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Survey-based qualitative exploration of user perspectives on the Philips Visual Patient Avatar in clinical situation management

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Philips Visual Patient Avatar is an innovative approach to patient monitoring. Computer-based simulation studies have shown that it can improve diagnostic accuracy and confidence while reducing perceived workload. Following its integration into clinical practice, we conducted a single-centre qualitative study at the University Hospital Zurich to explore the views of anaesthesia, post-anaesthesia and intensive care providers on their experience with the technology. We used an online survey to assess its contributions in different clinical situations. We analysed the data thematically to identify key themes. Of the 510 healthcare providers contacted, 131 (25.7%) completed the survey and 154 comments were collected. Key themes included the detection of specific vital sign changes, focusing on temperature and oxygen saturation (41.9%, 34/81 comments in the operating room; 38.6%, 17/44 comments in the intensive care unit; 10.3%, 3/29 comments in the post-anaesthesia care unit). Additionally, the technology was perceived to support daily routines and situational awareness (28.4%, 23/81 comments in the OR; 9.1%, 4/44 comments in the ICU; 10.3%, 3/29 comments in the PACU). The study provides early, but strong evidence that the Philips Visual Patient Avatar assists healthcare providers in specific clinical situations in the perioperative and critical care settings.

Keywords Patient monitoring, Philips Visual Patient Avatar, Qualitative research, Situation awareness, User-centred design

Patient monitoring is essential in perioperative and critical care settings, where early detection of pathological changes is necessary to identify and treat medical conditions^{1,2}. While advances in information technology have greatly improved patient monitoring, they also pose challenges to clinicians due to the increasing cognitive load caused by the density of information and the complexity of interpreting vital signs^{3,4}. The conventional approach to patient monitoring, where individual parameters are measured by a single sensor and displayed as discrete numerical values or waveforms, can create a mismatch between the amount of data available and the human ability to extract meaningful insights from it^{5,6}. This can have a negative impact on the situational awareness of healthcare professionals, with poor situational awareness accounting for approximately 80% of treatment errors in anaesthesia and critical care^{7,8}.

A user-centred design combines multiple parameters from different sensors into a single visual display, making the data more intuitive to view and interpret^{9,10}. It considers the principles of human visual information processing and integrates patient monitoring data based on the brain's innate ability to quickly recognize changes in colour, motion and shape^{11–13}. An example of a user-centred visualization technology designed to enhance situational awareness is the Philips Visual Patient Avatar (Royal Philips, Amsterdam, The Netherlands) developed at the University Hospital Zurich, Switzerland. The technology provides information on various vital signs through changes in colour, shape, and motion. The visual cues presented by the Visual Patient are designed to closely mimic reality while remaining simple enough to create an intuitive user interface that requires minimal training. Several computer-based and high-fidelity simulation studies have demonstrated that the use of the Visual Patient

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Avatar improves perception, verbalization, and diagnostic confidence in critical situations, ultimately leading to greater situational awareness^{14–16}. Additionally, Visual Patient has been found to reduce perceived workload and increase performance in the presence of distractions^{14,16,17}.

The recent introduction of the Visual Patient Avatar into clinical practice necessitates an examination of its use in the real world. This study aimed to investigate the impact of this novel technology in clinical practice, immediately after its first introduction, by gathering feedback from anaesthesia, post-anaesthesia care, and critical care providers on the specific clinical scenarios where the Philips Visual Patient Avatar has demonstrated its performance.

Methods

Approval and consent

The Ethics Committee of the Canton of Zurich, Switzerland, reviewed the study protocol and issued a declaration of non-jurisdiction (Business Management System for Ethics Committees number Req-2021-00756), which confirms that all methods were performed in accordance with the relevant guidelines, regulations and in accordance with the Declaration of Helsinki. When accessing the survey, participants were informed of the scientific purpose of the survey and were assured that all responses would be anonymous and not linked to any identifying information. Participation was voluntary and without compensation. An informed consent was obtained from all participants. Participants consented by clicking on the link, completing the survey, and submitting it.

Implementation of the Philips Visual Patient Avatar in the study centre

University Hospital Zurich, where the Philips Visual Patient Avatar was originally developed, introduced the technology in its operating rooms, post-anaesthesia care units and two intensive care units simultaneously in March 2023. The Philips Visual Patient Avatar has been integrated into conventional patient monitoring as a split-screen feature (Fig. 1). Before integrating the technology into clinical practice, educational sessions were held to introduce the concept to the team. First, we held lectures for the whole staff, including all professional roles, to present the theoretical concepts and key usage instructions of the technology. Secondly, we held bedside teaching sessions in smaller groups where practical aspects of the technology could be discussed in more detail. Additionally, an instructional video and a brief reference guide were made available on the study centre's intranet (Appendices A and B), which was announced to all personnel by e-mail. These resources were intentionally designed for easy access and consultation to provide support if any aspects needed further clarification. Our research team was readily available to provide support and guidance as needed.



Fig. 1. Split-screen display with a combination of conventional monitoring and the Philips Visual Patient Avatar.

Study design

This was an investigator-initiated, single-centre, qualitative descriptive study conducted at the University Hospital Zurich, Switzerland during two consecutive weeks in June 2023, three months after the integration of the technology into real clinical practice. We aimed to investigate the specific clinical situations and collect real-life experience data where the Philips Visual Patient Avatar demonstrates its performance, according to the care providers who are newly using the technology. The study included an online questionnaire with a combination of open-ended and closed-ended questions. The online survey invitation was emailed to all anaesthesia providers and post-anaesthesia care units as well as neurosurgical intensive care unit healthcare professionals (attending physicians, residents, and nurses). It was only possible to complete the survey once from the same account.

Online questionnaire

The online survey was created using Google Forms (Alphabet Inc., Mountain View, CA, USA). The initial invitation was followed by a reminder after one week (Appendix C). The questionnaire consisted of two parts. The first part contained two open-ended questions designed to elicit free-text responses about the clinical situations in which the Philips Visual Patient Avatar was helpful and whether the learning material was sufficient. The second part contained five closed-ended questions designed to collect demographic information from the participants (age, gender, professional position, and years of experience in anaesthesia or critical care). Participants were not required to provide self-identifying information. Responses to potentially personally identifiable questions were grouped together for this purpose. For example, participants were not required to indicate their specific age, but only to select a specific age group. In all cases, participants were given the option not to answer certain questions and to leave the field blank. In addition, we assessed the participants' familiarity with the educational materials provided. The translated questionnaire can be found in Appendix D.

We began by defining the objectives of the survey and sought expert input to assess content validity. Members of the anaesthesia team not participating in the study reviewed the questionnaire, identifying issues with question phrasing, clarity, and response options, which led to revisions based on their recommendations. The online interface, usability and technical functionality of the questionnaire were pre-tested with a target group in a pilot study. The responses collected during this pre-testing phase were deleted before the survey was distributed to participants and were not included in the statistical analysis.

Data analysis

First, the collected statements were categorized by department: operating rooms, post-anaesthesia care units and neurosurgical intensive care unit. We used an online translator, DeepL (DeepL GmbH, Cologne, Germany), to translate the responses from the original German to English. All translated statements are included in Appendix E.

We used a six-step thematic analysis method¹⁸ to examine the open-ended questions and find the dominant themes. After a thorough review of the collected data, our research team met to share their overall impressions and explore potential thematic concepts derived from the collected responses. Following the discussion, we developed three different coding templates for each of the departments to further analyse the data (Figs. 2, 3 and 4).

Participants' responses were reviewed separately by three team members, JL, DWT, and GG, who coded the statements independently. Any discrepancies that arose during the coding process were discussed and resolved in a joint discussion.

Demographic information was analysed using Microsoft Excel (Microsoft Corp., Redmond, WA, USA). Information was presented as numerical values with their respective percentage distributions or as medians with interquartile ranges.

Results

Participant and study characteristics

Of the 510 healthcare providers initially contacted, a total of 131 completed the questionnaire (25.7%) and 154 comments were collected. Detailed study and participant characteristics are shown in Table 1.

Statements about Philips Visual Patient Avatar

A total of 154 statements were collected during the survey. We identified two main themes within the responses: "I have experienced situations where Philips Visual Patient helped me" (88/154, 57.1%) and "I have not experienced situations where Philips Visual Patient helped me" (65/154, 42.2%). One of the 154 comments (0.7%) was not assigned to any group and was described as not codable. We further categorized the situations in which Philips Visual Patient Avatar helped healthcare providers by department and the identified sub-themes.

Philips Visual Patient Avatar in the operating room

We collected 81 statements from anaesthesia personnel in the operating room and grouped them into three distinct sub-themes: identifying changes in specific vital signs, supporting situational awareness in daily use, and entertainment value. Figure 2 shows the distribution of comments along with the themes identified and the number and percentage of statements.

Identification of changes in specific vital parameters

This subtheme dominated the responses of anaesthesia personnel working in the operating room, appearing in 34 out of 81 comments (41.9%). The most frequently mentioned specific parameter was temperature (13/81, 16.0%), followed by depth of anaesthesia (6/81, 7.4%), hemodynamic parameters (5/81, 6.2%), relaxation (4/81, 4.9%), and oxygen saturation (4/81, 4.9%).

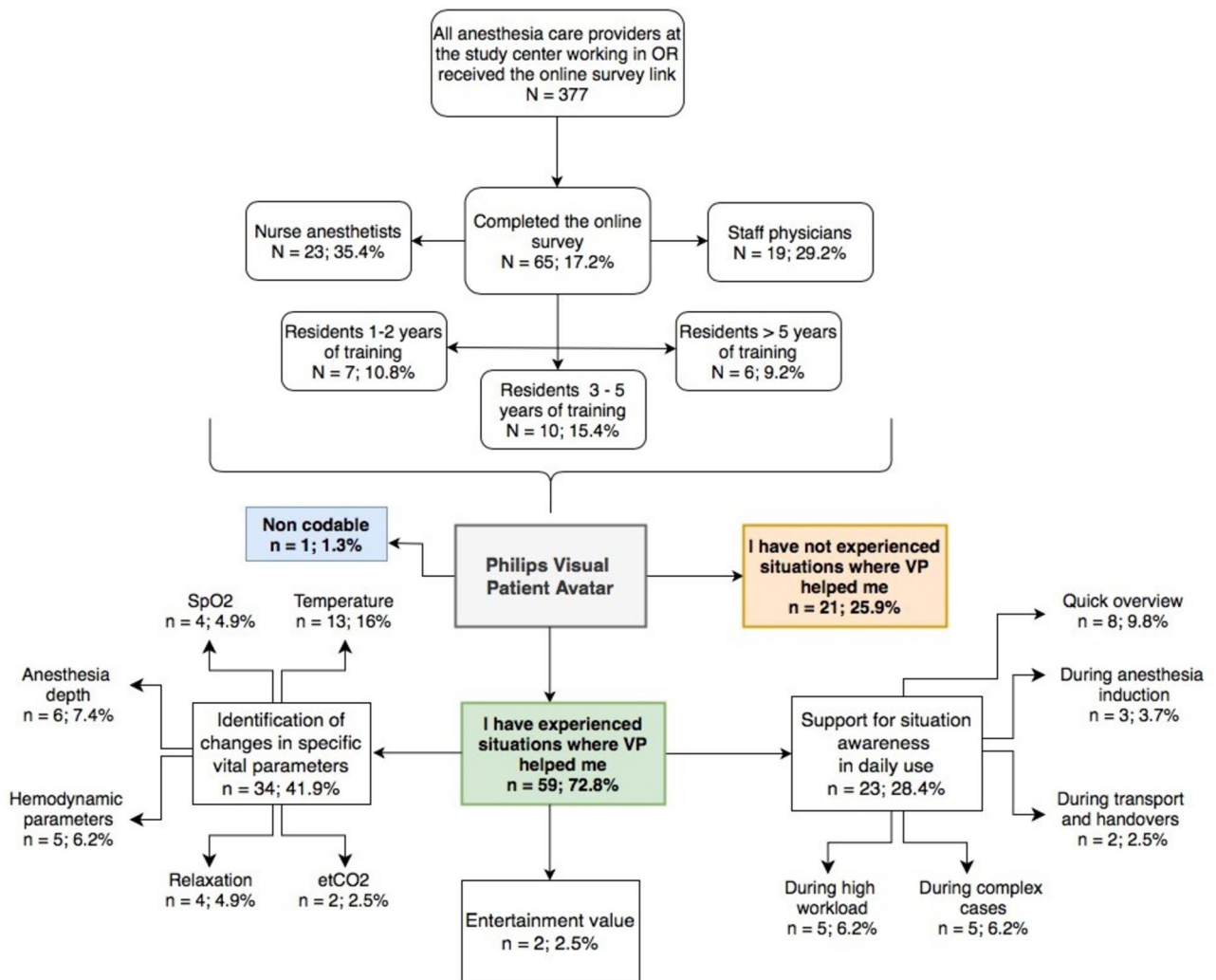


Fig. 2. Flowchart illustrating the response rate, breakdown of comments describing participants' experience with the Philips Visual Patient Avatar in the operating room, and sub-themes identified, including the number and percentage of statements. Abbreviations: OR, operating room; VP, Philips Visual Patient Avatar; SpO₂, oxygen saturation; etCO₂, end-tidal carbon dioxide; N, participants; n, collected statements.

"The use of the Phillips Visual Patient Avatar was a great help in my assessment of the patient's temperature."

Participant 27

"It helped me monitor anaesthesia depth, enabling me to detect inadequate anaesthesia more quickly."

Participant 17

"Identification of basal ischemia that may not be visible on the ECG."

Participant 4

"It helps to evaluate the state of relaxation."

Participant 10

"It greatly assisted in monitoring oxygen saturation during surgery."

Participant 24

Support for situation awareness in daily use

Of the 81 comments, 23 (28.4%) highlighted the Philips Visual Patient Avatar as a supportive element for improving situational awareness in daily clinical practice. Five out of 81 (6.2%) comments emphasized that the technology helps anaesthesia providers to interpret clinical situations more quickly during high workloads.

"Recognition of individual deviating parameters during periods of high workload."

Participant 8

Five out of 81 comments (6.2%) outlined that Philips Visual Patient Avatar was particularly helpful during complex cases, improving their ability to manage challenging clinical scenarios.

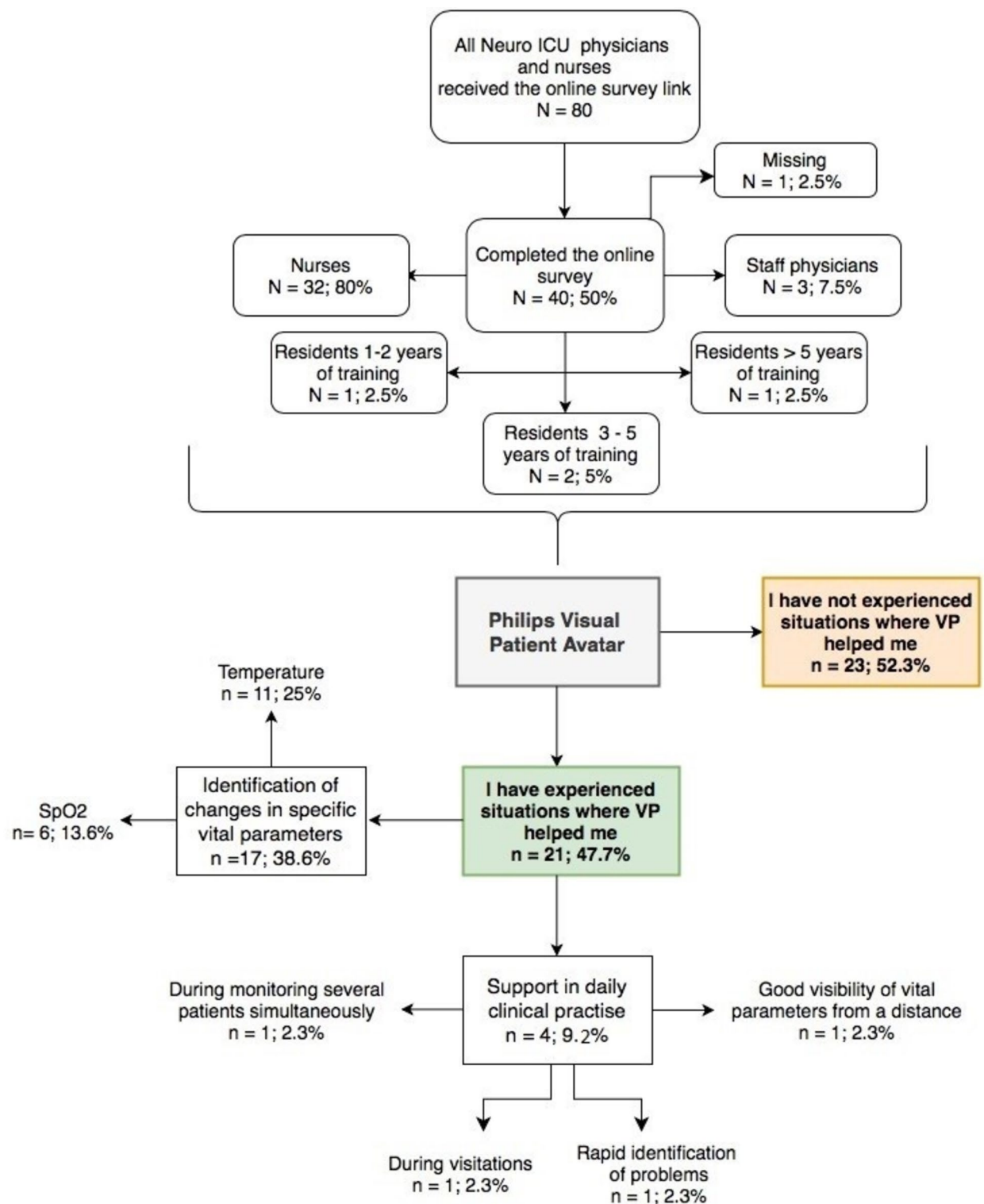


Fig. 3. Flowchart illustrating the response rate, breakdown of comments describing participants' experience with the Philips Visual Patient Avatar in the neurological intensive care unit, and subthemes identified, including the number and percentage of statements. Abbreviations: Neuro ICU, neurological intensive care unit; VP, Philips Visual Patient Avatar; SpO2, oxygen saturation; N, participants; n, collected statements.

"Assistance in evaluating and managing critically ill patients in high-stress clinical settings, such as the emergency room."
Participant 11

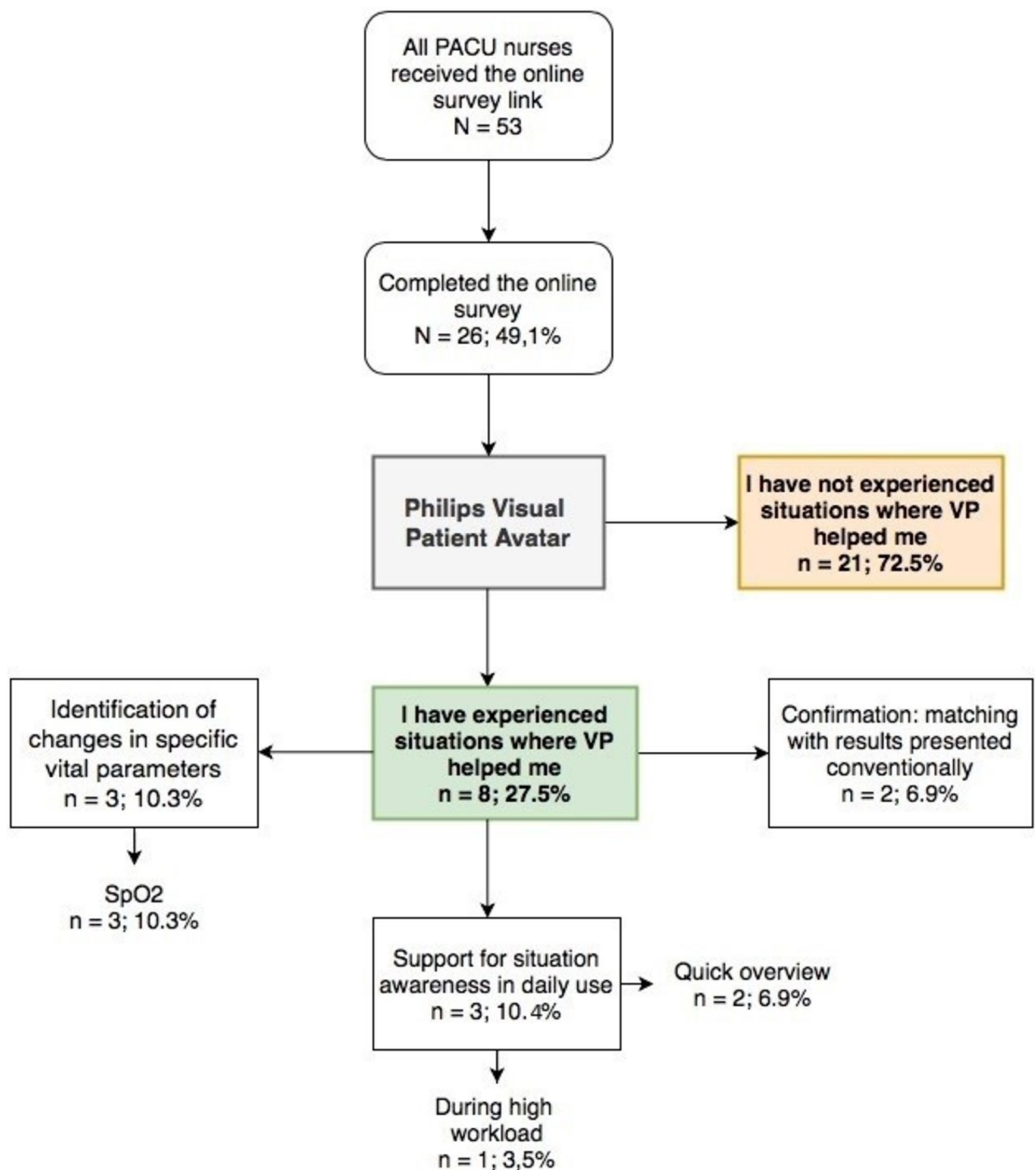


Fig. 4. Flowchart illustrating the response rate, breakdown of comments describing participants' experience with the Philips Visual Patient Avatar in post-anaesthesia care units, and sub-themes identified, including the number and percentage of statements. Abbreviations: PACU, post-anaesthesia care unit; VP, Philips Visual Patient Avatar; SpO2, oxygen saturation; N, participants; n, collected statements.

Three statements (3.7%) reported that the technology provided significant assistance during the induction phase of anaesthesia, which requires heightened attention and precision.

"Providing a quick overview during a hectic induction phase."
Participant 11

Two statements (2.5%) highlighted the importance of the Philips Visual Patient Avatar during patient transport and its practicality during the handover process.

"Rapid patient overview during a quick handover in an emergency shift."

	Participants			
	Total	OR*	ICU**	PACU***
Contacted	510 (100%)	377 (73.9%)	80 (15.7%)	53 (10.4%)
Completed the questionnaire	131 (100%)	65 (49.6%)	40 (30.5%)	26 (19.9%)
Collected statements	154 (100%)	81 (52.6%)	44 (28.6%)	29 (18.8%)
Sex				
Female	73 (55.7%)	33 (49.2%)	20 (50.0%)	20 (77.0%)
Male	50 (38.2%)	29 (46.0%)	16 (40.0%)	5 (19.2%)
Other gender identity	8 (6.1%)	3 (4.8%)	4 (10.0%)	1 (3.8%)
Participant age in years				
20–35	43 (32.8%)	23 (36.5%)	12 (30.0%)	8 (30.8%)
36–50	61 (46.6%)	32 (50.8%)	19 (47.5%)	10 (38.4%)
51–65	26 (19.8%)	10 (12.7%)	8 (20.0%)	8 (30.8%)
Missing	1 (0.8%)	–	1 (2.5%)	–
Experience in years, median (IQR)	13.6 (3.4–17)	8.0 (4–13.5)	17.0 (3–20)	8.0 (3.5–11.5)
Role				
Nurse anaesthetist/ICU in training	7 (5.3%)	1 (1.5%)	6 (15.0%)	26 (100%)
Certified nurse anaesthetist/ICU	74 (56.5%)	22 (33.9%)	26 (65.0%)	–
Resident 1–2 years of training	8 (6.1%)	7 (10.8%)	1 (2.5%)	–
Resident 3–5 years of training	12 (9.2%)	10 (15.4%)	2 (5.0%)	–
Resident > 5 years of experience	7 (5.3%)	6 (9.2%)	1 (2.5%)	–
Staff anaesthesiologist	22 (16.8%)	19 (29.2%)	3 (7.5%)	–
Missing	1 (0.8%)	–	1 (2.5%)	–
Educational material consulted				
Short manual only	36 (27.5%)	17 (26.2%)	16 (40.0%)	3 (11.5%)
Tutorial video only	13 (9.9%)	7 (10.8%)	2 (5.0%)	4 (15.4%)
Both	63 (48.1%)	33 (50.8%)	17 (42.5%)	13 (50.0%)
None	19 (14.5%)	8 (12.2%)	5 (12.5%)	6 (23.1%)

Table 1. Participant and study characteristics *OR Operating Room. **ICU Intensive Care Unit. ***PACU Post-Anaesthesia Care Unit.

Participant 3
“Observing patients on transport.”
Participant 21

Entertainment value

Two participants (2.5%) observed that Philips Visual Avatar caught the surgeon’s attention and led to targeted questions about the patient’s condition during surgery.

“The surgeons found the technology entertaining and had questions about certain parameters during its use.”
Participant 19

Philips Visual Patient Avatar in the neurosurgical intensive care unit

We collected 44 statements from the neurosurgical intensive care unit and found two subthemes: identification of changes in specific vital parameters and support in daily clinical practice. Figure 3 shows the distribution of comments along the identified themes, including the number and proportion of statements.

Identification of changes in specific vital parameters

This subtheme received the most comments with 17/44 (38.6%). Eleven comments (27.5%) highlighted the importance of a visually stimulating temperature display. Six comments (13.6%) indicated that it is easier to detect abnormalities in oxygen saturation.

“It helped me in situations where temperature measurement has been unintentionally forgotten.”
Participant 47
“It helped me in identifying a decrease in saturation after the alarm was deactivated.”
Participant 48

Support in daily clinical practice

In the second subtheme, four of the 44 statements (9.1%) explicitly stated that the Philips Visual Patient Avatar is a valuable additional support in daily clinical practice. Participants stated that Philips Visual Patient Avatar

provides them with a quick overview when monitoring multiple patients simultaneously, including during patient visits.

“Quick overview when caring for several patients.”

Participant 7

“It provides excellent support during visits and offers a good overview.”

Participant 11

Two statements out of 44 (4.5%) highlighted that the technology provides good remote visibility of vital parameters and allows them to quickly identify underlying problems in daily clinical practice.

“Avatar better visible from further away than the individual curves.”

Participant 24

“I notice a change more quickly.”

Participant 3

Philips Visual Patient Avatar in post-anaesthesia care units

We collected 29 statements from the post-anaesthesia care units. We grouped the comments into three subthemes: identification of changes in specific vital signs, support for situational awareness in daily use, and confirmation: match with conventionally presented vital signs. Figure 4 illustrates the distribution of comments along the identified themes, including the number and proportion of statements.

Identification of changes in specific vital parameters

Of the 29 statements, 3 (10.3%) expressed opinions about specific vital signs and their presentation, with a particular focus on oxygen saturation. Several participants noted that the colour of the Philips Visual Patient Avatar caught their attention more than the numbers and waveforms.

“The colour presentation of oxygen saturation provides a rapid assessment.”

Participant 8

“The colour of Visual Patient catches my attention the quickest.”

Participant 14

Support for situation awareness in daily use

Three of the 29 statements (10.3%) also noted that the technology helped them increase diagnostic confidence and reduce perceived workload.

“It provides a good, quick overview during high workloads.”

Participant 3

Confirmation: match with conventionally presented vitals

Two statements out of 29 (6.9%) indicated that comparing vital signs between the Philips Visual Avatar and conventional monitoring improved their diagnostic confidence.

“Primarily, I assess the patient’s subjective condition and the objective vital parameters. Finally, I check if the current parameters match with Visual Patient.”

Participant 5

Discussion

This single-centre, qualitative, descriptive study allowed us to determine whether the Philips Visual Patient Avatar supports anaesthesia, post-anaesthesia care and critical care providers in various clinical settings, including the operating room, post-anaesthesia care unit and intensive care unit, and in which specific real-world situations they find the technology most useful.

The key findings indicate that the Philips Visual Patient Avatar, when used as a split-screen feature alongside conventional monitoring, is perceived as a technology that complements the conventional display and provides a quick overview in the operating room, post-anaesthesia care and intensive care settings. In total, almost 60% of the participants’ statements indicated that they had already experienced situations where the Philips Visual Patient Avatar helped them in their clinical practice (73% in the operating room, 48% in the neurosurgical intensive care unit and 28% in the post-anaesthesia care unit). Participants indicated that the technology significantly contributes to the assessment of changes in certain vital signs, particularly temperature and oxygen saturation monitoring, ultimately increasing the efficiency of information transfer. It was also stated that the Avatar helps senior caregivers who are supervising several operating rooms and thus more than one patient at a time. As demonstrated in previous computer-based and high-fidelity simulation studies^{15,16,19}, the incorporation of numerical and waveform data presented visually through changing colours, shapes, and animations, as seen in the Philips Visual Patient Avatar, has been shown to accelerate decision making, improve the accuracy of clinical diagnoses, reduce perceived workload, and increase perceived diagnostic confidence. These results can be attributed to the user-centred design of the technology, which supports the use of direct visual representations of data to enhance situational awareness⁹. The visual cues representing the various states of patient status were specifically designed to present vital sign changes that healthcare professionals can easily associate with real-world situations. To ensure that all users, regardless of their background or experience, can effectively utilize and interpret the visual cues provided by the Avatar, ongoing training and support is provided at the study

centre. Nevertheless, the technology's intuitive and minimalistic design is targeted at all user groups working in the perioperative setting and is easily learned, as stated by 31/36 participants in a previous study¹⁹. Other investigations have also shown that healthcare providers performed better in vital sign recall when using the Philips Visual Patient Avatar compared to conventional monitoring after only a short educational session comprising of an introductory video for the novel technology^{14,16}.

Other key principles in the design of the Visual Patient technology include Wittgenstein's *Tractatus Logico-Philosophicus*²⁰ and the NASA publication "On Organization of Information: Approach and Early Work" by Degani et al.²¹. Wittgenstein stated that a logical image should have meaningful similarities to the reality it is intended to represent²⁰, as embodied in the Philips Visual Patient Avatar. Degani et al. emphasize that the pinnacle of "order and wholeness" is achieved by integrating all essential data into a unified display²¹. This method allows healthcare providers to quickly assess whether all parameters are within the normal range, providing immediate reassurance and reducing the cognitive load associated with examining each numeric value individually. While the synthesis and simplification of information transfer might give rise to concerns about a potential trade-off between the quality of the represented information and the accuracy or precision of the technology, the Philips Visual Patient Avatar is intended as a supplementary tool to the conventional display. Consequently, the technology does not compromise the accuracy or precision of the numeric or waveform presentations, as these are always accessible. Instead, the Avatar aims to enhance users' situational awareness in the early stages of perception and guides them to the measurements in question when these are outside of the normal range.

Other technologies that have been integrated into real-world clinical practice and translate alphanumeric patient data into visual representations include: the Dynamic Lung from Hamilton Medical AG²², the Alarm Status Visualizer from Masimo Corporation²³, and the HemoSight and Physiology Screen from Edwards Lifesciences²⁴. While the listed visualization technologies aim to improve clinical workflow and enhance patient monitoring by targeting specific areas of interest such as lung function, alarm status, or hemodynamic state, the Philips Visual Patient Avatar is the first to provide a holistic representation of patient condition by integrating multiple data sources into a single, intuitive graphical avatar.

Interestingly, the positive impact of the avatar in the post-anaesthesia care unit was rather low. The results suggest that this is the only area of the study where only nurses responded. The more negative responses from the post-anaesthesia care unit may have been influenced by differences in professional roles. However, it is also important to note that educational efforts aimed at nurses to familiarize them with the new technology at the post-anaesthesia care unit were less effective than in the other settings. This was reflected in a higher rate of participants at the post-anaesthesia care unit who had not consulted either of the educational materials. As we did not analyse the responses on the basis of different professional roles in the operating room and intensive care unit, this would be an interesting area for future studies.

Furthermore, participants highlighted the role of technology in supporting daily clinical practice by enhancing situational awareness, particularly in managing high workloads and complex, high-stress situations. It is common to observe a decline in performance during high-pressure situations^{25,26}, which may contribute to psychological distress^{28–30}. Challenging clinical scenarios require healthcare providers to process a significant amount of information in a short period of time²⁹, potentially leading to cognitive changes that impair concentration and memory, thereby reducing task effectiveness^{26–28}. Recent studies have also indicated that when cognitive resources are limited, the avatar-based technology can help alleviate cognitive load^{14–16}. These findings suggest that the Philips Visual Patient Avatar may enhance situational awareness in clinical settings. This is particularly pertinent in the domains of anaesthesiology and critical care, where a lack of situational awareness has been linked to a significant proportion of medical errors⁸. If healthcare professionals are able to utilise the technology effectively in real-world clinical settings, this technology may be a significant contributor to enhancing patient safety.

Strengths and limitations

This study has several limitations. First, the study has the inherent limitations of qualitative research. Qualitative analysis provides a detailed description without attempting to assign frequencies to the characteristics identified in the data—rare and more common phenomena are given equal attention. Second, survey results can be affected by non-response³¹, self-selection³², information bias³³, leading question/interviewer bias³⁴. If certain individuals choose not to participate in a survey, their absence can result in an incomplete and potentially biased dataset. Various reasons may underlie non-response of certain participants, such as personal motivation or temporal capacity. Consequently, the findings might not accurately reflect the broader population, and this limitation can impact the extent to which the results can be generalized. Conversely, when individuals decide to participate based on their personal experiences, interests, or motivations, the sample may not adequately represent the entire target population. While we have strived to develop a reliable data collection tool to maximize generalizability, information bias remains a significant factor that can impact survey results. When an interviewer asks leading questions that can systematically influence the respondent's answers. This bias can arise from attempts to 'clarify' questions, or by emphasising certain words differently when interviewing cases compared to controls (or vice versa). While this survey focused on the assessment of situations where the avatar has been found to be useful to anaesthesia providers, a previous qualitative analysis of the opinions of care providers regarding the new technology included a comprehensive thematic analysis of their views on both its strengths and limitations³⁵. Hereby, a key objective was to identify areas for improvement, as identified by users, with the aim of guiding the future development of the Visual Patient Avatar. This in-depth analysis was conducted in order to ensure that the technology aligns with the needs of healthcare providers. As the avatar inventors are part of the same institution where the survey was conducted, this could also influence participants' responses. Furthermore, although it was only possible to complete the survey once from the same account, we could not prevent multiple responses from the same participant logging in using the survey link and a different, e.g. non-institutional email address.

In addition, our study included clinicians with demanding clinical responsibilities, which may have discouraged participation due to time constraints. This issue, together with non-response, self-selection and information bias, may have contributed to the rather low response rate. Finally, this study was conducted at a single university hospital. Perceptions of healthcare providers may differ in different settings.

Conclusion

The Philips Visual Patient Avatar can support caregivers in assessing multiple vital signs, especially temperature and oxygen saturation, and provides greater situational awareness in complex, high-stress daily situations. Almost 60% of participants reported that the Philips Visual Patient Avatar was helpful shortly after its clinical introduction, with 73% working in the operating room, 48% in the neurosurgical intensive care unit and 28% in the post-anaesthesia care unit. Although some respondents had not yet experienced situations in which the new technology had proved beneficial, these preliminary findings suggest the usefulness of the avatar in real-world clinical settings. Future research is essential to explore these issues further and to assess opportunities for improving the technology in more detail.

Data availability

The datasets used and/or analysed during the current study and the analysis are provided within the manuscript or supplementary information files.

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Author contributions

Conceptualization: I.R., C.A.H., J.L., P.M., J.F.W., C.B.N., E.K., D.W.T., G.G.; Data Analysis: I.R., J.L., D.W.T., G.G.; Writing—Original Draft Preparation: I.R., C.A.H., G.G.; Writing—Review & Editing: I.R., C.A.H., J.L., P.M., J.F.W., C.B.N., E.K., D.W.T., G.G.; Visualization: I.R., P.M., G.G.; Supervision: D.W.T., G.G.; Project Administration: G.G. All authors read and approved the final manuscript. Participants were informed that their responses to the questionnaire would be used for scientific purposes. The participants' consent was implied by their completion of the form and its submission. Participation in the study was voluntary, ensuring anonymity, and without any compensation.

Ethics approval and consent to participate

The Cantonal Ethics Committee of the Canton of Zurich in Switzerland reviewed the study protocol, stated that the project does not fall within the scope of the Human Research Act, issued a declaration of no objection (Business Management System for Ethics Committees Number Req-2021-00756) and waived the need for ethical approval. Participants were informed that their responses to the questionnaire would be used for scientific purposes. The participants' consent to participate was implied by their completion of the form and its submission. Participation in the study was voluntary, ensuring anonymity, and without any compensation.

Competing interests

CBN is an inventor of Visual Patient and Visual Patient Predictive technologies, for which the University of Zurich and Koninklijke Philips N.V. hold patents, patent applications, design protections, and trademarks. Joint-development and licensing agreements exist with Philips Medizin Systeme Böblingen GmbH, Böblingen, Germany; Koninklijke Philips N.V., Amsterdam, The Netherlands; Philips Research/Philips Electronics Nederland BV, Eindhoven, The Netherlands; and Philips USA, Cambridge, MA, USA. Within the framework of these agreements, CBN receives travel support, lecturing and consulting honoraria, and may potentially receive royalties in the event of successful commercialization. CBN is an inventor of Visual Clot technology, with patent applications, design protections, and trademarks held by the University of Zurich. In case of successful commercialization, CBN may receive royalties. CBN is an inventor of Visual Blood technology, for which the University of Zurich holds patent applications and design protections; potential royalties may follow successful commercialization. CBN received travel support, lecturing, and consulting honoraria from Instrumentation Laboratory – Werfen, Bedford, MA, USA. DWT is the first named inventor of Visual Patient and Visual Patient Predictive technologies, for which the University of Zurich and Koninklijke Philips N.V. hold patents, patent applications, design protections, and trademarks. Joint-development and licensing agreements exist with Philips Medizin Systeme Böblingen GmbH, Böblingen, Germany; Koninklijke Philips N.V., Amsterdam, The Netherlands; Philips Research/Philips Electronics Nederland BV, Eindhoven, The Netherlands; and Philips USA, Cambridge, MA, USA. Within the framework of these agreements, DWT receives research funding, travel support, lecturing and consulting honoraria, and may potentially receive royalties in the event of successful commercialization. DWT also holds a position on the Philips Patient Safety Advisory Board. DWT is the first named inventor of Visual Clot technology, with patent applications, design protections, and trademarks held by the University of Zurich. In case of successful commercialization, DWT may receive royalties. DWT is the first named inventor of Visual Blood technology, for which the University of Zurich holds patent applications and design protections; potential royalties may follow successful commercialization. Additionally, DWT received travel support, lecturing, and consulting honoraria from Instrumentation Laboratory – Werfen, Bedford, MA, USA, the Swiss Foundation for Anaesthesia Research in Zurich, Switzerland, and the International Symposium on Intensive Care and Emergency Medicine in Brussels, Belgium. No other funding or competing interests declared. Other authors declare that they have no conflict of interest.

Additional information

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