Designing Care-fully: Robots for Acute Cancer Care

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Abstract

Patients with cancer (PwC) have a hard time getting prompt treatment in acute care settings, and feel unseen, unheard, and neglected. This is due to systemic problems: worldwide, Emergency Department (ED) healthcare workers (HCWs) are overworked and EDs are understaffed. Robots will not fix these problems; however, prior work suggests if well-designed and contextualized, they may support cancer care. Based on longstanding collaborations with PwC and ED HCWs, in this paper we report on an exploration of the design space of social robots for acute cancer care. Using a care ethics lens, we found robots can be uniquely positioned to amplify compassion within deeply human care relationships through their social presence, while performing routine tasks, such as patient monitoring. However, participants suggested the human experiences of pain and distress may remain elusive for robots to engage with meaningfully. Our work reveals HCWs and PwC saw robots as means to expand relational care in the ED, and explores how future HRI research may meaningfully support these care relationships.

CCS Concepts

• **Human-centered computing** → **Interaction design**; • **Applied computing** → *Life and medical sciences.*

Keywords

Social Robots, Care Ethics, Acute Cancer Care, Design

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1 Introduction

When PwC experience critical conditions, they often turn first to the ED for care [56, 57]. PwC present with high-stakes, complex symptoms that can be debilitating. For example, cancer-related pain (CRP), the leading cause of ED visits by PwC [67, 101] is life threatening if left untreated [64].

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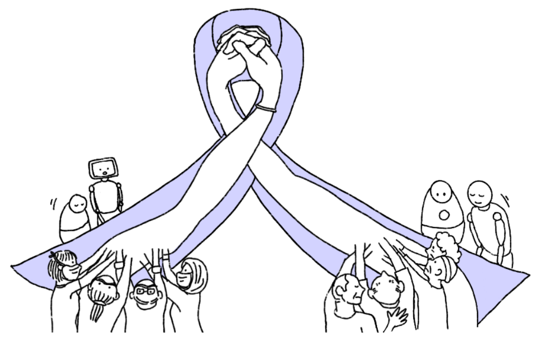

Figure 1: Cancer care is a complex, relational, deeply human process. We explore the design space of contextualizing robots for ED cancer care through lenses of knotworking and care ethics to address systemic frustrations, and amplify compassion.

However, cancer care is complex as EDs are chaotic, overcrowded, and under-resourced [15, 112], demanding rapid coordination of critical tasks among HCWs, PwC, and other ED actors. HCWs are understaffed and overworked, thus unable to quickly check in on PwC [77], leaving PwC to wait for hours untreated. As a result, ED HCWs who treat cancer experience high rates of burnout and emotional exhaustion [74, 87], and PwC express high rates of dissatisfaction and ED revisits [8, 76].

While technology cannot fix these systemic problems, researchers are exploring how it may support cancer care in sub- and non- acute settings, potentially easing the burden on HCWs and PwC. For example, researchers have developed tools to improve communication, cancer screening, and care management [13, 38, 93]. HRI researchers have used social robots for companionship and social connectedness in the context of pediatric cancer care [5, 12, 62, 71, 73, 116].

However, acute cancer care is both a medical process to stabilize critical conditions, and a relational process shaped by the contexts, needs and interdependencies between HCWs and PwC. This complexity is reflected in how many existing cancer care technologies are designed outside acute care, for either PwC (e.g., companionship, social inclusion) *or* HCWs (e.g., diagnostic tools). There is also a lack of prior research contextualizing the notion of robot-mediated relational care practices in critical, reactive systems like acute care. Thus, conceptualizing robots to support ED cancer care requires that they be situated within a complex, relational, dynamic care space in a manner that centers the voices of both PwC and HCWs.

To explore this unique design space of social robots for acute cancer care, we engaged in a collaborative research process with PwC and ED HCWs. We centered participants' lived experiences to gain a deeper understanding of how HCWs and PwC experienced the ED, and how deeply human interpersonal relationships guided how cancer care was provided and received.

The contributions of this work are threefold. First, we explore the design space of cancer care robots for EDs presenting three avenues where robots may facilitate cancer care 1) managing CRP 2) bridging communication gaps and 3) enhancing patient comfort. We discuss participants' considerations for such robots, including how they may amplify compassion in interpersonal human relationships by offering their presence, supporting routine clinical tasks, and using mindful communication strategies. Second, we analyze participants' experiences through the lenses of care ethics [20] and knotworking from activity theory [27, 72], contributing a unique perspective and novel application of these lenses to HRI (see Fig. 1). We draw three provocations for HRI research: 1) What does it mean for a robot to bear witness to distress?, 2) How might robots be situated within interpersonal relationships in acute care?, and 3) How could robots reinforce or mitigate knowledge and power asymmetries in cancer care? Finally, we contribute alternative research outcomes [120], including design artifacts from co-designing robots with participants with cancer and ED HCWs.

Our paper constitutes a critical design contribution [58, 92] as we critically engaged with the sociotechnical, ethical, and contextual nuances of acute care throughout our conceptually investigative design process [63], analysis, and interpretations. Through this work, we introduce a relational space for robots in hospitals.

2 Background

ED cancer care: PwC receive care in the ED from diagnosis, to survivorship, to end-of-life care [67]. PwC present with varied symptoms including CRP, respiratory issues, and anxiety [11]. ED HCWs manage these symptoms in the short-term, transferring patients to other care options as symptoms stabilize [21, 57].

ED cancer care is complex. EDs are overcrowded, chaotic, and busy, leaving PwC waiting untreated for hours [35], sometimes causing their symptoms to worsen [59]. They are also at an increased risk of infection often due to having compromised immune systems, which can lead to life-threatening complications [84, 101].

Another challenge is CRP assessment. Most hospitals assess pain using a standardized questionnaire (e.g., OPQRST [22]) and a pain score. HCWs also make holistic assessments using non-verbal cues and physical exams [66]. A key challenge to CRP assessments are HCW biases in pain perception, often along gender, complexion, and perceived class lines [42, 49, 51, 75, 90]. This can lead to HCWs undertreating CRP, thus exacerbating a patient's condition.

Prior HRI research shows that robots have been effectively deployed in acute settings, and to support children with cancer manage pain and distress [30, 71, 122]. These studies suggest that robots offer a unique potential to probe these gaps; on the one hand, they might help PwC receive pain treatment sooner. On the other hand, these studies also provide nuances on the ethical complexities of this domain, including how robots might worsen biases. Nonetheless, they raise interesting questions, which we explore in this paper.

Technology to support cancer care: Researchers have developed tools to support faster diagnosis [29, 31, 119], patient education and self management [16, 52, 61], cancer care continuity [18], and facilitate HCW-PwC communication [43, 55]. However, these technologies are not designed to support PwC and HCWs' personal challenges and frustrations with acute cancer care.

HRI researchers have explored robots to support pediatric cancer care [107], such as Arash, a socially assistive robot that helps children with cancer manage pain and distress [71]. Others explored how robots may support social inclusion [39, 82, 115], improve playfulness [5], and help during distressing procedures [48]. However, these robots were designed for children, not adults, and used in non-acute in-patient settings or at home.

Researchers have designed robots to support ED HCWs, by delivering supplies [23, 94], facilitating clinical teamwork [102, 104], and supporting telepresence [32, 70]. However, there is a lack of prior work exploring how robots may specifically navigate the ED's intertwined complexities in supporting relational *and* medical care.

Situating robots within care ethics: Situating robots within acute care requires careful reflection of what it means to give and receive care during a person's most vulnerable moments. Care ethics is a feminist moral philosophy that is a useful framework to understand care in the ED, as a relational, context-sensitive practice and moral disposition [85]. According to Tronto [108, 109], care involves the moral elements of attentiveness, responsibility, competence, and reciprocity, as well as the interdependence of multiple individuals and institutions that together form "circles of care". Science and technology studies (STS) scholars have extended the care ethics lens to include non-human actors [20, 37], like robots. These perspectives challenge existing power asymmetries in healthcare by asserting all parties involved (e.g., patients, HCWs, and even technologies) play a critical, reciprocal role in sustaining and navigating care relationships [20, 81]. They also highlight how technologies impact the distribution of care responsibilities, and reconfigure who cares, how, and under what conditions [24, 89, 110].

So, when designing care robots, it is essential to consider how they may help shape, or disrupt, existing care practices [111]. Prior work exploring robots through a care ethics lens primarily focuses on long-term, home care for older adults [44, 121]. Applying a similar lens may help HRI researchers reflect on the ethical implications of situating robots within the urgency and complexity of care coordination in acute settings. Thus, in our work, we aim to situate cancer care robots within care ethics to understand robot-mediated acute care, and its implications for care relationships.

Puig de la Bellacasa [20] proposed three critical modes of engagement with care that can help with this endeavour. "Thinking-with" care highlights the deeply entangled relationships between humans and technologies and how that affects care practices. "Dissenting-within" acknowledges the frictions and ethical tensions that emerge while working within imperfect care systems. Finally, "thinking-for" involves critically reflecting on the responsibility and risks of speaking for those unable to advocate for themselves [20, 37].

3 Methodology

Over the past several years, we have been collaborating with ED HCWs and PwC to explore the design space of how robots may support ED cancer care. Through long-term relationship building, we sought to engage with, and center participants' lived experiences, contexts, and unique perspectives. We engaged in collaborative design activities including interviews and co-design sessions [53,

Table 1: Demographics of research participants.

Role	Pseudonym	Experience (Years)
MD	Glenn-MD, Pablo-MD, Rafael-MD Elmer-MD, Marci-MD	Between 6 to 30
APP	Lea-APP, Ola-APP Tina-APP	Between 6 to 10 Between 41 to 45
RN	Nancy-RN	Between 21 to 25
PwC	Ava-PwC, Inez-PwC	N/A

83] where participants reported concerns in their experiences with ED cancer care and envisioned how robots might help address them. This study was approved by the UC San Diego IRB.

3.1 Participants

We recruited 9 HCWs from local hospitals by word of mouth (see Table 1). HCW participants included five attending physicians (MDs), three advanced practice providers (APPs), and one nurse (RN). MDs are responsible for diagnosing patients by examining histories, performing physical exams and tests, prescribing medications and interventions, and creating treatment plans. In the ED, APPs are either nurse practitioners or physician assistants who perform duties similar to physicians. ED RNs work alongside MDs, administering medication, performing procedures like placing IVs, and monitoring patient vitals and status changes. MDs, RNs, APPs, and other ED staff work together as a *care team* to provide cancer care.

Four HCWs self-identified as male and five as female, with ages from 33 to 65 years (mean = 45.4 years, SD = 10.7 years) , and had 7 to 45 years of experience (mean = 18.4 years, SD = 12.3 years). They all had extensive experience working with PwC. Six HCWs worked in the ED, three others did not but worked with PwC in palliative care and other parts of the hospital.

Over the course of two years, we recruited 9 PwC from our local EDs and by word of mouth. However, due to severe illness, exacerbation of symptoms, and several participants passing away, ultimately only two were able to fully collaborate with us. Both identified as women, and declined to state their ages. Dealing with loss can cause distress for researchers. We refer researchers to resources such as [113] to help cope with such circumstances.

3.2 Design Approach

To conduct research mindfully, we first established relationships with ED HCWs and PwC to understand their values, and attitudes towards robots for cancer care. We had several phone / in-person one-on-one conversations in casual settings with all participants to discuss their experiences and shape the design space we sought to explore. All participants expressed great interest in collaborating with us through semi-structured interviews and co-design sessions to share their stories, frustrations, and to co-design future robots.

Recent research in HCI reflects that design inquiry is often motivated by deficit-focused narratives [96] aiming to "improve" underrepresented groups to meet dominant narratives about "normal" bodyminds. These approaches perpetuate paternalism, and reinforce medical models of disability [14, 33, 78]. Thus, we positioned participants with cancer as partners in the research process, shaping the course of ideation of robot-mediated ED cancer care. Additionally, we took steps to alleviate their access labor in participating [7], by aligning with research accessibility recommendations from Mack et al. [65]. These included providing shortened sessions, adjusting our communication style, being flexible, such as during pain flare ups, etc.

3.2.1 *Collaboration with HCWs.*

Our initial research activities with HCWs involved a series of online one-on-one, semi-structured interviews with 5 MDs. We asked them about ED cancer care, the types of PwC they treated, how CRP was managed, and associated challenges. Then, to give them space to imagine robots that support cancer care, we introduced them to some existing robots used in healthcare (Pepper [80], Nao [1], Care-O-Bot [34], Toyota HSR [118], Arash [71], Moxi [23], PR2 [2], and Iris [70]). We discussed the design, capabilities, and participants' opinions on each robot.

All 5 MDs felt CRP management was particularly well suited for robots to support, as HCWs felt overextended in keeping up strict CRP assessment schedules while simultaneously tending to multiple patients. So, MDs used the sample robots as prompts to envision future robots to support periodic CRP assessments. They ideated on such a robot's appearance, communication modalities, how it might interact with HCWs and PwC, and specific use cases.

Following these interviews, we conducted design sessions one-on-one with seven HCWs: 3 MDs from the aforementioned interviews, and 4 new participants (3 APPs, 1 nurse). Our goal was to understand how HCWs envisioned robots supporting them with CRP management through live sketches made by a designer to represent their ideas (see Figs. 2, 4, 5). We focused on specific questions of how a CRP assessment robot might look, perform pain assessments, communicate with PwC and HCWs, and other capabilities. We explored ethical considerations, privacy considerations, and trust in depth, including whether HCWs would be willing to trust a robot's assessment of pain. Finally, we showed participants live sketches generated during the session and gathered their feedback. Participants also commented on sample storyboards from earlier design activities, and could use them to modify their own designs.

3.2.2 *Collaboration with People with Cancer.*

We conducted one-on-one, semi-structured interviews with participants with cancer, asking general questions about their experiences, how their pain was managed, and key concerns in the ED. To support them ideating on potential robots, and to be mindful of their limited time, we showed participants a subset of videos HCWs viewed (Pepper, HSR, Iris), and added Jibo as a sample tabletop robot. Then, we explored how robots or other technologies might be designed to address some of the concerns they described. A designer live sketched representations of participants' ideas during the interview. Finally, we discussed similar themes as with HCWs, including ethical considerations, privacy considerations, and trust. We concluded by showing participants the live sketches meant to reflect their ideas, sample storyboards from earlier design sessions with HCWs, and updated the sketches based on their feedback.

3.3 Data Analysis

Collectively, our research team has experience serving as both formal and informal caregivers of people with cancer; designing, developing, and deploying technology for acute care; and engaging

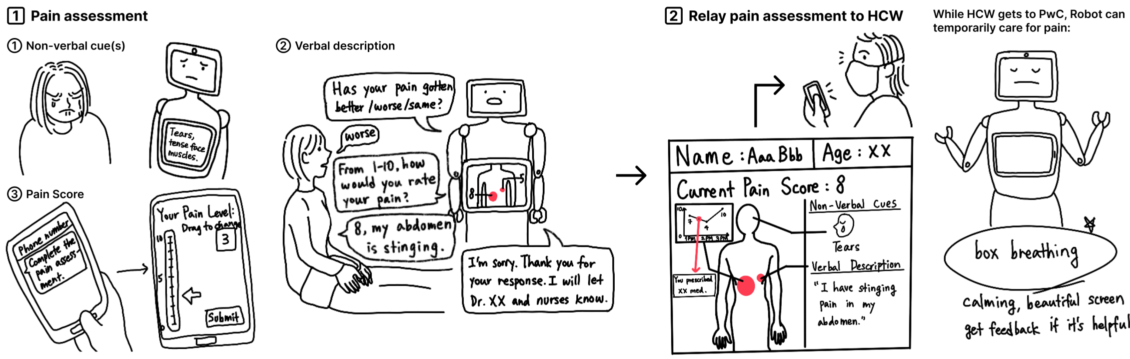

Figure 2: HCWs envisioned robot mediated CRP management. The robot would send the patient's verbal descriptions of pain, their self-reported pain scores, and observations of their non-verbal cues to their HCW. Then, it would present the patient with non-pharmacological interventions such as meditation until pain medication can be administered.

in HRI and CRP research and practice [15, 46, 103]. We aimed to remain reflexive throughout our analysis process, staying cautious of our positionality as HRI researchers in shaping how we interpreted our participants' experiences, and how we reported our findings.

Our data analysis focused on the interview transcripts, and used sketches / designer's notes to strengthen our interpretations therein. We analyzed the transcripts using reflexive thematic analysis (RTA) [9]. Two researchers independently reviewed each transcript to generate codes to account for differing interpretations. We iteratively refined our codes through discussions to identify overarching themes based on shared patterns of meaning. Finally, we used the themes to identify avenues where robots may support PwC and HCWs in EDs, and explored the provocations of such technologies.

4 Findings

4.1 Experiences in the ED

4.1.1 HCWs' Experiences. "Patients with all [stages of] cancer come to the ED: recent to end of life" (Pablo-MD). PwC present with a variety of complications, including fever, infections, surgical complications, and nausea. However, all HCWs noted a number of delays in ED cancer care.

HCWs attributed some aspects of such delays to how the ED systemically operates. They characterized ED care teams as constantly changing, "Every 12 hours, it's a new group of people" (Elmer-MD). "[No patient has] a dedicated provider. Nurses are usually taking care of 3 to 4 patients. Physicians typically [cover] 7 to upwards of 20 patients. So there's just a lot of difficulty in…following up with each [patient] immediately as a concern [arises]." (Rafael-MD).

Delays also stemmed from staff shortages, ED busyness, and gaps in the workflow. "[When medication is requested], the doctor [is busy and] can't get to it. They finally see [the request] and order it. Then it [goes] to the pharmacy, [gets] approved. Then the nurse has to get it, and administer it. So it's like 45 minutes until [the patient] can actually get that medicine delivered" (Marci-MD).

HCWs highlighted CRP as a pervasive and debilitating issue that they were "pretty aggressive about treating" (Elmer-MD). The multifactorial nature of CRP was often hard to manage clinically and emotionally as PwC "just want somebody to understand that [they are] suffering" (Glenn-MD).

HCWs felt delays in cancer care reflected personal shortcomings in their practice. "We as healthcare professionals get distressed when we feel someone is suffering alone" (Tina-APP). Pablo-MD suspected PwC felt neglected, "A big frustration with [PwC] is that [HCWs] haven't been in there to [support them]." This can cause HCWs to feel guilty, so, Glenn-MD said on busy days, he tried to see his patients with cancer briefly to say, "Hey, are you okay? I just want to make sure you know I'm here and that I'll be back."

4.1.2 Experiences of Participants with Cancer. Participants with cancer said HCWs were professional and nice, and CRP was managed in a timely manner. "[I went to the ED when my] pain had gotten really severe... right away they gave me an IV, and tried different medications to manage the pain. There was no delay" (Inez-PwC). However, both noted long wait times in being admitted, and waiting for labs, procedures, and consultations.

Both participants noted communication gaps with their clinical team. Ava-PwC said despite asking "a ton of questions" about how she was feeling, HCWs did not "necessarily listen." She was frustrated when HCWs misdiagnosed her, despite repeatedly stating, "Hey, this is my situation. [I] really know what's going on with [my] body." She continued, "[HCWs] just look at labs and don't listen… eventually I got the help I needed [after] 3 trips to the ER."

Ava-PwC said she had to repeat information to various HCWs. "Every time a new nurse comes on, they ask a series of [the same] questions [as] the nurse before. And they act like they don't know anything about what's going on with you." She wondered "People just asked me this, and typed it all into the computer… Where does that information go? What do you use it for if it's not [relayed]?"

Inez-PwC also reflected on communication difficulties, "Sometimes I have to take steroids [...]with food. [Once] I called for food and my nurse was on a break. So nobody else would get it for me. I had to wait long time to get it, so I ate it without food."

4.2 Contextualizing Cancer Care Robot Roles

4.2.1 Managing CRP. HCWs envisioned robots that could perform periodic pain assessments after an initial assessment by a physician. They felt the robot could help them monitor a patient's pain trend [66], allowing for better pain management.

HCWs designed a mobile manipulator that could support verbal and non-verbal communication (see Fig. 2). They wanted multilingual capabilities, and several interaction modalities (like touchscreen, buttons, speech) to promote accessibility. Five HCWs wanted the robot to emote while interacting with PwC, like expressing a sad face when a patient is crying.

HCWs brainstormed how robots may conduct CRP assessments. They emphasized CRP assessments go beyond standardized scores, including non-verbal cues, spiritual, and cognitive pain. "If somebody's clutching an area of their body, their face is grimacing, they're diaphoretic, that's a cue" (Glenn-MD). HCWs felt CRP is especially complicated to assess due to these nuances.

Thus, HCWs suggested their hospital's standardized assessment be translated to robots. To add nuance, robots "could take some facial cues, maybe look at the most recent vital signs or take a current set of vitals" (Pablo-MD). However, some HCWs were concerned if this would be feasible, "I wouldn't trust [a robot's] interpretation of non-verbal cues" (Rafael-MD).

Here, all HCWs raised a distinction in the role of a CRP assessment robot between being a *pain reporter* versus a *pain interpreter*. Six HCWs preferred the robot be a reporter, where it would simply collect information about a patient's pain, including pain score, the OPQRST questionnaire [22], and/or non-verbal cues, and pass it on to HCWs to make an assessment. Building on this, Glenn-MD and Rafael-MD wanted the robot to also serve as an interpreter, using algorithms to generate a pain assessment for them to review. Pablo-MD and Lea-APP said they would prefer the robot be a pain reporter initially, and interpret pain cues over time as HCWs and PwC became more familiar with it.

Six HCWs felt a pain reporter robot for CRP assessments made more sense for their context than an interpreter robot. "It would be pretty realistic to have one more 'robotic clinician' going around assessing patients" (Nancy-RN). Regardless, all HCWs viewed the robot only as an "extension" to the clinical team, and not, itself, a clinician. "There needs to be a disclaimer that the robot is a healthcare extender" (Glenn-MD).

4.2.2 Addressing Communication Gaps. Ava-PwC envisioned a decision support technology for *patient advocacy* to help HCWs with diagnoses. "If [HCWs] haven't had experience with [a diagnosis], they don't think about it. [Intelligent] diagnostic technology should [exist] –there's enough data there." "I'm [imagining] a screen that pops up an option for [HCWs] saying this is a suggested diagnosis, 'ask [the patient] about this' or 'check this'."

Ava-PwC imagined how such a system could support *information recall*. She wanted the screen to be next to her, record key points from conversations with HCWs, and track her symptoms over time. This would provide a "summary [that] should definitely [support] accessible [information recall for] the HCW."

Finally, both participants wanted a better sense of *status and communication* with their clinical team during long waiting periods. Ava-PwC explored how a sense of "status of what you can expect next" could be incorporated into her tool. She envisioned the screen to be a "little schedule of what's gonna happen", indicating "When's the next meal [coming] /pain med [coming]?"

4.2.3 Providing Ancillary Support. Both HCWs and Inez-PwC explored ancillary robot tasks to 1) enhance the comfort of PwC, 2) deliver items, 3) and monitor the vitals of PwC. Inez-PwC imagined robots supporting her when her clinical team was on a break.

HCWs envisioned robots could *enhance patient comfort* through distraction, with humor, meditation, games, or music as a non-pharmacological bridge while PwC waited on CRP medication. Inez-PwC similarly remarked, "if the robot can be cute [and empathic] a little bit, the patient might forget [their] misery." However, Tina-APP cautioned, "if [a patient's CRP] is acute, no amount of distraction will take it away".

All HCWs incorporated some form of *item delivery* capability into their CRP assessment robots, and Inez-PwC said this could help nurses spend "their time doing critical [tasks for] patients, [while] the robots take care of minor [tasks]" (see Fig. 3).

4.3 Designing Compassionate Robots

HCWs emphasized the robot expressing compassion as a core design requirement for cancer care robots. "If the robot is asking patients what their pain is and assessing how they're feeling, then it should also convey empathy for those that are experiencing pain" (Nancy-RN). Our participants felt robots could convey compassion through: 1) presence, 2) communication, and 3) inclusion.

4.3.1 Compassion through Presence. Most HCWs felt the robot would convey compassion by just "being there" for patients during a distressing time. "If [the robot went] around and [made] regular assessments for pain, that act alone would [convey empathy]" (Rafael-MD). Marci-MD added, "There's some uniqueness and a special factor when something appears and then it goes away. It almost creates a sense of 'I'm having a human interaction' because humans appear and they go away - they don't just sit with you all the time like an object does; like the [nurse call button] does."

They felt in bearing witness, the robot would amplify the human compassion backing its design and use. "It is a machine. But it was designed by people [roboticists and healthcare workers] who obviously care about alleviating human suffering" (Ola-APP).

HCWs also spoke of the emotional labor in bearing witness to pain, and wondered if it can truly be translated to a robot. "It is very difficult to bear witness. [It] involves a relationship and trust with a clinician that I don't think is [possible] with a robot" (Tina-APP).

Some HCWs felt robot presence could be a temporary stand-in. "Although ideally a human being [would be] there, holding the patient's hand or asking how they're doing, the next best thing would be a robot that has some of those qualities" (Glenn-MD). However, other HCWs felt a robot bearing witness may be inappropriate. "If a patient were having a miscarriage, I don't think a robot being in the room would be comforting to the patient versus another human being" (Nancy-RN). Regardless, HCWs clarified the robot's compassion would only be "an adjunct to the compassion that [HCWs] show" (Pablo-MD). HCWs shouldn't shirk away from this lest they "lose an important part of their job and their humanity" (Pablo-MD).

4.3.2 Compassion through Communication. Participants said robots could be compassionate in their communications by being polite, professional, and respectful at all times. HCWs felt providing "the patient with some reassurance that they haven't been forgotten" (Rafael-MD) would remind patients that they are cared for. They

Figure 3: Inez-PwC envisioned ways robots could provide ancillary support to make her more comfortable.

also suggested the robot provide status about their treatment process by "saying, 'I'll make sure that the information is passed along to your providers' " (Rafael-MD).

HCWs brainstormed phrases the robot could safely use to show empathy without coming off as shallow (see Fig. 4), so the patient was not wondering "is it truly empathizing with me?" (Rafael-MD). They suggested the robot "just be sorry." (Glenn-MD, Lea-APP), "be respectful and professional" (Lea-APP, Ola-APP), and "nod its head appropriately like I'm hearing and understanding you" (Tina-APP). Some even suggested the robot take time to build connections with patients by saying "'It's my honor to wait with you while a response is expected from your provider.' Its presence with an introduction would be great" (Ola-APP). On the other hand, some HCWs felt since robots cannot feel pain, irrespective of "the word choices, empathy [tries] to relate to the patient experience without belittling it." (Tina-APP), and thus would be challenging for robots.

Inez-PwC explored how robots may be compassionate by perceiving emotions. Similarly, Pablo-MD felt if the robot "notices the patient is sad, it can convey [empathy by addressing] that."

4.3.3 Compassion through Inclusion. Participants designed their robots to be customizable in terms of their appearance (e.g., customizable faces, Fig. 5), voices, and genders. "We occasionally get sexual assault victims… not comfortable with [some genders] in the room, or [have] religious preferences [about the robot's identity]. It would be cool if the patient could pick the robot's gender they were most comfortable with" (Pablo-MD). Supporting the benefits of customizable robot embodiments to foster inclusion, Inez-PwC shared her religious and cultural values, "I am a strong believer in God, and nobody can create a human but God. So it's better to make [a robot that] looks more like a robot."

4.4 Considerations for Privacy

Physical Privacy: HCWs described nuances on what it means for robots to touch patients. "You have to be invited to touch someone – you don't just do it right off the bat" (Tina-APP). If done

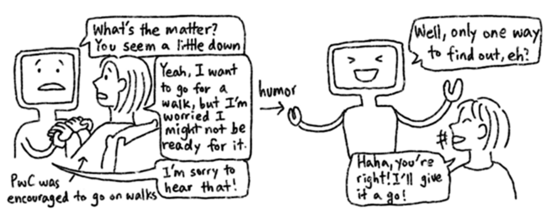

Figure 4: Lea-APP felt the robot could encourage PwC to follow HCW's recommendations through humor and compassionate dialog.

right, "the robot could touch the patient in some way, [maybe] hold [their] hand [to convey empathy]" (Pablo-MD). Others felt it was inappropriate for the robot to physically touch patients.

All HCWs felt robots should not perform physical exams or administer medication. "What are the risks of injuring a patient? I don't think it should be able to examine a patient in any way [or] touch patients" (Lea-APP). "Safely administering medications should be done by a human [not] a robot" (Tina-APP).

HCWs and PwC discussed how robots could protect the physical privacy of human users through good social practices. For example, a robot should always knock on a patient's room door before entering, and be respectful of patients' personal space. It should be weighed down and visible to HCWs, patients, and other bystanders to prevent people bumping into it, tripping over it, or using it to cause destruction. If the robot were transporting sensitive items (e.g., lab samples), it should be locked.

Social and Psychological Privacy: Both HCWs and PwC explored how robots could monitor PwC to ensure timely care. Inez-PwC envisioned a tabletop robot that could "monitor your [vitals]… throughout the day." However, many participants were concerned about surveillance. "People [may feel like] 'I'm being watched [and] recorded, all this is going somewhere.' [People may feel] paranoia and safety concerns about speaking to a machine" (Tina-APP).

4.5 Trust in Cancer Care Robots

Participants had mixed feelings on the trustworthiness of cancer care robots. Glenn-MD felt that robots could be more objective in assessing pain because "[HCWs] all have their implicit bias. Taking those biases out… by having assessments done by the robot could actually help." Lea-APP took this sentiment further, saying "I would trust [the robot] more than a colleague, depending on the colleague." However, Pablo-MD questioned, "Could[n't] the robot end up having biases based on who programs or designs the robot?"

HCWs also noted how patients' biases may affect the robot's CRP assessment. In case of a *reporter robot*, pain would be "self-reported by the patient. [So, the robot's assessment] could be biased on the patient's end" (Elmer-MD). HCWs also commented "patients are

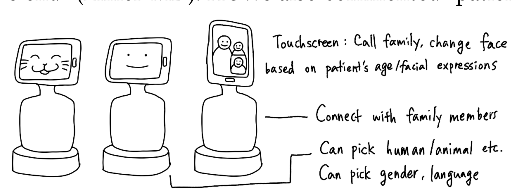

Figure 5: Several HCWs and Inez-PwC felt that the robot being customizable could support inclusion.

Figure 6: Elmer-MD wondered if PwC might only report high pain scores to the robot in order to reach a "human operator".

[not] very good at using a [pain] scale out of 10. 30% of the time, somebody gives me a number greater than 10" (Rafael-MD).

HCWs wondered if patients would deliberately just say "10, 10, 10 every time to try to bypass the system and get a [HCW] to come through sooner" (Elmer-MD), likening the experience to getting through to a "human operator" (see Fig. 6). Regardless, all HCWs felt that patients would over or under-report pain to robots as they do with HCWs, as pain experience varies by person.

Similarly, recounting her misdiagnoses, Ava-PwC indicated she would trust a diagnosis of an intelligent software tool more than a HCW. She felt it could "[use] statistics or suggestions [to recommend] a diagnosis that's based off of data that's been gathered."

5 Discussion

To understand how care is enacted in the ED, and how robots can be situated within complex care practices, we draw from Puig de la Bellacasa's concepts of *thinking-with*, *dissenting-within*, and *thinking-for* care (see Sec. 2). We further apply the lens of knotworking to examine acute care as interpersonal networks of actors to ask broad questions of how future robots may be positioned within such networks, and the implications thereof. Through these lenses, we examine interpersonal relationships, fluctuating roles and circumstances, and what it means to provide and receive care during charged moments of human life. We then offer three provocations to guide future HRI research toward a relational, care-oriented approach to designing acute care robots.

Acute Cancer Care Robots through a Care Ethics Lens: HCWs highlighted the fragmented nature of cancer care in the ED, attributing it to transient care teams that rotate every shift, and high patient volumes within an already overburdened system. Patient check-ins are sporadic, triggered by overt signs of pain or other anomalies. This reactive approach to care is a feature, not a flaw, of the ED, reflecting its specialized role and distinct demands compared to other non-acute care settings. Yet, given PwC remain in the ED for hours or even days, this approach leads to gaps in care continuity and overlooks other important aspects of care for patients experiencing a life-threatening illness like cancer.

While urgent CRP was appropriately managed, participants with cancer noted significant communication gaps with their clinical team that impacted how they *experienced* care. Such issues caused Inez-PwC to take strong medications without food, and Ava-PwC to be misdiagnosed thrice. Participants with cancer acknowledged that these are not the fault of individual HCWs but systemic issues that need to be addressed. Nonetheless, they felt unheard and unseen, and ultimately neglected. This demonstrates care, both giving and receiving, is a complex, relational process. It distinguishes clinical care for physiological stability, and the feeling of "being cared for" not only as a patient, but as a person in distress. Providing this emotional labor can be challenging for HCWs in acute care, where there is a multitude of tasks to attend to, with severe consequences for every action and decision.

HCWs expressed guilt when they felt the care they provided fell short, despite acknowledging that such compromises are necessary to attend to the needs of other ED patients. They were distressed about being absent when PwC were "suffering alone", or unable to perform small, compassionate acts (e.g., bringing a blanket).

These reflections showed participants were *thinking-for* care as they envisioned how robots might act as healthcare extenders or patient advocates and address unmet needs on a relational and logistical level. However, all participants were also *thinking-with* care. Participants were not only ideating, but also contemplating and grappling with the emotional weight and ethical tensions of practicing or experiencing care under the ED's systemic constraints (i.e. "staying with the trouble" [19, 20, 36]) which in turn influenced how they conceptualized any form of robot-mediated "care". At the same time, they were *dissenting-within* by critiquing existing ED practices (e.g., biases in pain assessment), and voicing concerns about the ways robots might inadvertently undermine care (e.g., shallow empathy, culturally or contextually insensitive design).

This furthers the notion that care in the ED is not just a set of tasks to be delegated. Instead, situating robots in such spaces requires careful consideration of the roles and characters they assume [17, 47, 91], and how their expression of care impacts those involved in the care process [117]. Our findings contrast with the current scope of robots deployed in hospitals (e.g., functional tasks like deliveries, disinfection etc.), posing new opportunities for HRI research to explore relational capabilities for care robots.

What does it mean for robots to bear witness to distress? It is inherently true that a robot situated in the ED will bear witness to distress from patients, their loved ones, and HCWs. Such robots may witness patients and their loved ones undergoing some of their most painful moments, and HCWs' deep distress when patients suffer alone. This raises questions about how these robots can sensitively bear witness by (1) being present, (2) acknowledging/validating distress, and (3) communicating/reporting distress.

In providing such support, participants stressed that a robot should not be displacing HCWs' moral and emotional labor, and instead act as a temporary stand-in. This was seen in our findings, where HCWs felt robots could serve as a temporary stand-in, offering PwC comfort when HCWs were unavailable. By being present in this manner, robots could hold space for HCWs to re-engage meaningfully in the emotionally heavy act of bearing witness in a stressful work environment. However, HCWs also questioned what it means for a robot to be present and acknowledge distress, given the tensions between privacy and the need for empathetic support that does not come across as "shallow" or "patronizing".

Given surveillance concerns, how would a robot note when a patient or clinician is in distress? To whom does it report this without the report "vanishing into the void" and furthering gaps in interpersonal communication?

How might care robots be situated within interpersonal relationships in acute care? HCWs explored how the robots they envisioned might interact with, build relationships with, express compassion to, and support PwC. Similarly, participants with cancer wondered how their ideations might interface with the different members of their care team. This led us to wonder what care relationships cancer care robots may eventually be part of, and how we may begin situating robots in such complex acute care networks.

To explore this, we draw on the concept of knotworking from activity theory [3, 72]. Through this lens, the ED is a care network of interconnected *knots*, or tasks, accomplished by actors (e.g., physicians, nurses, patients), each with *activity systems* consisting of *activity threads* (e.g., a physician has activity threads of conducting physical exams, procedures, and diagnoses). Actors achieve tasks collaboratively when their activity threads come together, forming knots that evolve as actors switch in and out, and (re)negotiate responsibilities. Knotworking is particularly complex in the ED due to the rapid, chaotic, and reactive evolution of circumstances.

A robot introduced in the ED would then have its own activity system through which it collaborates with other actors. For instance, a CRP support robot would play into the knot of cancer care, by performing pain assessments and communicating key information to PwC and their care team. However, the robot might be part of more than one knot, like if it also delivered items, it would in turn need to work with people who manage the supply room. Marci-MD remarked on how these coordination activities the robot undertakes, moving in and out of spaces, appearing and disappearing affects its role. She suggested these create a unique role for care robots as more compassionate, humanlike actors within the ED care network, distinct from other ED technologies (e.g., nurse call buttons).

This notion uncovers new challenges and questions about robot-mediated cancer care. For example, what is the role of a robot in supporting cancer care? How does it go in and out of various knots, and convey what it is doing to others in a way that reflects compassion? How does its activity system evolve and reconfigure to support various care tasks? What happens when the robot breaks down, affecting the delivery of cancer care? What types of invisible work may HCWs undertake to mitigate this?

These questions align with prior research in articulation work [97] that explores the challenges of communication and coordination in complex, collaborative workplaces. For example, to interface with new technologies, HCWs make invisible, continuous adjustments, and reconfigure roles [4, 6, 54, 106]. Our HCW participants expressed concerns about this, deeming some tasks as inappropriate for robots, like administering medication, due to unmitigable safety risks (e.g., injuring patients) and unclear accountability.

Despite this, participants felt well-situated robots may smooth HCW-PwC communication frictions, such as by helping HCWs recall information about PwC, and providing status updates and reassurance to PwC. This aligns with evidence that technologies can act as coordination mechanisms to assist clinical teams with articulation work [68, 79, 86], ultimately supporting relational care.

How could care robots reinforce or mitigate knowledge and power asymmetries? Knowledge asymmetries and power hierarchies exist among all ED actors [95, 99, 105]. These are both between interprofessional HCWs (e.g., physician vs. nurse), and between HCWs and patients [95]. HCWs have medical knowledge that can inform how best to treat a patient, but patients have intuitions and knowledge about their own bodies, which can aid HCWs in diagnosing atypical symptoms [88]. Ava-PwC felt unheard by her clinical team when requesting certain tests or treatments that ultimately proved necessary. In a similar vein, HCWs noted how patients' and their own biases affected CRP management.

These biases reflect how HCWs and participants with cancer were *dissenting-within* the asymmetries, biases, and hierarchical structures of ED cancer care. Most participants situated their robot designs in priorities that arose from this dissent. For instance, HCWs felt that a robot performing CRP assessments could remove inherent biases in pain assessment by removing the human from the equation. Similarly, Ava-PwC felt a smart diagnostic tool could support patient advocacy.

Research shows patient advocacy is a useful role for robots and AI in healthcare [10, 50, 69]. So, Ava-PwC's intuition that robots / AI could support patient advocacy may suggest a way to flatten some of the asymmetries between themselves, their care team, and other healthcare entities affecting patients' access to treatments.

This notion was already gaining prevalence with the rise of the internet empowering patients to self-advocate from positions of more knowledge than a 'lay'person [28]. Our findings suggest that robots could further this, supporting patients and HCWs by using data-based insights to support providing and receiving care. For example, robots for patient advocacy could not only support PwC in expressing their intuitions, but also support HCWs to advocate for PwC to receive access to the corresponding treatments. This could be particularly beneficial in cancer care, where PwC and HCWs fight an uphill battle to ensure PwC are correctly diagnosed, approved for, and receive access to the care they need within dysfunctional healthcare systems [25].

Limitations and Future work: Our work faced a few limitations. First, despite recruiting 9 PwC over the course of two years, ultimately only two were able to collaborate with us. To avoid being extractive, we followed best practices from the design justice, critical access studies, and research ethics literature [14, 41, 60, 98, 100] to reassess the harms of imposing on this population, and adjusting our study methods to involve PwC meaningfully. That being said, we plan to continue involving PwC in our research, ensuring their voices are heard and amplified in shaping the technologies we design to support them. We are currently conducting collaborations with patients to define the nature of interpersonal relationships and boundaries with robots.

Second, our participants were primarily based in the United States. While this limits the generalizability of our findings, we note the overarching lenses we use to frame our findings are generalizable to EDs globally [26, 40, 45, 85, 114]. For instance, knotworking situated in care ethics provides a valuable theoretical framework for HRI researchers to situate future robots in acute care.

Conclusion: In this work, we explored the design space of social robots to support cancer care in EDs through longtanding collaborations with ED HCWs and PwC. The ideas HCWs and participants with cancer described squarely indicated that they were envisioning such robots as a means to expand networks of care in the ED, highlighting that while healthcare is a deeply human experience, well-contextualized robots may serve to bridge frustrations arising as a result of systemic issues in healthcare. Our resulting design artifacts and provocations contribute considerations for future HRI researchers in designing and situating care robots within the complex relational care spaces.

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