for relevance and 47 descriptors for feasibility (3 or 4 on the four-point Likert scale). The strength of agreement related to relevance was high for 43 descriptors (IQR ≤ 1·5), but lower for 6 descriptors; and related to feasibility was high for 37 descriptors (IQR ≤ 1·5), but lower for 12 descriptors (Appendix, table S2). We detected some inconsistencies in the findings of 2 descriptors among PPI and clinic and academic experts.

Round 2 questionnaire results

Sixteen participants (100%) responded to the second round. There were high levels of agreement for 40 descriptors, with medians in the strong range of agreement for relevance and 26 descriptors for feasibility (4 on the four-point Likert scale) (Appendix, Table S4). The strength of agreement related to relevance was high for all 42 descriptors (IQR ≤ 1·5). However, the strength of agreement related to feasibility was high for 28 descriptors (IQR ≤ 1·5), but lower for 12 descriptors (Appendix, table S4).

Qualitative content analysis of open-ended responses identified a new descriptor, i.e., '*Aseptic technique using sterile gloves for insertion and care of the short peripheral intravenous catheter and midline catheter, and aseptic technique using clean gloves when intravenous therapy is administered*'. This descriptor was amended in light of the feedback (Appendix, Table S5), and included in an extra round of the survey with three new descriptors to ensure accuracy and clarity.

Extra round questionnaire results

Sixteen participants (100%) responded to the extra round. There were high levels of agreement for three descriptors, with medians in the strong range of agreement for relevance and three descriptors for feasibility (4 on the four-point Likert scale). The strength of agreement related to relevance was high for all three descriptors, both relevance and feasibility (IQR ≤ 1·5) (Appendix, table S6).

Finally, 30 descriptors (Table 1) were selected as the consensus by the expert panel members, as relevant for reducing PIVC failure and feasible for implementation in any clinical setting worldwide.

Discussion

To our knowledge, this is the first consensus using the e-Delphi approach with patient representatives, and clinical and academic experts from an extensive geographical location, reporting on the relevance and feasibility of clinical practice recommendations to reduce complications from PIVC failure. The systematic and iterative process resulted in high levels of expert agreement on the six domains of clinical practice, thus conforming to the best available knowledge and skills required for optimal PIVC care. The REFERENCE study offers clear recommendations for implementation in clinical contexts, approaching the best available evidence more directly to clinicians. Additionally, the experts appraised the implementation feasibility of the high-value recommendations based on contextual features and economic resources worldwide.

Table 1
Expert Consensus of interventions to reduce PIVC failure and infections.

Domain one: General asepsis and cutaneous antisepsis
1. Hand hygiene with an alcohol-based hand rub for 20–30 s or liquid soap and water for 40–60 s if soiled or potentially contaminated with blood or body fluids, before and after any contact with the peripheral intravenous catheter or insertion site, following WHO recommended hand hygiene standards.
2. The aseptic non-touch technique (ANTT) using clean gloves for insertion and care of the short peripheral intravenous catheter and aseptic technique using clean gloves when intravenous therapy is administered.
3. The aseptic non-touch technique (ANTT) using sterile gloves for insertion and care of the midline catheter and aseptic technique using clean gloves when intravenous therapy is administered.
4. Cutaneous antisepsis at the insertion site with a single-use application of chlorhexidine gluconate greater than 0.5% in 70% isopropyl alcohol (or povidone-iodine in alcohol or 70% isopropyl alcohol for patients with sensitivity to chlorhexidine) allowing to dry for at least 30 s, if the manufacturer recommendations indicate, before inserting the peripheral intravenous catheter.

Domain 2.- Catheter adequacy and insertion: selection of catheter type and insertion site
1. Do not use of a peripheral intravenous catheter for perfusions with osmolarity > 800 mOsm/L, or the administration of irritant or vesicant medications.
2. Selection of the appropriate peripheral intravenous catheter insertion site, assessing risks for infection, against the risks of mechanical complications and patient comfort unless clinically contraindicated or in an emergency.
3. Use of the upper extremity, preferably the forearm (for short peripheral intravenous catheter insertion) and the arm (for midline insertion) unless clinically contraindicated.

Domain 3.- Catheter and catheter site care
1. Use of a sterile, transparent, semi-permeable polyurethane dressing to cover the intravascular insertion site.
2. Application of a sterile, transparent, semi-permeable polyurethane dressing without stretching it to prevent medical adhesive-related skin injuries.
3. Change of transparent, semi-permeable polyurethane dressings every 7 days, or sooner, if it is no longer intact or if moisture collects under the dressing.
4. Use of a sterile gauze dressing if the patient has profuse perspiration or if the insertion site is bleeding or leaking, and change at least every 48 h, or when inspection of the insertion site is necessary, or when the dressing becomes damp, loosened, or soiled.
5. Use of the stretching technique, from outline to centre, in the removal of the transparent polyurethane dressing to avoid skin injuries.
6. Application of single-use of chlorhexidine gluconate greater than 0.5% in 70% isopropyl alcohol (or povidone-iodine in alcohol for patients with sensitivity to chlorhexidine) to decontaminate the peripheral intravenous catheter insertion site during dressing changes and allow to air dry.

Domain 4.- Catheter removal and replacement strategies
1. Inspection of the peripheral intravenous catheter insertion site at a minimum during each shift, recording the Visual Infusion Phlebitis score and/or infiltration score and/or any complications.
2. Removal of the peripheral intravenous catheter when complications occur, or as soon as it is no longer required.
3. Removal of the peripheral intravenous catheter when clinically indicated and not routinely unless device-specific recommendations from the manufacturer indicate otherwise.
4. Surveillance for the occurrence of unexplained fever or pain at the insertion site, examining for the occurrence of redness, erythema, or inflammation.

Domain 5.- General principles for catheter management
1. Use of sterile normal saline for injection to flush and lock catheter lumens that are accessed frequently.
2. Flushing of the peripheral intravenous catheter lumen with sterile normal saline with at least twice the volume of the catheter (and add-on devices), through push-stop-push technique.
3. Application of a single-use of chlorhexidine gluconate greater than 0.5% in 70% isopropyl alcohol (or only 70% isopropyl alcohol for patients with sensitivity to chlorhexidine) to decontaminate the access port or catheter hub, cleaning for a minimum of 15 s and allowing to dry before accessing the system.
4. Do not routinely use of antimicrobial lock solutions to prevent catheter-related infections.
5. Do not routinely administer systemic antimicrobials before insertion or during the use of a peripheral intravascular device to prevent catheter colonisation or bloodstream infection.
6. Do not use of systemic anticoagulants routinely to prevent catheter-related bloodstream infection.
7. Do not replace administration sets in continuous use more frequently than every 96 h and up to 7 days unless device-specific recommendations from the manufacturer indicate otherwise or disconnect or replace the intravascular access device.

(*continued on next page*)

Table 1 (*continued*)

8. Change of the administration sets for blood components when the transfusion episode is complete or every 12 h, whichever is sooner.
9. Change of administration sets used for lipid-containing parenteral nutrition every 24 h.
10. Use an extension tubing, preferably with a neutral displacement needleless connector instead of a three-way connector or bifurcated extension tubing connected to the peripheral intravenous catheter for treatment.

Domain 6.- Organisational environment

1. Record of peripheral intravenous catheter status including insertion process, assessment of insertion site and functionality.
2. Record of peripheral intravenous catheter removal reason in the patient's health record.
3. Implementation of a protocol of intravenous therapy procedures in the hospital units.

The results of our Delphi study show specific and well-described recommendations addressing the insertion, adequacy, maintenance, management, and removal of PIVCs, plus organisational environment recommendations. We observed descriptors that are strong enough to be considered as high-value recommendations for implementation in clinical settings. Clinical and academic experts and patients provided the recommendations with high scores in terms of relevance and feasibility, which have not been achieved before in similar studies of this magnitude [33,34]. Hand hygiene, cutaneous antisepsis with chlorhexidine gluconate greater than 0·5% in 70% isopropyl alcohol, and the aseptic non-touch technique are the most effective measures for reducing the risk of CRBSI during the preparation of the insertion site, maintenance, and management of PIVCs [13,35,36]. Furthermore, the selection of the appropriate peripheral intravenous catheter insertion site, preferably the forearm for short PIVC and the arm for midline, optimal PIVC maintenance with use of transparent polyurethane dressing, defined flushing technique, and visual inspection of insertion site at a minimum during each shift removing when clinically indicated are additional solid recommendations in terms of relevance and feasibility for reducing all-cause PIVC failure [13,37]. Nevertheless, some of these recommendations related to PIVC care may unavoidably modify in the coming years due to the continuous introduction of technological and behavioural innovations in clinical practice.

The appraisal of feasibility of implementation in clinical practice of the recommendations was one of the areas with lowest agreement among the experts. This uncertainty may be influenced by individual, social, and context determinants, which fuels suboptimal care of PIVCs [6] and impacts in the funding capacity of their health service systems [38]. In this regard, contextual information from multiple organisational levels is needed to warrant effective knowledge mobilisation [39]. The lack of agreement observed between stakeholders may be present in clinical settings and may be able to explain the scarce progress preventing complications related to intravenous therapy seen at the health systems level. This feasibility of implementation is a relevant aspect to explore further, considering the contextual differences between developing and developed countries. Despite this, we discovered in our study a high variability in the response of experts from developing and developed countries.

Additionally, the responses from academic and clinical stakeholders and those of patient representatives diverged in some areas. For example, patients rated the recommendation *'A healthcare professional should not spend more than 25 min for successful cannulation of the peripheral intravenous catheter*' as very relevant but of low feasibility. However, clinical and academic experts rated this descriptor as low in both relevance and feasibility for implementation due to the lack of evidence. We also found disagreement between these groups regarding the recommendation *'Removal of the unnecessary peripheral intravenous catheter when intravenous treatment is not administered after 24 h*'. The descriptor was rated by clinical and academic experts as high in relevance. Yet, some patients may consider this item as low in relevance. This response might be influenced by impoverished experience during the last admission, i.e., numerous attempts and punctures during the insertion of PIVC, which resulted in pain and stress experience when was required the restart of intravenous therapy once removed. [5,40]. This scenario highlights how patient involvement may not receive significant attention during PIVC care decision-making. In this regard, health literacy in vascular access is needed for patient empowerment in self-care and shared decision-making for preventing PIVC failure and infections. In some countries, this is an emerging approach to research enquiry in others accepted as necessary and commonplace [27,41]. More studies are needed that integrate the patient experiences for improving decision-making related to the care of PIVCs. Therefore, we consider that this methodological approach may reduce the uncertainty concerning the nature of recommendations for optimal decision-making of PIVC care, improving the credibility of evidence and supporting the implementation process.

The main strengths of this study include the participation of an international panel of multidisciplinary clinical experts and patient representatives, who actively engaged in the process as suggested by the excellent response rate, and that it summarises the most relevant and feasible recommendations for supporting the implementation of new safety and quality strategies. This Delphi study has some limitations which must be considered before interpreting the results. We used a purposive and snowball sampling methods to recruit participants with a broad expertise in vascular access management including experience in implementation, adoption, and diffusion of clinical interventions, and therefore equipped to consider feasibility challenges. However, as we included a limited participants from each country, the full spectrum of stakeholders involved in clinical and implementation decisions in practice may be unrepresented.

In conclusion, our Delphi study provides a consensus based on the summary of the most relevant and feasible recommendations related to the insertion, adequacy, maintenance, management, and removal of PIVCs, exploring the relevant contributing characteristics of the organisational climate. Implementing the REFERENCE consensus will help to appraise knowledge gaps and the impact of missed care within PIVC care. Future research should be necessary to define optimal clinical practices to ameliorate the uncertainty between different organisational levels during the implementation process, integrating the experiences of patients, the expertise of healthcare professionals, and the views of decision-makers.

Authors' contributions

IB-M and CP-L are the principal investigators of the study. All authors contributed to the original idea and design of the study. All authors are responsible for the conduct of the study. Only IB-M and CP-L had full access and verified to all data. IB-M prepared the first draft of the manuscript. IB-M, CP-L, JDP-G and EC-S provided statistical expertise, revising findings of the primary statistical analyses. All authors provided critical commentary on drafts and approved the final manuscript.

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Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Celia Personat Labrador reports financial support was provided by The College of Nurses of the Balearic Islands.

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Ethical approval and consent to participate

The research ethic committee of the Universitat de les Illes Balears approved this study (146CER20).

Consent for publication

This manuscript does not contain data from any individual person.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jiph.2023.10.004.

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