



UvA-DARE (Digital Academic Repository)

Education and training of nurses in the use of advanced medical technologies in home care related to patient safety: A cross-sectional survey

ten Haken, I.; Ben Allouch, S.; van Harten, W.H.

DOI

[10.1016/j.nedt.2021.104813](https://doi.org/10.1016/j.nedt.2021.104813)

Publication date

2021

Document Version

Final published version

Published in

Nurse education today

License

CC BY

[Link to publication](#)

Citation for published version (APA):

ten Haken, I., Ben Allouch, S., & van Harten, W. H. (2021). Education and training of nurses in the use of advanced medical technologies in home care related to patient safety: A cross-sectional survey. *Nurse education today*, 100, [104813].
<https://doi.org/10.1016/j.nedt.2021.104813>

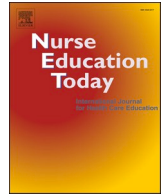
General rights

It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: <https://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.

UvA-DARE is a service provided by the library of the University of Amsterdam (<https://dare.uva.nl>)



Education and training of nurses in the use of advanced medical technologies in home care related to patient safety: A cross-sectional survey

Ingrid ten Haken^{a,*}, Somaya Ben Allouch^{b,c}, Wim H. van Harten^{d,e}

^a Research Group Technology, Health & Care, Saxion University of Applied Sciences, P.O. Box 70.000, 7500 KB Enschede, the Netherlands

^b Research Group Digital Life, Amsterdam University of Applied Sciences, Wibautstraat 2-4, 1091 GM Amsterdam, the Netherlands

^c Informatics Institute, University of Amsterdam, Science Park 904, 1098 XH Amsterdam, the Netherlands

^d Faculty Behavioural, Management and Social Sciences (BMS), Department Health Technology & Services Research (HT&SR), University of Twente, P.O. Box 217, 7500 AE Enschede, the Netherlands

^e Rijnstate General Hospital, Wagnerlaan 55, 6815 AD Arnhem, the Netherlands

ARTICLE INFO

Keywords:

Home care
Medical technologies
Nursing education
Patient safety
Risk management
Survey research

ABSTRACT

Background: To use advanced medical technologies (AMTs) correctly and safely requires both specialist knowledge and skills, and an awareness of risks and how those can be minimized. Reporting safety concerns about AMTs in home care can contribute to an improved quality of care. The extent to which a health care organization has integrated the reporting, evaluation and learning from incidents is a key element of that organization's patient safety culture.

Objectives: To explore nurses' experiences regarding the education followed in the use of AMTs in the home setting, and their organizations' systems of reporting.

Design: Descriptive cross-sectional design.

Methods: 209 home care nurses from across the Netherlands who worked with infusion therapy, parenteral nutrition and/or morphine pumps responded to the online questionnaire between July 2018 and February 2019. The analysis of the data was mainly descriptive.

Results: Educational interventions that are most often used to learn how to use AMTs were, as an average over the three AMTs, instruction by a nurse (71%), practical training in the required skills (71%) and acquiring information to increase theoretical knowledge (69%). Considerable attention is paid to patient safety (88%) and the home setting (89%). However, a substantial proportion of the nurses (up to 29%) use AMTs even though they had not been tested on their skills. 95% of the respondents were well acquainted with the incident reporting protocol of their organization, but only 49% received structural or regular feedback on any actions taken as a result of event reporting.

Conclusions: This study revealed aspects of nurses' education that imply risk factors for patient safety. Practical training is not always given, additional or retraining is often voluntary, and the required skills are not always tested. However, the results show that nurses do have a good awareness of patient safety. Incidents are mainly discussed within the team, but less at the organizational level.

1. Introduction

Developments in and the increased use of advanced medical technologies (AMTs) in the setting of the home have led to various and increasingly complex educational challenges within the nursing domain (McGrath and Higgins, 2006; Shin et al., 2006). To use AMTs correctly and safely requires both specialist knowledge and skills, and an

awareness of risks and how those can be minimized. This can be achieved through educational interventions tailored to the device, education about the risks and how to deal with them (Fex et al., 2012; Porte et al., 2018). For the purpose of this study, we use the definition of AMTs as 'devices that are life-supporting or life-sustaining in their application, or their use is of substantial importance in preventing impairment of human health, or their use prevents a potential unreasonable risk of

* Corresponding author.

E-mail addresses: i.tenhaken@saxion.nl (I. ten Haken), s.ben.allouch@hva.nl (S. Ben Allouch), w.h.vanharten@utwente.nl, WvanHarten@Rijnstate.nl (W.H. van Harten).

<https://doi.org/10.1016/j.nedt.2021.104813>

Received 25 August 2020; Received in revised form 22 January 2021; Accepted 3 February 2021

Available online 12 February 2021

0260-6917/© 2021 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

illness or injury' (APSF, 2016).

Several studies have shown that educational interventions in learning how to use medical devices properly and safely are both essential and effective (Keller et al., 2017; Shukla and Muthal, 2017). Although educational interventions are effective, at least in the short-term, continual systematic training, periodical intervention reinforcement and assessment are necessary after formal education has been completed (Ewertsson et al., 2015; Forsberg and Engström, 2018). Medical devices are continually developing and therefore an approach of lifelong learning is essential among professionals who use such technologies (Keller, 2010). In nursing, learning also relates to active reflection about existing situations and concrete actions have to be taken to generalize knowledge and skills. Experiential learning, according to Kolb's learning cycle, applies to a process of having a concrete experience grounded in practice, reflective observation about the experience, learning from the experience through abstract conceptualisation and active experimentation of what has been learned (Kolb, 1984).

From the 1990s, frequently identified methods of learning how to use a medical device were trial and error (self taught), learning by watching a video or slide tapes, training on-the-job or receiving instruction from another staff nurse (McConnell and Hilbig, 2000). Other forms of learning used over time include instructions by manufacturers, user manuals, and simulations (Fu et al., 2012; Gaba, 2004). New technologies to improve and extend learning in healthcare include web-based instruction, apps and social media (Bullock and Webb, 2015). An emerging educational technology in training in the use of medical devices is that of virtual reality simulation (Lino et al., 2016). The benefits of virtual simulation are, for example, that it offers a cost-effective approach to providing students with sufficient preparatory information to improve their knowledge and skills, and allowing practice in dealing with incidents in a safe environment, including allowing the trainee to make mistakes (Foronda et al., 2017; Kay et al., 2018).

A study conducted by Porte et al. (2018) in hospitals showed that as the risks in the use of medical devices increase, the frequency and type of training and examination are also increased and are also more extensive. Regarding high-risk devices, 69% of the staff in the study followed practical training in the necessary skills, 38% received education based on theoretical knowledge, 15% read the manual but 4% of the staff who use high-risk devices had received no education or training. Compared to hospital care, home environmental factors also affect device use (Fu et al., 2012; Keller et al., 2017). However, nursing education emphasizes hospital-based care and nursing students typically have little experience of home care (Mason, 2016). Home care nurses request more training on the various medical devices that they use in the home, because they do not always have the opportunity to develop sufficient skills with all devices they come across in daily practice (Hilbers et al., 2013; Munck et al., 2011). It is argued that information about safety aspects regarding the use of the devices in home care should be included in training (Fu et al., 2012; Keller, 2010).

Reporting safety concerns regarding AMTs can help bring about an improved quality of care. Most healthcare workers in hospitals are familiar with the incident reporting system of their organization (Evans et al., 2006; Mahajan, 2010). However, there are some factors that impede professionals from reporting incidents especially those involving the use of medical devices. Users do not always recognize an event as an incident; they may lack the time to report or be uncertain about whether an event must be reported and there may be liability concerns or a fear of punishment (Ewertsson et al., 2015; Leape, 2002). Even though receiving feedback as a result of the reports is a factor that positively influences the reporting of events, usually no structural feedback is given by the organization (Evans et al., 2006).

The extent to which a health care organization has integrated its reporting, evaluation and learning from incidents is a key part of its patient safety culture (VMSzorg, n.d.). Dutch hospitals use the 'Instrument voor Zelfevaluatie Patiëntveiligheidscultuur' (IZEP), an instrument for the self-evaluation of the patient safety culture, to determine

their positions on the 'culture ladder' on several dimensions. One dimension that can be scored on is 'reporting, evaluating and learning from incidents'. Having insight into which rung of the ladder the organization is on offers opportunities for further improvement of patient safety (see Fig. 1).

This study is part of a more comprehensive research project into patient safety. The education and training of nurses, learning from concrete experiences and learning from incidents are essential parts of knowledge management in order to improve patient safety and therefore the quality of care. It concerns a process of life-long learning and the recurring education of professional nurses. Like in hospitals, home care organizations are increasingly paying attention to patient safety and the vital contribution of educational interventions. However, a review conducted by ten Haken et al. (2018) revealed a scientific gap regarding the perspective of home care nurses in this area. Much research has been done into the effects of education and training on patient safety, but to the best knowledge of the authors little is yet known about how safety is treated in education in relation to specifically home care. Therefore, the following research questions were addressed from the perception of nurses:

- What educational interventions did the nurses receive in the use of advanced medical technologies in home settings?
- To what extent did those educational interventions focus on incidents?
- To what extent were those educational interventions adequate to support the safe use of advanced medical technologies in home settings?
- What do nurses in home care know about their organizations' systems for reporting incidents?

2. Methods

2.1. Design

A descriptive cross-sectional design was used, following a quantitative approach. The study is part of a more comprehensive research project into the safe use of AMTs in home care, which includes two studies conducted among the same group of nurses. Both studies concerned three AMTs that are often used in home care: infusion therapy, parenteral nutrition and morphine pumps. The other study focused on identifying, reporting and actions taken following incidents in daily practice involving the use of these AMTs by home care nurses, and the effects on patient outcomes (ten Haken et al., 2020). The present study explored the perspectives of the nurses in using the technologies in home care in terms of educational interventions and patient safety. For the purpose of this study, 'education' will be used as an overarching term for all learning activities engaged in by the respondents and the term 'incident' to include 'adverse event' and 'near-miss'.

2.2. Participants

Purposive sampling was used for the selection of organizations, while for the selection of nurses within the organizations survey sampling was used. Home care organizations were selected from both urban and rural settings, in various regions across the Netherlands, and that employed specialized and general nursing teams using AMTs. Participants were recruited by email and phone, and provided with information about the study in a digital information letter. All home care teams that were willing to participate were asked if they were eligible for inclusion, i.e. if their nurses work with at least one of the technologies infusion therapy, parenteral nutrition or morphine pump, regardless of how frequently. They were also asked about their degree of specialization in the use of these particular AMTs. However, participation of individual nurses was on a voluntary basis and the number of participants per team varied. After the initial recruitment, a total of 340 nurses

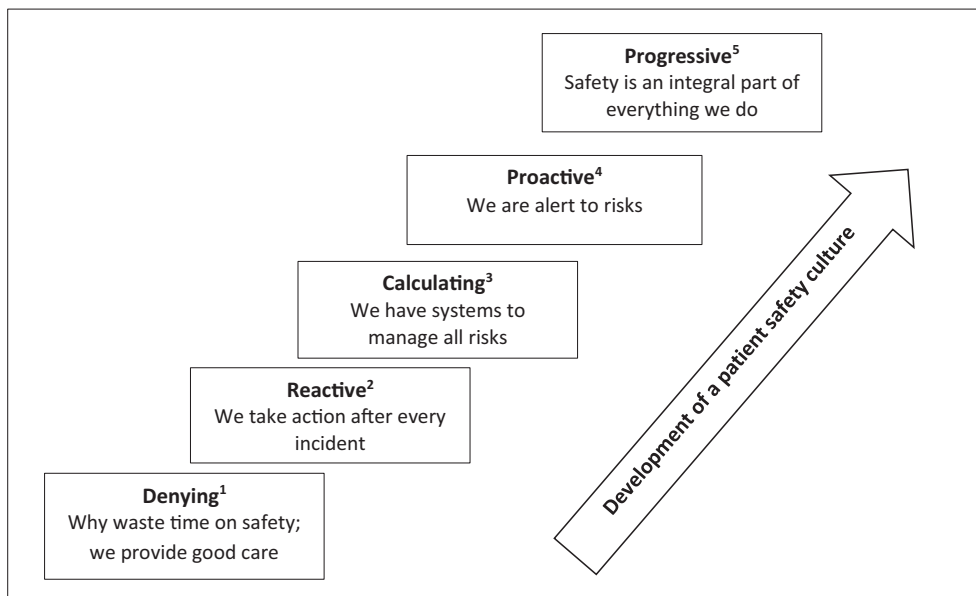


Fig. 1. Culture ladder in IZEP (VMSzorg, n. d.).

¹Incidents are rarely reported in our department.

It is common to hide mistakes and no learning takes place. Management and healthcare professionals do not want any hassle but want to get back to work as quickly as possible.

²Although there are formal agreements in place covering the reporting of incidents, healthcare professionals are reluctant to report incidents, neither are they stimulated to do so.

In the main, only serious incidents are reported but there is rarely any feedback on a report.

Serious incidents temporarily put patient safety on the agenda. An improvement is then devised ad hoc that will not be followed for long.

³There is a reporting system, but healthcare professionals do not feel secure enough to report all types of incidents.

The incidents are discussed at a department level. The emphasis is more on analyzing and less on seeking improvement.

Management is primarily interested in

registering the number of reports.

⁴Most healthcare professionals report almost all types of incidents. Many incidents without harm to the patient are also reported.

The incidents are discussed at a department level. Improvements are introduced with the aim of preventing recurrence.

Improvements are actively sought to prevent the incidents reported (both within and outside of our own department) in the future. Patients are typically involved.

⁵Healthcare professionals are aware of their responsibilities and report all incidents to help prevent recurrence.

They provide quick and targeted feedback on the reported incidents. Improvements are fed back and monitored.

All those involved in the care process are constantly alert to risks, make improvements and share good practice with the rest of the organization.

expressed interest in participating in the study.

2.3. Data collection

A questionnaire was developed that contained general questions about the respondent, such as age and gender. It included also more specific items related to educational interventions that participants had received in the use of AMTs in the home, forms of testing and their self-perceived competence in using AMTs in the home in a patient-safe way. Most questions followed a multiple-choice format, but for some multiple answers were possible. Categories of answers are based on the literature (see the Introduction) and were verified in interviews with two expert home care nurses. The survey was piloted with a team of home care nurses and subsequently improved to increase its efficacy. The adjustments were mainly to wordings and, to a lesser extent, to the order of the questions.

The period of data collection was from July 2018 until February 2019. The questionnaire was distributed by email as a link to an online survey over the internet using the Qualtrics software. A reminder message was sent after a few weeks to help increase the response rate.

2.4. Ethical considerations

According to the policy activities that constitute research at the University of Twente, this work met the criteria for operational improvement activities exempt from ethics review and data protection rules were followed accordingly. The study was deemed an improvement activity in professional practice and not as research on human subjects. Nurses were informed in advance via email about what participation would entail. They could then decide whether or not to participate. Questionnaire responses were strictly anonymous to ensure nurses' privacy. Data cannot be traced back to individual respondents or

organizations.

2.5. Data analysis

Data were analyzed using descriptive statistics to characterise respondents' profiles. This includes mean values and standard deviations for the continuous and categorical variables, and using proportions for categorical and ordinal variables. Frequencies and percentages of responses were calculated for respondents' experiences. Where applicable, responses to the items on the questionnaire were grouped into positive categories (e.g. 'very competent' and 'sufficiently competent') and into negative categories (e.g. 'insufficiently competent' and 'very incompetent'). Missing data were excluded on a question-by-question basis. All analyses in the study were conducted using the IBM SPSS for Windows, Version 24.0 statistical software package.

3. Results

3.1. Respondent characteristics

A total of 209 home care nurses completed the online questionnaire, which corresponds to a response rate of 61%. Table 1 provides an overview of the respondent characteristics. Most respondents had a bachelor degree as their highest education completed in nursing. Education 'other' was mainly described as a 'MGZ-course (maatschappelijke gezondheidszorg)': a course in social health care at the level of higher education. Further education or specialist training cited by the respondents mainly involved CCU/IC (critical care unit/intensive care), wound care, medical technical skills in nursing, palliative care, dialysis, oncology and management.

Table 1
Respondent characteristics (total n = 209).

Age mean (SD) (n=207)	46.1 years (11.4)
Gender % (n=207)	
Female	91% (188)
Male	9% (19)
Highest completed education in nursing (Dutch titles in brackets) % (n=205)	
Bachelor of Nursing (HBO-V)	44% (90)
Secondary vocational education (MBO-V)	20% (41)
In-service education (in-service)	30% (61)
Other education	6% (13)
Employment status in FTE mean (SD) (n=208)	0.7 FTE (0.2)
Situation most applicable to their work % (n=205)	
A. A specialized nurse who performs specific care tasks for patients at home using advanced medical technologies	62% (127)
B. A nurse who usually performs various care tasks for patients at home, including the care using advanced medical technologies if necessary	38% (78)

3.2. Experiences with and education about infusion therapy

Most respondents (81%; n = 169) had more than two years of practical experience in inpatient and/or outpatient care in the use of infusion therapy (see Table 2), and a majority (62%) use infusion therapy during (almost) every shift (see Table 3). Nurses who use infusion therapy had received some form of education in 97% of the cases. Educational interventions followed are presented in Fig. 2. About a quarter of the respondents have received other forms of education, including e-learning, courses from the 'KMBV educational institution (Kwaliteitsbevordering voor Management en Bestuur van Verzorgingshuizen)', skills lab, attending congresses and experience in daily practice.

86% of the respondents believed that during their education or training, sufficient attention was paid to patient safety, risks or incidents regarding the use of infusion therapy and about the same proportion think that sufficient specific attention was paid to using the device concerned in the home setting. However, 14% of the nurses believed that insufficient attention is paid to safety aspects and the home environment. Almost all respondents (99%) have followed retraining or additional training; the various ways are shown in Fig. 3 and the most common way (72%) is periodically, whereby participation is mandated by the organization.

According to the respondents, in 82% of the cases their skills related to the use of infusion therapy are tested but in 18% of the cases they are not. Fig. 4 presents the various methods used for testing nurses' skills. Other test forms mentioned are assessment in a skills lab, peer review and testing by the KMVB. Almost all respondents (94%) considered themselves to be sufficiently competent (including 62% very competent), to use infusion therapy in a patient-safe way in home care. However, 6% of the respondents still use these technologies while considering themselves to be insufficiently competent.

Table 2
Years of experience in total (inpatient and outpatient care) with the use of the technology.

Years of experience in total (inpatient and outpatient care)	Technology		
	Infusion therapy n (%)	Parenteral nutrition n (%)	Morphine pumps n (%)
>2 years	169 (81)	161 (78)	173 (83)
1–2 years	11 (6)	14 (7)	16 (8)
6–12 months	8 (4)	6 (3)	11 (5)
<6 months	7 (3)	4 (2)	7 (3)
Never used it	13 (6)	22 (10)	1 (1)
Total	208 (100)	207 (100)	208 (100)

Table 3
Frequency on average in the use of the technology in home care.

Frequency on average in the use in home care	Technology		
	Infusion therapy n (%)	Parenteral nutrition n (%)	Morphine pumps n (%)
(Almost) daily/(almost) every shift	129 (62)	105 (50)	115 (55)
A few times a month	12 (6)	31 (15)	33 (16)
A few times every 6 months	12 (6)	10 (5)	31 (15)
A few times a year	20 (10)	15 (7)	21 (10)
Less than once a year	16 (7)	16 (8)	5 (3)
Never used it	19 (9)	31 (15)	3 (1)
Total	208 (100)	208 (100)	208 (100)

3.3. Experiences with and education about parenteral nutrition

More than three-quarters of the participants (78%; n = 161) had more than two years' experience in using devices involving parenteral nutrition in inpatient and/or outpatient care (see Table 2). Half of the respondents (50%) use devices for parenteral nutrition during (almost) every shift in home care (see Table 3). Of the respondents who use these devices in home care, 89% have received some form of education in the use of these technologies. At the same time, 11% of the nurses use these devices without having received any form of education. Fig. 2 presents the various educational interventions followed in the use of parenteral nutrition. A small proportion indicated that they have followed 'other' forms of education, such as KMBV-courses, e-learning and in-service training within the organization.

88% of the surveyed home care nurses were positive about the attention paid during education to patient safety, risks or incidents during the use of devices for parenteral nutrition. A similar outcome (87%) can be seen regarding the attention paid to the specific situation of the home during education. However, 12% of the nurses thought that in education insufficient attention is paid to safety aspects and 13% to aspects of the home setting. Almost all nurses surveyed (98%) have followed some form of retraining or additional training (see Fig. 3) and in two-third of the cases this is periodically, whereby participation is mandated by the organization. Other forms of extra education mentioned are keeping up with the professional literature and annual symposia presented by device manufacturers.

In about three-quarters (77%) of the cases, skills in the use of parenteral nutrition are tested whereas in about a quarter of the cases they are not. Testing methods used are shown in Fig. 4. Other forms of testing that have been mentioned are peer review and a KMVB-course. Nurses who use parenteral nutrition in home care practice consider themselves competent (95%; including 48% 'very competent'). However, 5% considered themselves as insufficiently competent in using these technologies.

3.4. Experiences with and education about morphine pumps

When asked how many years of experience they have in using morphine pumps in inpatient and/or outpatient care, 83% (n = 173) of the respondents answered 'more than two years' (see Table 2). More than half of the respondents (55%) use morphine pumps during (almost) every shift (see Table 3). Of the nurses who use morphine pumps in home care, 96% have received some form of education but 4% have not. Forms of education followed can be found in Fig. 2. Educational interventions in the category 'other' are reported to be 'peer training by expert colleagues', 'we have to follow the rules and protocols', 'a KMVB-course' or 'symposia'.

During education, according to 90% of the surveyed nurses, sufficient attention was paid to patient safety, risks or incidents during the use of morphine pumps (of which 46% indicated 'ample attention'). 93% of the respondents think that, during education, sufficient attention

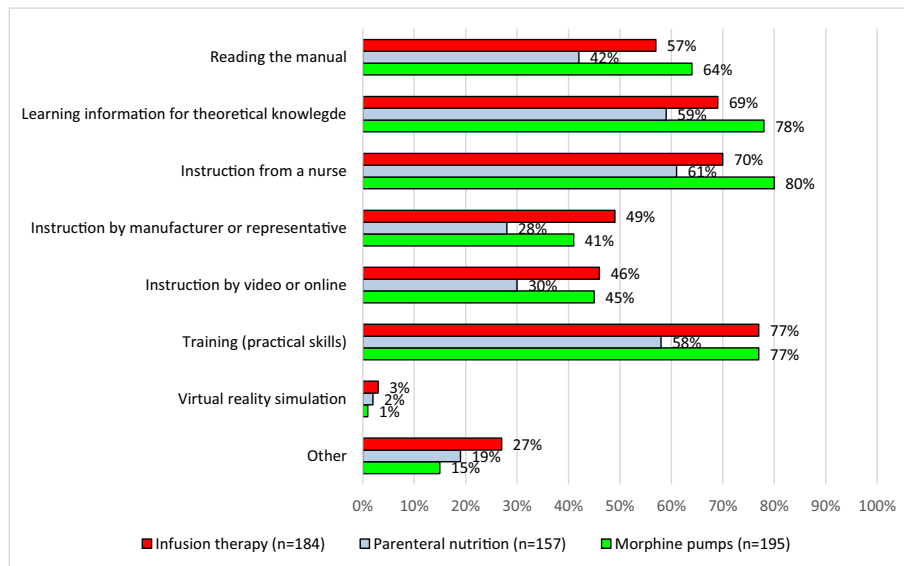


Fig. 2. Educational interventions followed by nurses in the use of the AMTs (multiple answers possible).

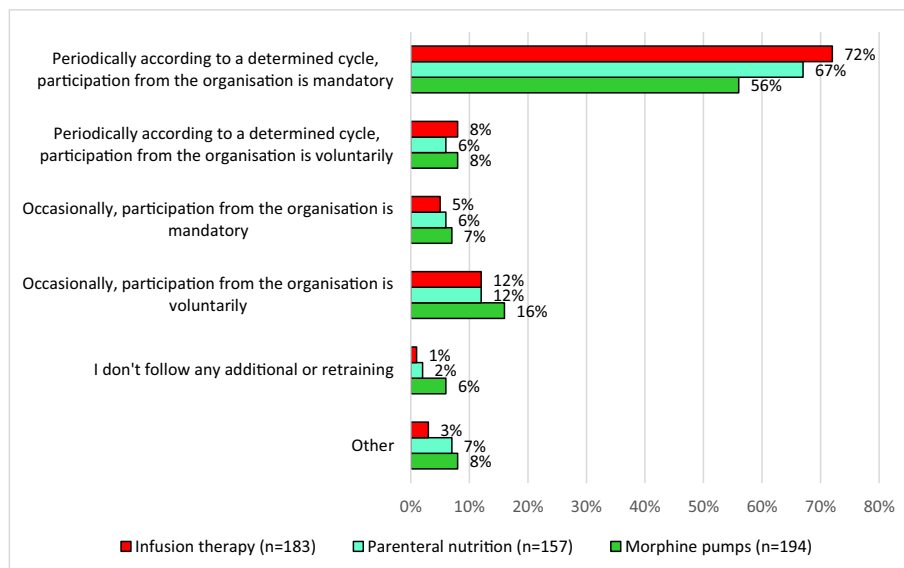


Fig. 3. Ways in which the respondents follow retraining or additional training.

was paid to the use of morphine pumps in the home setting (including 55% ‘ample attention’). However, 7% of the nurses say that insufficient attention was paid to the specific setting of the home. 94% of the respondents follow additional or retraining in the use of morphine pumps. Over half of the respondents (56%) stated that they follow additional or retraining periodically, whereas participation is mandated by the organization. Other extra education, as followed by 8% of the morphine pump users, typically only occurs when a new type of pump is introduced, as necessary or self-education through reading and practising relevant new techniques.

A majority (71%) of the nurses who use morphine pumps in home care stated that their skills are tested, but a significant minority (29%) said they are not. Forms of testing used are shown in Fig. 4. ‘Other’ testing methods are mainly peer review, KMBV-certification, e-learning or by using an app. Home care nurses who use morphine pumps in home care considered themselves in over 96% of the cases to be competent in the safe use of such devices in this setting (including 60% ‘very competent’) but 4% considered that they are insufficiently competent.

3.5. Reporting incidents within the organization

Almost all respondents (95%; n = 196) are familiar with the incident reporting protocol used within their organization and know how to formally report incidents; 4% of the nurses know that there is a protocol for incident reporting but do not know what it contains and 1% are unaware of any protocol. Most (85%) do not experience factors impeding the reporting of the incidents. However, if they do, 48% say that they do not have sufficient time, 29% do not know whether it is worth reporting an event, 10% do not report because they do not know what the liability for the organization might be and 7% fear sanctions or punishment. No one mentioned ‘don’t know how to report the incident’ as an obstacle to reporting. 61% of the home care nurses mentioned other obstacles to reporting incidents, such as a user unfriendly and time-consuming reporting system, loyalty towards a colleague, that reporting incidents is not yet part of the team culture, an uncomfortable feeling at exposing mistakes, no feedback on any report and the notion that it makes more sense to discuss incidents within the team.

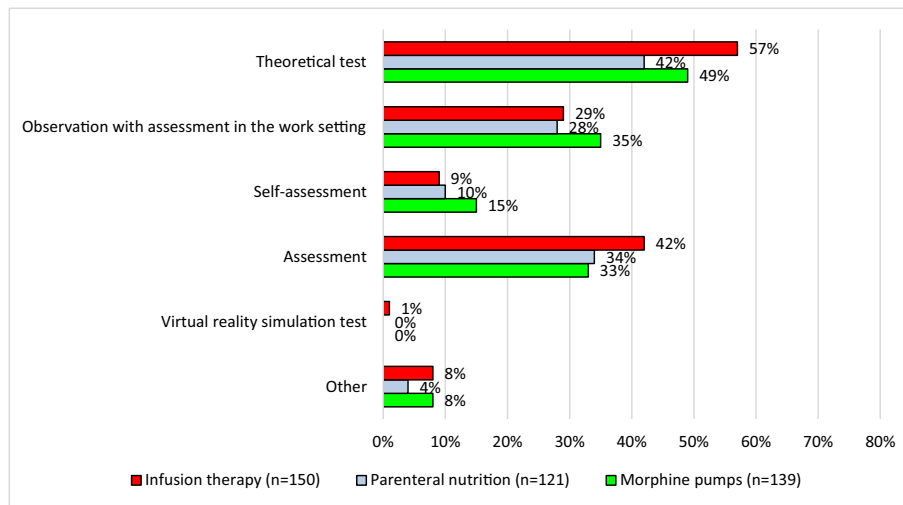


Fig. 4. Methods used for testing the competence in the use of AMTs by nurses (multiple answers possible).

On the question of whether they receive feedback about what actions have been taken as a result of incident reports, including reports by others, 32% of the nurses say that this happens in a structural way, 17% experience that this happens regularly but not structurally and 28% think that this happens only occasionally. Nearly a quarter (23%) say that receiving feedback about actions on reported adverse events (almost) never happens. If respondents do receive feedback, 67% say that this is done through discussion in their teams, 21% receive a personal message, 11% receive the information through messages on the intranet, 10% through annual reports by the management and 5% through newsletters. 17% of the respondents indicated that they receive feedback via other information modalities, such as only when you ask for it, via a system in which you can read the information, via a colleague, some don't know how feedback takes place and a substantial proportion say that they do not receive any feedback at all.

The respondents were asked which situation is most applicable to the patient safety culture within their individual organizations regarding reporting, evaluating and learning from incidents. More than half of the surveyed nurses (56%) identified their organization as 'proactive'. In 20% of the cases, the nurses describe their organization as 'progressive', whereas 13% of the respondents see the patient safety culture of their organization as 'reactive', 11% of the respondents term their organization 'calculating', and 1% think that the organization has a 'denying' nature.

4. Discussion

The results demonstrate that nurses use a variety of educational interventions to acquire knowledge and develop skills regarding the use of AMTs. The most commonly used methods are instruction by a nurse, training in the required skills, learning information to gain theoretical knowledge and reading the product manual. New digital educational forms, such as instruction by video or online and e-learning, are already being used. Regarding parenteral nutrition, it is remarkable that a considerable percentage of the nurses use these technologies in home care without having received any form of education in this. The proportion of nurses who use the AMTs but have not been tested ranges from 18% to 29%. This means that there can be no certainty that they have sufficient skills to use the technologies in a patient-safe way.

Respondents are positive about the attention paid to patient safety, risks or incidents with the technology during the education they have followed. A proportion of 86–91% of the nurses considers the degree of attention as sufficient or more than sufficient. However, there is still a substantial percentage who think that too little attention has been paid

to this aspect. Considering retraining or additional training, there is a substantial proportion of respondents, especially in relation to morphine pumps, who participate only occasionally, on a voluntary basis or not at all. This must be considered as a serious risk factor, since many nurses may not have adequate skills to use AMTs in ways that are safe for patients.

There is a substantial proportion (7–14%) who believe that during education the degree of attention paid to the setting of the home was insufficient. It is noteworthy that the percentage of dissatisfied respondents who use infusion therapy and parenteral nutrition is twice as high as for morphine pumps. Furthermore, although most of the nurses see themselves as competent in the safe use of the technologies in the setting of the home, 4–6% use these AMTs while considering themselves insufficiently competent. This clearly implies patient safety risks. An earlier study within this research project into the safe use of AMTs in home care identified that, on average for the three AMTs, in 2.4% of patient contacts an incident occurred (adverse events and near misses) and that 40% of those adverse events resulted in mild to severe harm to the patient (ten Haken et al., 2020). That data were used to alert the participating organizations to the clear patient safety risks. It is now recommended that the management of home care organizations (1) recognize quality circles at various levels of their organization; and (2) be aware of existing informal mechanisms for mitigating safety risks.

Most respondents are familiar with their organizations' protocols and know how to report incidents according to their local protocols. However, a small proportion still experience obstacles to reporting such events. As a lack of time and user-unfriendly reporting systems are major impediments to reporting incidents, it is recommended that investments are made in systems that will help make formal reporting easier and less time-consuming. These would preferably be systems that provide structural feedback on the actions taken as a result of reported incidents. At the same time, it is concluded that nurses in home care certainly pay attention to patient safety. The results show that two-thirds of the respondents discuss incidents within their team. The score on the ladder regarding patient safety culture also shows that three-quarters of the home care organizations in which the nurses work are seen as proactive or progressive regarding reporting, evaluating and learning from incidents. This score corresponds to the experiences of the same group of nurses that incidents are discussed within their teams (ten Haken et al., 2020). However, the current study shows that, at the organizational level, formal feedback on the reported incidents is rare.

This study explored the perspectives and experiences of nurses working in home care. Our findings are broadly in line with the results of studies highlighting the experiences of healthcare professionals working

in inpatient care. In the footsteps of hospital nurses (Ewertsson et al., 2015), home care nurses consider their nursing education as a mainly sufficient preparation for handling AMTs and most see themselves as competent to use these devices in their work setting. As found in the study by Porte et al. (2018) conducted in Dutch hospitals, the home care nurses in our study had received practical training in the skills necessary for the use of AMTs, but more frequently education was based on theoretical knowledge and reading the product manual. The percentage of health care professionals who use high and medium risk AMTs but without education or training is 1–2% in hospitals (Porte et al., 2018), and in our study in home care organizations 3–4% for infusion therapy and morphine pumps, and 11% for parenteral nutrition.

Most home care nurses are familiar with the incident reporting system of their organizations, as are most other healthcare workers (Evans et al., 2006; Mahajan, 2010). In home care, nurses experience similar impeding factors to reporting incidents as those faced by other healthcare professionals (Ewertsson et al., 2015; Leape, 2002). However, contrary to an earlier study (Evans et al., 2006), the results of our study show that home care nurses receive - to some extent - structural feedback from their organizations on the actions taken as a result of reported incidents.

This study is part of a larger research project into patient safety involving the same group of respondents. A remarkable outcome is that, although a large majority of the nurses (85%) do not experience impeding factors in reporting incidents and almost all (95%) are familiar with their organization's protocol, only 16% of all incidents were formally reported according to each organization's protocol (ten Haken et al., 2020). More research is needed into why nurses not experiencing impeding factors nevertheless do not formally report incidents. It is also strongly recommended that home care organizations and schools of nursing incorporate the results of this study within their policy regarding the education of nurses, especially on using Safety II techniques in home care settings.

4.1. Strengths and limitations

This study yielded valuable knowledge about the education of home care nurses regarding their use of AMTs. The sample taken largely indicates representativeness of the national picture of home care in the Netherlands. Furthermore, the findings are expected to be valid for other advanced industrialized countries. The overall response rate suggests the interest of home care nurses in the subject of this study. Almost all the questionnaires were fully completed and the respondents provided ample additional information where requested. This study does justice to the position of nurses in their use of AMTs in home care by investigating the subject from their perspective, and thereby it narrows the scientific gap in this research field. To the best knowledge of the authors, this is one of the first studies that examines nurses' education in the use of AMTs in home care in relation to patient safety. This study has clarified several learning experiences of nurses in the use of AMTs that we consider of great importance for nursing education in general and the training of home care nurses in particular as part of the process of lifelong learning.

However, this study has also a number of limitations. Participation by respondents was on a voluntary basis, so does not represent a truly random sample. Nurses with a special interest in the subject or with certain experiences that they want to share might have been more willing to participate in the study, which may have biased the results. Although the overall response rate was relatively high, the sample was too small to perform statistically significant calculations on certain underlying categories. Finally, the questionnaire has a subjective dimension; for example, with regard to which nurses see themselves as competent to use the AMTs in a safe way in the home setting. Considering test results would give a more objective picture of their skills.

5. Conclusions

This research adds to the body of knowledge about the various aspects of nurses' education in the use of AMTs in home care in regard to patient safety. The results emphasize the importance of considering patient safety during the education and training of nurses, and also the specific the setting of the home. The profession of nurse implies a process of lifelong learning, involving recurring education and additional training. The study also reveals several aspects of education that impact on patient safety risks, such as that training in skills has not always been received by nurses, additional or retraining is often on a voluntary basis and skills are not always tested. However, the results show that nurses have a good awareness of patient safety. Incidents are mainly discussed within the team, but less at the level of the organization. Organizations must move towards a situation in which safety is even more integral to everything they do, particularly with regard to the formal reporting of incidents and the provision of feedback on such events at the organizational level.

Funding statement

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

CRedit authorship contribution statement

Ingrid ten Haken: Conceptualization; Methodology; Software; Investigation; Resources; Data curation; Formal analysis; Validation; Writing - original draft; Visualization; Project administration; Somaya Ben Allouch: Conceptualization; Methodology; Validation; Writing - review & editing; Supervision; Wim van Harten: Conceptualization; Methodology; Validation; Writing - review & editing; Supervision; Funding acquisition: not applicable.

Declaration of competing interest

None.

Acknowledgments

The authors express their sincere thanks to all home care organizations and nurses who participated in this survey and gave generously of their time.

References

- APSF, 2016. Definition and examples of Advanced Medical Technology (AMT). Available from: <http://www.apsf.org/initiatives.php>. (Accessed 29 June 2016) (2016, cited 2016 June 29, WWW Document).
- Bullock, A., Webb, K., 2015. Technology in postgraduate medical education: a dynamic influence on learning? *Postgrad. Med. J.* 91, 646–650. <https://doi.org/10.1136/postgradmedj-2014-132809>.
- Evans, S.M., Berry, J.G., Smith, B.J., Esterman, A., Selim, P., O'Shaughnessy, J., DeWit, M., 2006. Attitudes and barriers to incident reporting: a collaborative hospital study. *BMJ Qual. Saf.* 15, 39–43.
- Ewertsson, M., Gustafsson, M., Blomberg, K., Holmström, I.K., Allvin, R., 2015. Use of technical skills and medical devices among new registered nurses: a questionnaire study. *Nurse Educ. Today* 35, 1169–1174. <https://doi.org/10.1016/j.nedt.2015.05.006>.
- Fex, A., Flensner, G., Ek, A.-C., Söderhamn, O., 2012. Self-care agency and perceived health among people using advanced medical technology at home. *J. Adv. Nurs.* 68, 806–815. <https://doi.org/10.1111/j.1365-2648.2011.05781.x>.
- Foronda, C.L., Alfes, C.M., Dev, P., Kleinhessel, A.J., Nelson, D.A., O'Donnell, J.M., Samosky, J.T., 2017. Virtually nursing. Emerging technologies in nursing education. *Nurse Educ.* 42, 14–17. <https://doi.org/10.1097/nne.0000000000000295>.
- Forsberg, A., Engström, Å., 2018. Critical care nurses' experiences of performing successful peripheral intravenous catheterization in difficult situations. *J. Vasc. Nurs.* 36, 64–70. <https://doi.org/10.1016/j.jvn.2018.02.002>.
- Fu, M., Weick-Brady, M., Tanno, E., 2012. Medical devices in the home: a unique challenge for the FDA. *Work* 41, 361–365. <https://doi.org/10.3233/WOR-2012-1305>.

- Gaba, D.M., 2004. The future vision of simulation in healthcare. *Qual. Saf. Health Care* 13. <https://doi.org/10.1136/qshc.2004.009878>.
- Hilbers, E.S.M., de Vries, C.G.J.C.A., Geertsma, R.E., 2013. Medical technology at home: safety-related items in technical documentation. *Int. J. Technol. Assess. Health Care* 29, 20–26. <https://doi.org/10.1017/S0266462312000694>.
- Kay, R., Goulding, H., Li, J., 2018. Assessing the impact of a virtual lab in an allied health program. *J. Allied Health* 47, 45–50.
- Keller, J., 2010. Instructions included? Make safety training part of medical device procurement process. *Mater. Manag. Health Care* 19, 26–29.
- Keller, S.C., Gurses, A.P., Werner, N., Hohl, D., Hughes, A., Leff, B., Arbaje, A.I., 2017. Older adults and management of medical devices in the home: five requirements for appropriate use. *Popul. Health Manag.* 20, 278–286. <https://doi.org/10.1089/pop.2016.0070>.
- Kolb, D.A., 1984. *On Experiential Learning*. In: Englewood Cliffs. Prentice Hall, New York.
- Leape, L.L., 2002. Reporting of adverse events. *New English. J. Med.* 347, 1633–1638.
- Lino, J.A., Gomes, G.C., Sousa, N.D.S.V.C., Carvalho, A.K., Diniz, M.E.B., Viana Junior, A. B., Holanda, M.A., 2016. A critical review of mechanical ventilation virtual simulators: is it time to use them? *JMIR Med. Educ.* 2, e8 <https://doi.org/10.2196/mededu.5350>.
- Mahajan, R.P., 2010. Critical incident reporting and learning. *Br. J. Anaesth.* 105, 69–75. <https://doi.org/10.1093/bja/aeq133>.
- Mason, D., 2016. Promoting the health of families and communities: a moral imperative. *Hast. Cent. Rep.* 46, 48–51. <https://doi.org/10.1002/hast.633>.
- McConnell, E.A., Hilbig, J., 2000. A national study of perioperative nurse education in two technologies. *AORN J.* 72, 254–264. [https://doi.org/10.1016/S0001-2092\(06\)61937-6](https://doi.org/10.1016/S0001-2092(06)61937-6).
- McGrath, D., Higgins, A., 2006. Implementing and evaluating reflective practice group sessions. *Nurse Educ. Pract.* 6, 175–181. <https://doi.org/10.1016/j.nepr.2005.10.003>.
- Munck, B., Fridlund, B., Mårtensson, J., 2011. District nurses' conceptions of medical technology in palliative homecare. *J. Nurs. Manag.* 19, 845–854. <https://doi.org/10.1111/j.1365-2834.2011.01231.x>.
- Porte, P.J., Verweij, L.M., de Bruijne, M.C., van der Vleuten, C.P.M., Wagner, C., 2018. Exploring medical devices: the use of risk assessment tools and their link with training in hospitals. *Int. J. Technol. Assess. Health Care* 34, 218–223. <https://doi.org/10.1017/s026646231800020x>.
- Shin, K., Jung, D., Shin, S., Kim, M.S., 2006. Critical thinking dispositions and skills of senior nursing students in associate, baccalaureate, and RN-to-BSN programs. *J. Nurs. Educ.* 45, 233–237.
- Shukla, K., Muthal, S., 2017. Mishandling of medical devices in hospital icu: analysis of causes, revenue drains and training needs of ICU staff. *Indian J. Public Heal. Res. Dev.* 8, 755–761.
- ten Haken, I., Ben Allouch, S., van Harten, W.H., 2018. The use of advanced medical technologies at home: a systematic review of the literature. *BMC Public Health* 18, 1–33. <https://doi.org/10.1186/s12889-018-5123-4>.
- ten Haken, I., Ben Allouch, S., van Harten, W.H., 2020. Reporting incidents involving the use of advanced medical technologies by nurses in home care: a cross-sectional survey and an analysis of registration data. *BMJ Qual. Saf.* 1–8. <https://doi.org/10.1136/bmjqs-2019-010510>.
- VMSzorg. IZEP-dimensies. Instrument voor zelfevaluatie patiëntveiligheidscultuur. URL: <https://www.vmszorg.nl/wp-content/uploads/2017/06/IZEP-8-dimensies-drukbestand.pdf>. (Accessed 23 April 2019) (n.d., WWW Document).