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Major Article

Hazards from physical attributes of the home environment among patients on outpatient parenteral antimicrobial therapy

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Background: Outpatient parenteral antimicrobial therapy (OPAT) requires that patients and their caregivers administer antimicrobial medications in the home via venous catheters. Hazards from physical attributes of the home environment may impede safe performance of OPAT tasks.
Methods: We performed a qualitative study, including semistructured telephone interviews and contextual inquiries, of patients performing OPAT tasks inside the home. Eligible participants were discharged from 2 academic medical centers in Baltimore, Maryland, on OPAT. We coded interview transcripts and contextual inquiry forms based on a model of healthcare work systems.
Results: Twenty-nine patients underwent semistructured telephone interviews, and 14 patients underwent contextual inquiry. We identified hazards including bathing, animal or pets, extremes in temperature, household clutter, indoor soil and food exposures, outdoor soil, and travel. Patients often developed strategies to mitigate these hazards.
Discussion: Multiple hazards related to the home environment could have led to harm, and in the absence of specific guidance, patients developed strategies to mitigate these hazards.
Conclusions: Educational interventions to improve OPAT should incorporate an understanding of hazards that may occur in the home environment.

Outpatient parenteral antimicrobial therapy (OPAT), in which patients and caregivers are given instruction and support in venous catheter maintenance and parenteral medication administration but perform their own infusions, is received by close to 500,000 patients annually in the United States.[1] Guidelines adapted from inpatient nursing standards describe how patients and caregivers should perform infusions and care for the catheter.[2] However, we do not know what safety hazards or mitigating factors patients and caregivers might experience in following these guidelines.

In particular, patients and caregivers may experience hazards from physical attributes of the home environment that might impede OPAT care. When compared with hospital patient rooms, which may contain relatively well-controlled and standardized physical environments, patient homes vary greatly with respect to temperature, noise, crowding, lighting, and cleanliness, and therefore potential hazards.[3-8] Studies of the home environment's impact on home healthcare have focused primarily on home health nurses' perspectives.[7,8] No studies have focused on the patient and caregiver experience of how physical attributes of the home environment may become hazards (something that can lead to a failure in a process or system)[9] impeding OPAT performance.

We evaluated how hazards from physical aspects of the home environment may impact the ability of patients and caregivers to safely

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perform OPAT-related tasks.[9-14] We sought an in-depth understanding of how the home environment hinders safe performance of OPAT-related tasks, and how patients mitigate these safety hazards.[9,15]

METHODS

Design

We used 2 qualitative approaches to evaluate patient experiences with home-based OPAT. One approach consisted of semistructured telephone interviews with patients on OPAT. Another approach consisted of contextual inquiries of patients and caregivers performing OPAT-related tasks at home (eg, medication infusion, catheter care) within 2 weeks of hospital discharge,[16] with second visits just prior to completion of therapy for a subset of patients on at least 4 weeks of OPAT. Our semistructured interview guide and contextual inquiry tool were based on a human factors engineering work system model—the Systems Engineering Initiative for Patient Safety 2.0 model.[11]

Settings and participants

We used a convenience sample and performed purposive sampling within the convenience sample to ensure capture of experiences from both men and women, different racial and ethnic groups, both participating hospitals, and different home infusion agencies providing care in semistructured interviews and contextual inquiries.[17] Eligible patients were ≥18 years of age and discharged to the home from 2 tertiary care academic medical centers in Baltimore, Maryland. Patients could have used any home infusion or home nursing agency for antimicrobial agents and supplies and training and support in venous catheter care, respectively. Patients had peripherally inserted central catheters (PICCs), tunneled central venous catheters (TCVCs), or midline catheters for OPAT. Patients were ineligible if they were in hospice care, did not speak English, or could not provide written consent.

Patients eligible for semistructured telephone interviews were among those who had consented for enrollment in a prospective cohort of OPAT patients between November 2015 and December 2017.[18] Interested patients returned written consent forms via mail. Semistructured telephone interviews allowed us to include patients who lived near or far from the discharging hospitals. Patients eligible for contextual inquiries lived within a 45-minute drive of the 2 hospitals and were recruited via telephone ≤5 days of hospital discharge, with written consent forms completed at the time of the contextual inquiry. Patients were separately enrolled in either the semistructured interview or the contextual inquiry. This study was approved by the Johns Hopkins School of Medicine Institutional Review Board.

Data collection and analysis

One of 3 investigators (S.C.K., M.K., A.K.) conducted semistructured interviews over the telephone between November 2015 and December 2017. Patients who had returned a completed, signed consent form were contacted via telephone to schedule an interview. Each interview took approximately 30-45 minutes and was audio-recorded and transcribed.

Contextual inquiries were performed between May 2017 and January 2018. Within 2 weeks of hospital discharge, 1 or 2 investigators (S.C.K., M.K.) observed the patient or caregiver performing OPAT-related tasks (eg, medication infusion, catheter care). The first 5 observations occurred with both investigators, as the qualitative methods expert trained the clinician observer. A second observation was conducted near the end of OPAT treatment for participants who remained on OPAT for at least 4 weeks. Investigators asked clarifying questions and took handwritten notes describing what was seen and heard from the initiation to completion of the task. Tools, equipment, and physical surroundings were photographed after additional written consent.

We first created a preliminary coding template after 2 researchers (S.C.K., H.C.) had each reviewed the same 3 randomly selected transcripts and contextual inquiry notes. The 2 researchers completed coding independently and compared codes. This coding template was revised as subsequent transcripts were reviewed, with changes being applied retroactively.

We performed directed content analysis,[19] focused on hazards from physical attributes in the home environment. Although the overall analysis, including the identification of major categories of hazards, was deductive and based on the Systems Engineering Initiative for Patient Safety 2.0 model,[11] we used inductive reasoning in developing subcategories that emerged from the data.[13] These emergent subcategories focused on hazards from physical attributes of the home environment and strategies for mitigating these hazards. Analysis was facilitated with NVivo Version 11 software (QSR International, Victoria, Australia). Thematic saturation was reached for the findings presented.[20]

RESULTS

We performed 29 semistructured interviews and 14 contextual inquiries (7 of which included 2 visits and 5 of which included visits by 2 investigators) (Table 1). Among those patients completing semistructured interviews, 44.8% (N = 13) were women and 86.2% (N = 25) were white. Among those who underwent contextual inquiries, 28.6% (N = 4) were women and 57.1% (N = 8) were white. We identified 7 main categories of hazards from physical attributes of the home environment and described the mechanism of the safety

Table 1
Characteristics of patients on outpatient parenteral antimicrobial therapy who participated in semistructured interviews or contextual inquiries

Characteristic or demographic variable	Semistructured interviews: number (% of N = 29)	Home visit contextual inquiries: number (% of N = 14)
Female gender	13 (44.8)	4 (28.6)
Age (mean, standard deviation)	55.0 (11.5)	51.5 (15.2)
Race/ethnicity		
White	25 (86.2)	8 (57.1)
Black/African American	3 (10.3)	5 (35.7)
Hispanic	0 (0)	1 (7.1)
Other	1 (3.5)	0 (0)
Discharging hospital		
Hospital 1	26 (89.7)	9 (64.3)
Hospital 2	3 (10.3)	5 (35.7)
Home infusion agency: affiliated	23 (79.3)	7 (50.0)
Presence of caregiver at time of first visit	N/A	10 (71.4)
Two visits completed	N/A	7 (50.0)

N/A, not applicable.

hazard, the potential outcome, and the strategies used to mitigate these hazards (Table 2).

Bathing

Keeping the venous catheter dressing dry is essential for maintaining its integrity and preventing catheter-associated bloodstream infections, and is especially important when bathing. Strategies included covering the venous catheter with plastic, purchasing special shower devices, arranging the body to avoid water exposure, getting help from others, and bathing infrequently.

Patients used different strategies to cover the venous catheter while bathing. Some were given supplies by home health nursing. However, this was not always adequate: "The only time [the catheter dressing] really got wet is when [my nurse] gave me that long . . . plastic thing for my whole arm." Others stated that they had discovered, or that their nurses had recommended, commercially available cling wrap, in this case to cover a TCVC placed in the subclavian vein:

> "[The nurses down at the hospital] said that I could [use cling wrap] . . . [which] was a lot . . . cheaper than those other plastic-y things [home infusion therapy] had, and . . . I'll tell you the truth, I felt like that worked much better because you could just make it . . . to what the shape of your breast was."

Others developed their own strategies to cover the venous catheter dressing:

> "I then cover it with [cling wrap] on most of my arm, and then I take the ends of it, the top and the bottom, so I have an inner layer, a protective thing that was supplied by the [home infusion

Table 2
Hazards related to physical attributes in the home environment in outpatient parenteral antimicrobial therapy provision and patient- and caregiver-developed strategies to mitigate these hazards

Hazard	Mechanism of hazard	Potential outcome of hazard	Strategies to mitigate hazard
Bathing	Patient unclear on how to bathe with catheter	Venous catheter dressing becomes wet and dressing integrity lost	Patient avoids bathing Patient positions body in unusual configurations to prevent dressing catheter from getting wet Friend or family helps patient bathe Shower heads to direct water away from catheter Patient bathes in sink
	Cover over catheter dressing does not fit well	Venous catheter dressing becomes wet and integrity lost	Patient purchases own cling wrap Tools provided by home health
	Additional OPAT-related tools (eg, pumps) are not covered while bathing	Pump becomes wet, which may impact its functionality	Patient rearranges shower to keep pump dry
Animals	Pets shed fur	Fur impacts integrity of venous catheter dressing	Patients keep pets away from venous catheters
	Pets create waste	Venous catheter exposed to pet waste	Other family members care for pets Wearing gloves
	Pets tug on venous catheter lines	Venous catheter dislodgment or inadvertent removal	Taking extra care
Extremes in temperature	Home is excessively warm	Medication less effective or expires more quickly Patient discomfort	Using ice packs Store medications in more temperate parts of home Reconstitute medications just prior to infusion
	Supplies are left outdoors in the heat or cold	Medication less effective or expires more quickly	Bring medications inside immediately on delivery
	Perspiration from excessive warmth in home	Perspiration impacts catheter dressing integrity	Patients spend time in more temperate parts of the home
Household clutter	Mobility equipment does not fit through certain parts of the home	Patient cannot access certain parts of the home Venous catheter gets caught on clutter while trying to pass from place to place	Create paths in the home where mobility equipment can fit
	Supplies stored in different parts of the home	Needing to go to different parts of the home to perform OPAT tasks, with wasted time and potential for missed steps	Co-localization of all OPAT-related supplies
	Excessive clutter due to mental disorder (eg, hoarding behaviors)	Potential for vermin to impact venous catheter or antimicrobial agents Misuse of supplies for unintended purposes	Maintaining in all homes a clean, uncluttered place for OPAT supplies
Indoor soil and food	Physical state makes it difficult to clean or cook	Cleaning and cooking cause fatigue or exhaustion	Handing off tasks to family or friends Hiring assistants
	Patient needs to perform household chores	Venous catheter exposed to soil or food	Using gloves Cover venous catheter with clothing Using extra precautions or taking care
Outdoor work	Patients are exposed to soil	Venous catheter dressings are exposed to soil or dirt Respiratory concerns from soil exposure	Clothing (eg, long-sleeved shirts) to cover venous catheter Sitting on equipment (eg, riding lawn mower) to limit direct exposure to soil
Travel	Patients must carry many supplies	Patients may drop supplies	Careful preparation prior to leaving the home
	Patients must deliver antimicrobial agents at certain times	Antimicrobial agents infused late	Careful timing of leaving the home Seldom leaving the home
	Patients must perform tasks outside of the home	Patients perform infusions without necessary supplies Patients may skip steps (eg, washing hands)	Co-workers or others may help with tasks

OPAT, outpatient parenteral antimicrobial therapy.

therapy] people, [and I] cover it, and then I put [cling wrap] around the outside of it."

Other strategies included positioning themselves in unusual ways to avoid getting the dressing wet. Some used shower devices to make it easier to bathe. Others took a bath rather than a shower or washed in a bathroom sink:

"What I would do is I would have like a little . . . food [plastic] bag that I would cut in half . . . so that they opened up. [Then I] unfold it, and I would take half of that and put that over the site and then tape around that to keep it there just to make sure nothing got to it."

For patients who were on continuous-infusion antimicrobial agents, bathing became even more complicated. They could disconnect from the pump to bathe, but this was a long and complicated process. Some instead rearranged their bathroom to keep the pump dry:

"I had the choice of disconnecting and then infusing with heparin later, but I just chose to wrap it and then keep the pump outside the shower door. I have a shower where I can direct the water wherever I want to, and I just left the pump outside on a stool, on a little basket."

For many patients, reliable assistance from friends or family was essential for bathing. For some, this required adjusting their schedule: "Normally I take a shower every single morning, but . . . I didn't want to impose on my friends to come over at 6:30 [in the morning] and wrap me up, so I started having to take a shower in the evening or when it was convenient to somebody else . . ."

With these difficulties, a final strategy for some patients was bathing infrequently. As 1 patient stated, "I just decided I wanted no part of it."

Animals

Another common hazard was caring for household pets. Pets created solid or liquid waste, pet fur could impact the integrity of the dressing, and pets could pull on the catheter or trip the patient. For example, during 1 contextual inquiry, a dog sitting on a patient's lap jumped up just as the patient stood up to answer the door, causing the patient to trip. Others noted this as well: "So that was . . . a big concern that [my dogs] would . . . [pull on the PICC]. A couple of times they did latch onto [my PICC] but, you know, it was stitched in and it kind of hurt."

Patients perceived that home health staff often gave conflicting guidance or no guidance about handling pets, leading to uncertainty:

"[My cat] is a very friendly cat, and when the home nurse comes, she hangs around the whole time that the nurse is here . . . and I said to the nurse, should I put her out? She's [said] no, [the cat's] okay. . . . So we're doing all this infection control stuff, but we've got a cat walking around while we're doing this stuff . . . I trust the nurse, but it seems a little weird to me."

In the absence of clear guidance, patients developed strategies to mitigate risks to safe OPAT care while also caring for their pets. Some transferred pet care tasks to other family members, whereas others took extra precautions:

"I was careful not to put the cat near the [TCVC] because I know cats . . . carry diseases . . . so I was very careful. . . . Any time I touch the cat I wash my hands afterward . . . Because of the [TCVC] I really wanted to keep hygiene . . . a priority."

Extremes in temperature

Patients described, and we observed in contextual inquiries, antimicrobial agents being exposed to temperature extremes in the home. Patients worried about the impact of heat or cold on medication integrity and of perspiration on catheter dressing integrity, especially if they lacked central air conditioning or control over the temperature in their respective homes. During 2 separate contextual inquiries on a 37°C day, the inside of patients' homes exceeded 29°C. Strategies to mitigate these hazards included quickly bringing deliveries inside, choosing temperate areas of the home to store medications, using ice packs, and reconstituting medications just prior to infusion.

Household clutter

Pre-existing household clutter led to the potential for vermin, wasted time, tripping, pulling on the venous catheter or other medical devices, and unsafe treatment of supplies. For example, 1 patient with a hoarding disorder stored used medical supplies under his couch, along with other objects he had acquired, including empty elastomeric devices and saline and heparin flushes (Fig 1C). This could have led to tripping hazards, as well as vermin, and created a risk for potential contamination if the supplies were reused. Strategies to mitigate hazards associated with clutter included moving all OPAT-related supplies to 1 location or taking extra care when moving around the home.

Indoor soil and food

Similarly, patients faced hazards related to soil and food while cleaning or cooking. Patients developed strategies such as covering the catheter with clothing and having family members take over tasks. The latter was especially important if the patient's physical state prevented them from cooking or cleaning: "When I had [the PICC], I just had the opportunity to have my wife do it all." Patients also identified other hazards associated with cooking and cleaning, such as heat: "I . . . just had to be careful with my right arm to make sure I didn't drag my line through anything or get too close to the burner."

Outdoor work

Patients experienced hazards involving outdoor work that led to exposures to soil. Strategies to mitigate these hazards included using physical barriers, such as clothing. One patient who worked in maritime construction performed infusions in the cab of an excavator to limit his direct exposure to river sediment (Fig 1B). Patients noted they were not given specific instructions about avoiding hazards related to outdoor work.

Travel

Another category of hazards was experienced when patients left the home. Patients needed to time antibiotic infusions carefully, determine how to perform tasks outside the home, and carry supplies:

"Oh, it was a big pain in the butt. . . . Especially driving. . . . I'd have to work things out so the pump was in the passenger seat next to the driver's seat. And, God, I remember one time I went to the grocery store and I was trying to juggle the pump and take things

Fig 1. Images obtained during contextual inquiries of the physical environment in which patients on outpatient parenteral antimicrobial therapy work. (A) A patient prepares a vancomycin infusion via elastomeric device from the front seat of his pickup truck while parked in a parking lot. (B) A patient working in maritime construction sits on an excavator on a floating dock while performing his vancomycin infusion. (C) A patient with a hoarding disorder saves empty used elastomeric devices and heparin and saline syringes in a bag next to the couch where he performs outpatient parenteral antimicrobial therapy tasks.

down from the shelf and wheel the grocery cart out to the car. I don't know how on earth I did it. Probably I shouldn't have been doing it at all."

Some locations where patients performed infusions required patients to store supplies or even initiate infusions in their vehicles (Fig 1A).

DISCUSSION

Although OPAT is a safe and commonly used way to receive long-term antimicrobial therapy,[21] as in hospital settings, understanding and mitigating potential safety hazards in OPAT is important. These safety hazards can lead to a loss of catheter dressing integrity, catheter-associated bloodstream infection, catheter dislodgment, lack of supplies, and dissatisfaction and anxiety. To mitigate these safety hazards, we present some potential best practices for OPAT provision in the home (Table 3).

In the present study, there was ambiguity in keeping the catheter dressing dry while bathing.[9] Home health and home infusion nurses should consider bathing with a catheter a skill and educate patients in the performance of this skill—for example, with visual or written demonstrations and with teach-back.

Patients also had to manage temperature extremes. Recent work investigating the stability of antibiotics with volunteers carrying elastomeric devices showed that temperatures of 27°C-28°C did not lead to decreased concentration.[22,23] Few antimicrobial agents have been tested for stability at temperatures such as what may be experienced in some American cities in the summer.[24] In some of the home infusion agencies that served the patients in this study, home health nurses were asked to instruct patients to turn off fans prior to changing TCVC dressings, which could also have led to increased perspiration. Prescribers and pharmacists may need to consider ambient temperature when choosing antimicrobial agents or delivery devices.

Cluttered homes presented hazards. Others have noted clutter in homes as an occupational hazard in home healthcare.[25] However, to our knowledge, this is the first description of the impact of clutter in the home on patient-performed OPAT tasks. Assisting patients with locating an area to perform OPAT-related tasks should be part of a start-of-care visit and readdressed on return visits as well.

Patients also used strategies to manage hazards from household tasks such as cleaning, cooking, and pet care. Family and friends took on many of these tasks. When hazards were unavoidable, patients developed strategies such as wearing gloves or covering the catheter with clothing. The "home" environment of OPAT has expanded beyond the home. Strategies to assist with this could include helping patients plan for travel outside the home, including bringing extra supplies, if needed.

To our knowledge, this is the first study that used qualitative methods, including interviews and observations, to study OPAT patients. Our findings will allow us to develop targets for potential interventions to mitigate hazards related to physical attributes of the home environment.

This study had several limitations. First, we focused on the experiences of patients receiving home-based OPAT after discharge from 2 hospitals in 1 American city; the study was not designed to represent all OPAT experiences. Additionally, although the study population is smaller than most quantitative analyses, we exceeded the mean sample size of 31 described in a survey of qualitative doctoral theses.[26] Furthermore, we did achieve thematic saturation for the findings reported in this article. Because this is a qualitative study, the focus was not on generalizability but rather hypothesis generation and

Table 3
Potential best practices for mitigating exposures in the home environment for patients on OPAT

1. Take a patient-centered approach in determining what specific types of education or training individual patients need to avoid hazards.
2. Bathing with the venous catheter should be considered a skill to learn and specific education around bathing provided.
3. Consider ambient temperature when choosing antimicrobial agents or delivery devices.
4. Assist patients with locating an uncluttered, clean area in the home where all OPAT-related supplies can be stored.
5. Provide patients education around household tasks such as cleaning, cooking, pet care, and outdoor work.
6. Encourage patients to ask friends and family members to take on household tasks such as cleaning, cooking, pet care, and outdoor work.
7. If household tasks must be performed, encourage patients to cover the venous catheter as much as possible by wearing gloves, covering the catheter with clothing, and avoiding direct exposure to soil.

OPAT, outpatient parenteral antimicrobial therapy.

guiding intervention development. Qualitative methodology is more conducive to a depth of understanding of a specific phenomenon and context rather than generalizability, and might not be applicable to other patients in other settings.[27] Our focus was on patients and caregivers and on their activities when home health professionals were not observing their performance; therefore, we did not interview other key stakeholders, such as home health staff, and did not observe interactions between patients and home health staff. We depended on patients to describe training.

CONCLUSIONS

Many patients experienced hazards based on physical attributes of the home environment. Patients perceived that they were not given clear information or training in how to avoid these hazards and often developed their own mitigating strategies. Some of these strategies may have been less effective or even harmful, such as storing used syringes for potential later use, and should be discouraged. However, some of these strategies may have been helpful and could be disseminated (eg, methods of wrapping the venous catheter for bathing). Education aimed at developing not only knowledge but also skills in managing bathing, animals, temperature extremes, clutter, indoor soil or food, outdoor work, and travel should be provided to patients. In addition, research should focus on ways to best prevent complications from these hazards. Research should also look at the efficacy of antimicrobial agents at temperatures experienced by patients, and ambient temperature should be taken into account when choosing medications or providing infusion devices. A fuller understanding of hazards experienced in patient homes can aid in improving OPAT provision and developing best practices for OPAT delivery.

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