Towards Bridging the Research-Practice Gap: Understanding Researcher-Practitioner Interactions and Challenges in Human-Centered Cybersecurity

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Abstract

Human-centered cybersecurity (HCC) researchers seek to improve people's experiences with cybersecurity. However, a disconnect between researchers and practitioners, the *research-practice gap*, can prevent the application of research into practice. While this gap has been studied in multiple fields, it is unclear if findings apply to HCC, which may have unique challenges due to the nature of cybersecurity. Additionally, most gap research has focused on research outputs, largely ignoring potential benefits of research-practice engagement throughout the entire research life cycle. To address these gaps, we conducted a survey of 133 HCC researchers. We found that participants most often engage with practitioners during activities at the beginning and end of the research life cycle, even though they may see the importance of engagement throughout. This inconsistency may be attributed to various challenges, including practitioner and researcher constraints and motivations. We provide suggestions on how to facilitate meaningful researcher-practitioner interactions towards ensuring HCC research evidence is relevant, available, and actionable in practice.

1 Introduction

Human-centered cybersecurity (HCC) (also known as *usable security*) involves the social, organizational, and technological influences on people's understanding of and interactions with cybersecurity [43, 56]. Taking a human-centered approach to cybersecurity is critical given the significant role of human behavior in cyber incidents [3, 32, 74]. Yet, poor usability and over-reliance on technology to solve cybersecurity problems have led to frustration, anxiety, confusion, or complacency among both cybersecurity non-experts and experts [11, 45, 54].

The HCC research community endeavors to better understand and overcome these challenges, with an ultimate goal of facilitating human-centric design and implementation of cybersecurity technologies and processes that result in positive experiences and outcomes [43, 56]. HCC research can greatly benefit practice. For example, catalyzed by HCC password research [15, 65, 71], a revision of widely-adopted, practitioner-developed digital identity guidelines shifted burden (e.g., frequent password changes) away from end users, thus improving user authentication experiences [55]. Research on internet of things security and privacy labels [12, 28] informed the layered label approach of the new U.S. Cyber Trust Mark [30].

However, these examples are not the norm. Research and practitioner concerns may be out of sync, resulting in research with low likelihood of practitioner uptake [24]. Even when practitioners see the value of HCC, they may struggle to know how to implement HCC principles into their work [41], so fail to to effectively address the critical human component of cybersecurity [57]. To remedy these issues, it is imperative to encourage stronger connections between HCC research and practice [24, 41].

Unfortunately, research efforts in diverse disciplines have found that interests, incentives, values, and work routines of practitioners and researchers diverge in ways that make meaningful integration and collaboration a challenge [4, 6, 10, 44]. These disconnects, known as the *research-practice gap*, can adversely impact both communities [9, 10, 23, 44]. Practitioners may not benefit from research insights that could advance their work. Researchers may not benefit from practitioners' insights that could inform the pursuit of research meaningful and actionable to practitioners [17].

To date, there has been little investigation of the research-practice gap in the HCC field. Therefore, it is unclear if prior findings are applicable to HCC, given that cybersecurity is often cited as uniquely challenging because of its rapidly evolving technology and threats, adversarial setting, and so-

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ciotechnical implications [22,25,31,60]. While a prior survey explored practitioner perspectives on HCC research-practice integration [41], the researcher perspective is missing. Moreover, research-practice gap research has typically focused on activities at the culmination of research efforts (e.g., writing and distributing outputs) [18,66], seldom addressing potential benefits of practitioner engagement from the "beginning to the end of the knowledge-creation process" [6]. Without an understanding of researcher-practitioner interactions in HCC, solutions to promote the integration of HCC research into practice cannot be developed and people will continue to struggle in their cybersecurity interactions. To remedy this, we conducted an online survey of 133 HCC researchers to answer the following research questions:

RQ1: What are HCC researchers' perceptions and experiences engaging with and considering practitioners and practitioner resources throughout the research life cycle?

RQ2: How do HCC researchers share research evidence with practitioners?

RQ3: What are barriers to practitioner engagement, if any?

RQ4: How do HCC researcher experiences differ, if at all, based on practitioner demographics?

We found that participants most often engage practitioners at the beginning and end of their research. Although they see the importance of engagement in most research activities, they do not always do so as they experience a high level of challenge. We identify a variety of challenges to these interactions, including a perceived lack of practitioner interest and researchers not knowing how to best engage.

Our study makes several contributions. We extend existing research-practice gap literature to provide domain-specific evidence valuable to the HCC community. Further, we provide the HCC researcher perspective, which can help identify disconnects in relation to HCC practitioner research [41]. We uniquely explore researcher-practitioner interactions across the entire research life cycle, providing novel insights into research activities that could benefit from increased interactions to ensure research is practice-appropriate and relevant from the start. We also identify interaction challenges and provide suggestions that can help researchers engage with practitioners and alleviate the burden currently placed on both communities. Lastly, we recommend future research that can extend our results and identify viable solutions for the HCC research-practice gap, ultimately working towards "important research" that "meets the needs of practice by addressing a real-world problem in a timely manner" [24].

2 Related Work

2.1 Research-Practice Challenges

Literature in diverse disciplines (e.g., social work [23], human-computer interaction [5,17,35], business [4,6,9], and conservation [44]) identify challenges that hinder research from making an impact on practice. Most focus on challenges at the end of the research life cycle: translation and sharing of research outputs. While researchers often carry the burden of knowledge translation, they do not always have credibility with practitioner audiences, the skills and experience to translate in formats and language understandable to practitioners, or time and resources [4,17,38,44]. Further, academic researchers are often incentivized by obtaining a degree or tenure, which are dependent on producing novel contributions and publishing in academic forums. Therefore, they may not expend effort transferring their research into practitioner-focused formats [4,17,44]. Yet, some criticize practitioners for using low-quality or no research in their practice [4] or for misinterpreting research results [66]. In reality, practitioners may lack access or time to read research papers not in a format understandable to them [9,17] and may not view research publications as timely given long publication timelines [4,17]. Since practitioners are focused on maintaining daily operations or making a profit, they may be hesitant to change their processes to incorporate research recommendations when return on investment may be unclear [9,47]. They may also not know how to apply research findings due to non-actionable or non-transferable recommendations [4,5,14,17] or the theoretical nature of some research [8,33].

Beyond research outputs, most challenges pertain to lack of cross-community communication and understanding. Practitioners rarely communicate their ideas about problems of most interest because there are few avenues for them to do so [4,5,17,35]. This may result in the selection of research topics not compatible with practitioners' needs [4]. Additionally, researchers who lack practitioner experience themselves can have inaccurate or incomplete abstractions of practice that compromise the validity and applicability of their results [4,35]. While practitioner resources, such as industry reports or technology news articles, can provide insights into practitioner contexts, researchers may be hesitant to use these [68]. Academic standards depend upon reliability, validity, and analyses as prerequisites for publishing in peer-reviewed journals. In contrast, practitioner publications may rely on case study examples with organizational viewpoints, have undisclosed methodologies and measures, focus on practical rather than theoretical implications, or place emphasis on emotion rather than facts [68].

2.2 Human-Centered Cybersecurity

While the research-practice gap exists in multiple fields – including the closely-related human-computer interaction (HCI) field – it is uncertain how manifestations of the gap in HCC may differ due to distinctive characteristics of cybersecurity. To start, cybersecurity exists in an ***adversarial setting*** [51,60]. Adversaries are not just limited to malicious actors, but, of particular import to HCC, can also include end users viewed

as "enemies" or "the weakest link" [2, 36, 67, 75]. Cybersecurity is also characterized by its ***rapid pace of change*** with constantly evolving threats, technologies, and regulations [25, 26, 60]. Therefore, keeping up with the latest developments can be difficult for practitioners and researchers alike [22, 25, 51, 63]. Further, the ***intangible, uncertain nature*** of cybersecurity impacts, victims, and threats can hamper accurate assessments of risks, possibly leading to failure to act [22, 67]. Cybersecurity's uncertainty and dynamism result in ***contested debate about which solutions are most effective*** and how to show return on investment [22, 25, 63]. Cybersecurity researchers, in particular, are challenged to demonstrate definitive, reproducible results in the presence of myriad confounding variables [13]. Finally, and of particular HCC relevance, cybersecurity involves complex, ***sociotechnical relationships*** [22, 52, 60]. However, practitioners often take a techno-centric approach and may not be well-versed in human factors influences [21, 57].

To the best of our knowledge, only two studies addressed the research-practice gap in cybersecurity. One was focused on research topics [24], and the other, while looking at HCC, took a practitioner perspective [41], leaving the researcher perspective unknown. Further, existing research-practice gap literature provides a limited view of researcher-practitioner engagements, with none exploring interactions across the entire research life cycle. These shortfalls leave the HCC research community unsure about when is most advantageous to engage practitioners and how to ensure their research evidence is relevant, available, and actionable for practitioners to leverage. Our study begins to address these gaps.

3 Methodology

To explore researcher engagement with practitioners, we conducted an anonymous, online survey of 133 HCC researchers in July 2023. Our Research Protections Office approved the study. On the first survey screen, we provided information about participant rights and data protection. Participants did not receive monetary compensation. Responses were anonymous and assigned identifiers (e.g., R10).

3.1 Survey Development

We selected a predominantly quantitative survey study design since existing qualitative literature (e.g., [9, 14, 17, 24, 66]) served as a foundation for developing survey questions and responses and we wanted to gauge the prevalence of those findings within HCC. Further, the survey format afforded identification of areas of interest that could be targeted in future HCC-specific studies. Two subject matter experts reviewed an initial draft to check for clarity and completeness. Each reviewer had over 20 years of experience conducting usability and HCC research, and one had prior practitioner experience. We adjusted the survey instrument based on their feedback. The final survey (Appendix A) consisted of select-one-option, select-all-that-apply, Likert scale, and open-ended questions.

3.1.1 Topics

The first survey section collected professional demographic information. Participants then indicated the frequency, perceived importance, level of challenge, barriers, and methods of consulting practitioners (obtaining input directly from practitioners, e.g., via email or in-person) or practitioner resources during various research activities. We aligned the activities with research life cycle phases for which practitioners or practitioner resources could potentially be consulted [76]: Research Conceptualization; Study Design; Data Collection; Data Analysis; and Dissemination.

3.1.2 Terminology

To ensure participants had a common understanding of HCC and practitioners, we described each term at the beginning of the survey (Appendix A). Since there is no standard definition for ***human-centered cybersecurity*** or the related term usable security [70], we created a description based on explanations from other HCC research groups [39, 43, 56, 72]. Our description of ***practitioners*** was largely informed by a prior narrative on security information workers [77]. Examples of practitioners include: cybersecurity practitioners, such as analysts, architects, and consultants; IT practitioners, such as administrators, help desk, system and network architects; developers; organizational leadership; policy makers; and cybersecurity educators and trainers. When asking about practitioner engagement, we also included consultation of ***practitioner resources*** (e.g., industry and government reports, technical standards and guidelines, and policies) since these can serve as a proxy for practitioner perspectives.

3.2 Survey Data Collection and Participants

Eligible participants had to be adults (18+ years of age) and have experience conducting HCC research. To recruit participants, we sent email invitations to a compiled list of authors of HCC papers published the prior three years at applicable conferences (e.g., Symposium on Usable Privacy and Security, USENIX Security Symposium). The full list of conferences is in Appendix B. We also emailed professional contacts and advertised via social media posts and a cybersecurity mailing list. The survey, implemented on the Qualtrics platform, was open for three weeks. During a data quality check, we excluded partial responses and responses where participants indicated they were not researchers. We also looked for abnormally low completion times and nonsensical open-ended responses (not finding either), finalizing on 133 survey responses.

Table 1 shows participant demographics. The largest percentage were tenure-track/tenured faculty, followed by graduate students. The majority (75%) had 10 or fewer years of

Table 1: Participant demographics (N = 133)

Demographic	Response Option	n	%
Research position	TT* faculty	53	39.85%
	Non-TT* faculty	14	10.53%
	Graduate student	41	30.83%
	Other researcher	25	18.80%
Practitioner experience	Yes, currently	32	24.06%
	Yes, in the past	59	44.36%
	No	42	31.58%
Years of experience	Less than 1	7	5.26%
	1 to 5	51	38.35%
	6 to 10	42	31.58%
	11 to 15	19	14.29%
	16 to 20	8	6.02%
	More than 20	6	4.51%
Organization type	Academic	106	79.70%
	Private industry	14	10.53%
	Non-profit	4	3.01%
	Government	8	6.02%
	Other	1	0.75%
Region	Africa	4	3.01%
	Asia	5	3.76%
	Europe	56	42.11%
	North America	66	49.62%
	Oceania	2	1.50%

* TT = tenure-track

experience conducting HCC research. Most worked in an academic institution. Ninety-two percent worked in North America or Europe. Sixty-eight percent indicated that they had been or currently were practitioners. Of those participants, 45% had security practitioner experience, 43% indicated developer experience, 29% had been educators/trainers, 25% had been IT practitioners, 23% had management experience, 9% were policy makers, and 7% indicated "Other."

Participants reported the user populations that have been the focus of their HCC research, and then the populations that could make use of or put into practice the implications and recommendations from their research (Fig. 1). Participants most often studied general public end users (71%), followed by organizational end users (50%) and security practitioners (47%). Among those who selected Other, vulnerable and at-risk populations (e.g., individuals with disabilities, children, the elderly) were the most mentioned, so are specifically included in the figure. Populations who can make use of participants' research were much more evenly distributed, with over half selecting all but three populations. The most-selected were security practitioners (74%) and policy makers (71%). Only nine did not select a practitioner group.

3.3 Survey Data Analysis

We calculated descriptive statistics and inferential statistics at a significance level of $\alpha = 0.05$ to explore differences across the data. We also conducted qualitative data analysis for the one open-ended survey question.

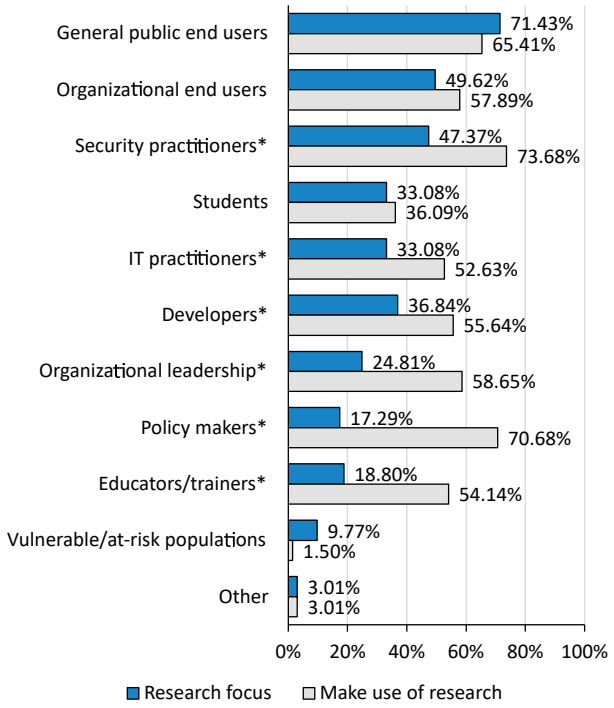

Figure 1: Population focus of research and populations who could use research (n = 133). * practitioner population.

3.3.1 Statistical Analysis

We compared independent groups for three participant demographic variables with potential to influence responses, combining several demographic groups for greater statistical power. Based on literature suggesting that researchers with non-academic experience engage in more external interactions [40] and that "pracademics" (those with both academic and practitioner experience) are useful in bridging the theory-practice gap [59], we posited that prior or current ***practitioner experience*** might influence participants' experiences and views about engaging practitioners during research activities. Practitioner experience consisted of two groups: those with prior or current experience as a practitioner (n = 91) and those without practitioner experience (n = 42). We were also interested in the impact of ***organization type*** since institutional incentives were found to be a factor in prior research-practice gap literature [44]. Groups included academic (n = 106), private industry (n = 14), and "other," primarily consisting of participants from non-profits and government (n = 13). Finally, we tested the impact of prior experience conducting ***practitioner-focused research*** since connections made during this research may afford researchers the ability to enlist practitioner support for future efforts [64]. We considered participants with practitioner-focused research (n = 96) to be those who indicated at least one practitioner population in Fig. 1. All others were in the "no practitioner-focused research"

group (n = 37).

To compare ordinal (Likert scale) responses for variables with two independent groups (e.g., practitioner experience), we used Mann Whitney U tests, reporting significant results with the z-statistic. For the three groups of organization type, we performed an initial Kruskal Wallis H test with a post-hoc Dunn's test adjusted for multiple comparisons using the Holm-Šidák correction [1], reported with z. We also report the effect size, Cohen's d, with the following thresholds: small 0.20; medium 0.50; and large 0.80 [16]. A medium or large effect size may indicate that a finding has practical significance [69].

For categorical question responses, we used Chi-square tests of association – reported with χ^2 (one degree of freedom) – or Fisher's exact tests in instances of five or less occurrences [46]. We report the effect size, Cramer's V. For one degree of freedom, small, medium, and large effect size thresholds are 0.10, 0.30, and 0.50, respectively [46].

Note that an *a priori* power analysis [29] for a Mann-Whitney U test with similarly-sized groups (medium effect size, $\alpha = 0.05$, power = 0.8) yielded a minimum sample size of 134, while we had 133. Because of challenges recruiting this specialized population and unevenness of group sizes due to convenience sampling, we acknowledge that statistical power may be lacking, thus creating a risk of not finding a difference that is actually there [37].

3.3.2 Open-ended Question Analysis

We employed qualitative coding techniques to analyze responses from an open-ended question at the end of the survey asking participants if they had additional thoughts. Two research team members first individually read through the responses and developed an initial set of codes. They then met to discuss and decide on a codebook. Since the data set was small (30 responses averaging 45 words per response), there were only five codes (see 4.6.3). The two researchers then independently coded all responses using the codebook and met again to discuss and resolve the few coding differences.

4 Results

We report summary statistics and significant inferential statistical results. The absence of significant result reporting for a question signifies there were no differences for any variable of interest. We organize this section by research phase. Figures 2, 3, and 4, referred to throughout, show the frequency, importance, and challenge ratings, respectively, for research activities. Frequency responses were on a 5-point scale ranging from never to always. Importance was rated on a 5-point scale from not important to extremely important. Level of challenge was on a 5-point scale from extremely challenging to not challenging with a "no experience to judge" option.

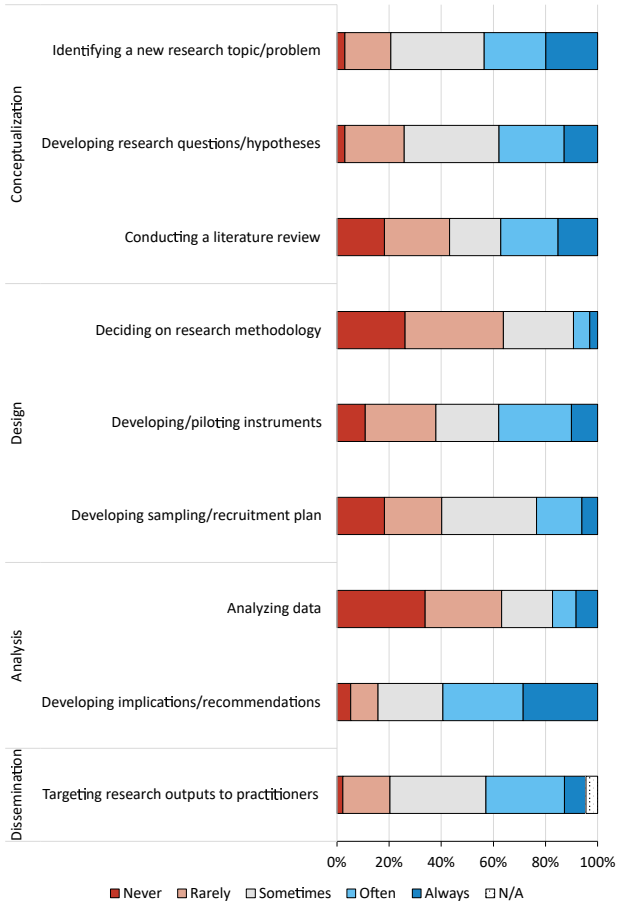

Figure 2: Frequency with which participants consult practitioners/practitioner resources during research activities. N/A only applies to "Targeting research outputs to practitioners," indicating a participant does not produce research outputs.

4.1 Research Conceptualization Phase

Participants answered questions about three activities within the research conceptualization phase.

Identifying a new research topic or problem. Less than half (44%) said they consult practitioners or practitioner resources often or always when identifying a new research topic, with 21% selecting never or rarely (Fig. 2). Seventy percent said consulting practitioners was moderately or extremely important for this activity (Fig. 3). Forty-two percent said that practitioner consultation had been moderately or extremely challenging (Fig. 4).

Developing research questions or hypotheses. Just 38% of participants said they often or always consult practitioners when developing research questions or hypotheses, and 26% said they rarely or never do (Fig. 2). Over half (56%) said that it was moderately or extremely important to do so (Fig. 3). About three-quarters (76%) indicated that it was at least somewhat challenging to consult practitioners during this

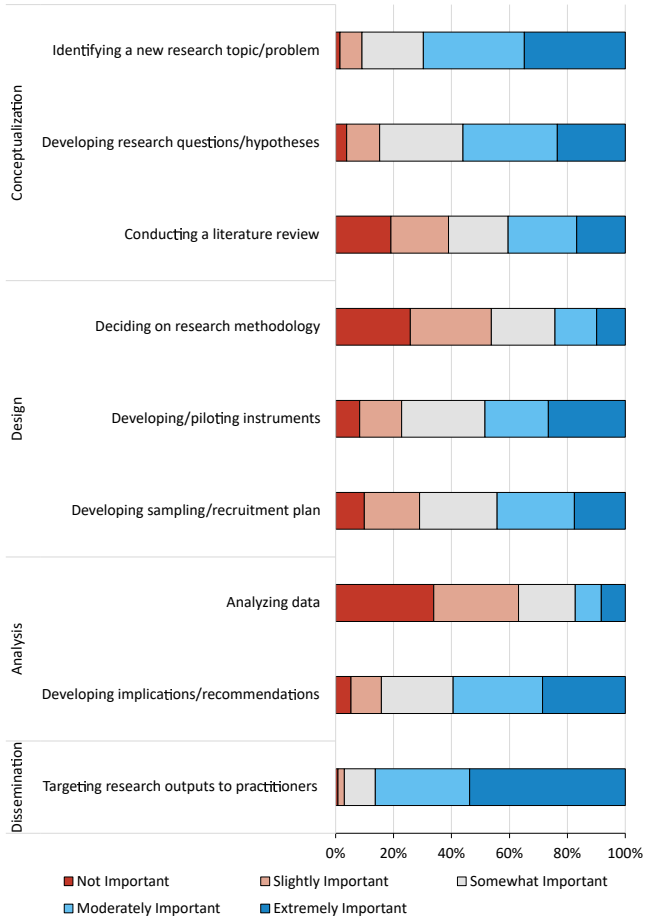

Figure 3: Perceived importance of consulting practitioners/practitioner resources during research activities

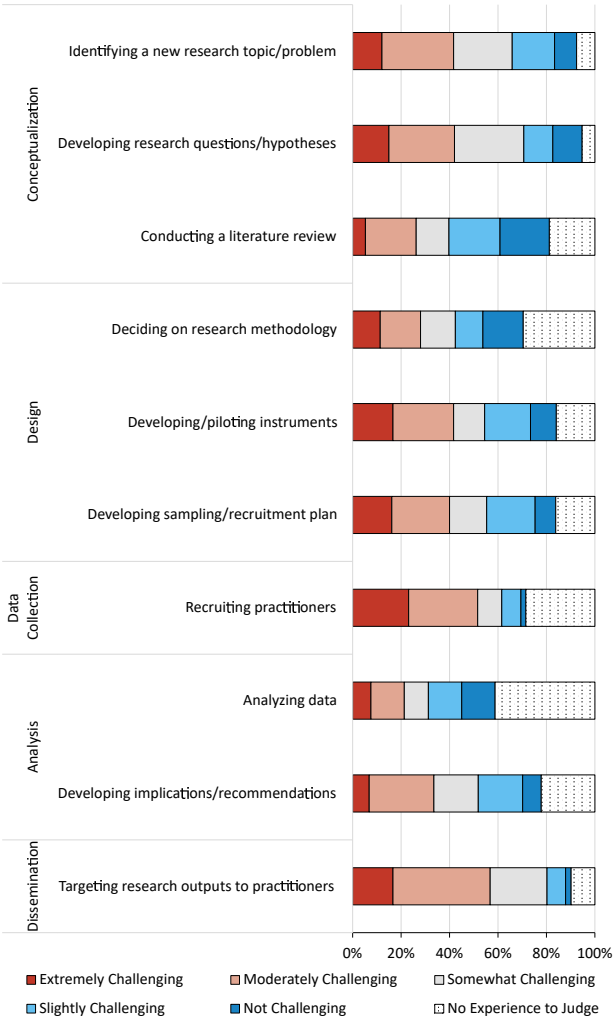

Figure 4: Level of challenge consulting practitioners/practitioner resources during research activities. Participants who did not recruit practitioners are counted as "no experience to judge."

activity (Fig. 4).

Conducting a literature review. Thirty-seven percent consult practitioners/practitioner resources often or always when conducting a literature review (Fig. 2). They generally viewed consultation during this activity as less important (40% not/slightly important) (Fig. 3). Only 26% found this to be moderately/extremely challenging, with 19% not having the experience to judge (i.e., they had never attempted it) (Fig. 4).

Demographic differences. When *identifying a research topic*, industry participants consulted practitioners significantly more often as compared to those working in academia and other organizations ($z = 3.05$, $d = 1.31$). Additionally, participants who had conducted practitioner-focused research more frequently consulted practitioners ($z = 2.67$, $d = 0.48$) and rated consultation higher in importance ($z = 2.64$, $d = 0.50$) compared to those who had not. When *developing research questions*, industry participants consulted practitioners more often than those in academia ($z = 2.63$, $d = 0.79$)

4.2 Study Design Phase

We asked participants questions related to three activities in the study design phase.

Deciding which research methodology is most appropriate. Only 9% of participants often/always consult practitioners when deciding on research methodology, with 64% selecting never or rarely (Fig. 2). Few thought practitioner consultation was important (24% moderately/extremely important, 54% not/slightly important) (Fig. 3). Twenty-eight percent said it was moderately/extremely challenging, and 30% had no experience to judge (Fig. 4).

Developing and piloting research instruments or experiments. A minority (38%) often/always consult practitioners when developing and piloting their research instruments or ex-

periments, with the same percentage never/rarely consulting (Fig. 2). A higher percentage (48%) said consulting during this activity was moderately/extremely important (Fig. 3). Participants expressed a fair amount of challenge for this activity, with 42% saying it is moderately/extremely challenging to consult practitioners (Fig. 4) and 16% indicating they had no experience to judge.

Developing a sampling or recruitment plan. Few participants (24%) indicated that they often/always consult practitioners when developing a sampling or recruitment plan, with 40% selecting never or rarely (Fig. 2). More thought consulting during this activity was important (44% moderately/extremely important) (Fig. 3), although challenging (42% moderately/extremely challenging) (Fig. 4). Thirty percent said they had no experience to judge the challenge.

Demographic differences. For *developing/pilot research instruments*, participants who had conducted practitioner research more frequently consulted practitioners ($z = 3.35$, $d = 0.68$) and had higher importance ratings ($z = 3.21$, $d = 0.62$) compared to those who had not. For this same activity, importance ratings from participants in other organizations were significantly higher than ratings from those in academia ($z = 2.59$, $d = 0.77$) and industry ($z = 2.25$, $d = 0.98$). When *developing a sampling/recruitment plan*, those who had conducted practitioner-focused research consulted practitioners significantly less frequently ($z = -2.22$, $d = 0.44$).

4.3 Data Collection Phase

We had a different vein of questioning for the one activity, recruiting practitioners, in the Data Collection phase since not all researchers enlist practitioners as research subjects. Therefore, questions related to frequency and importance were not applicable for this activity.

Among the 68% who had recruited practitioners, interviews (63%) and surveys (61%) were the most common study types, with 32% recruiting practitioners for experiments, 32% for focus groups/workshops, and 14% for another purpose. These participants were asked two additional questions.

Recruitment methods. Professional contacts and snowballing were the most popular methods of recruiting practitioners (Fig. 5). Among those who selected "Other," conferences and events (5 participants) and freelance platforms such as UpWork (4) were most mentioned. Other recruitment mechanisms included GitHub, Discord/Slack, contacting practitioners mentioned in online articles and websites, and soliciting participants from prior studies.

Recruitment challenge. Most (72%) indicated that recruiting practitioners was moderately/extremely challenging, with only 3% saying it was not challenging (Fig. 4).

Demographic differences. For *recruitment methods*, participants in academia were more likely to select snowballing as compared to those in industry ($\chi^2 = 6.21$, $V = 0.25$).

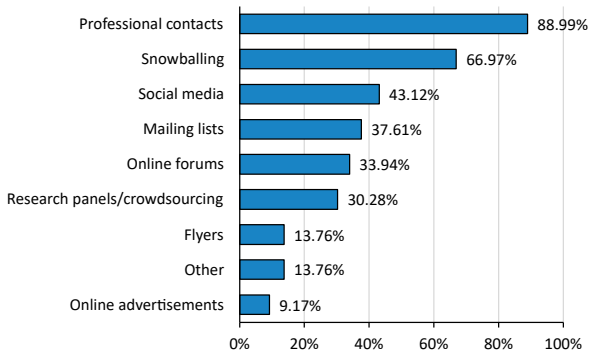

Figure 5: Practitioner recruitment methods (n = 109)

4.4 Data Analysis Phase

Participants answered questions related to two activities within the data analysis phase of research.

Analyzing data. Participants infrequently consult practitioners when analyzing data, with 64% selecting rarely or never (Fig. 2). This was also reflected in importance ratings, with 63% rating consultation as not/slightly important (Fig. 3). Only 22% were moderately/extremely challenged consulting practitioners during this activity (Fig. 4), with an appreciable number (41%) indicating they had no experience to judge.

Developing implications, recommendations, and solutions. Participants frequently consult practitioners when developing implications, recommendations, and solutions (59% often/always) (Fig. 2) and believe doing so to be important (59% moderately/extremely important) (Fig. 3). Thirty-four percent were moderately/extremely challenged, with 22% indicating they had no experience to judge (Fig. 4).

Demographic differences. Academic participants rated the challenge during the *analyzing data* activity significantly higher than those in other organizations ($z = 2.42$, $d = 0.83$).

4.5 Dissemination Phase

We asked participants several questions pertaining to the research output dissemination phase.

Producing or contributing to research outputs targeted at practitioners. Participants indicated the frequency with which their research outputs (e.g., papers, tools) are targeted at practitioners on a 5-point scale (never - always) with a "I do not produce or have not yet produced research outputs" option (Fig. 2). Just 38% said they often/always produce these outputs. However, 75% said they at least sometimes do. Most (86%) thought it was moderately/extremely important to produce these outputs (Fig. 3). Yet, over half (57%) indicated that this was moderately/extremely challenging to do (Fig. 4).

Research output dissemination channels. Participants who produced practitioner-targeted research outputs at least rarely (n = 124) were asked how they disseminate those (Fig. 6).

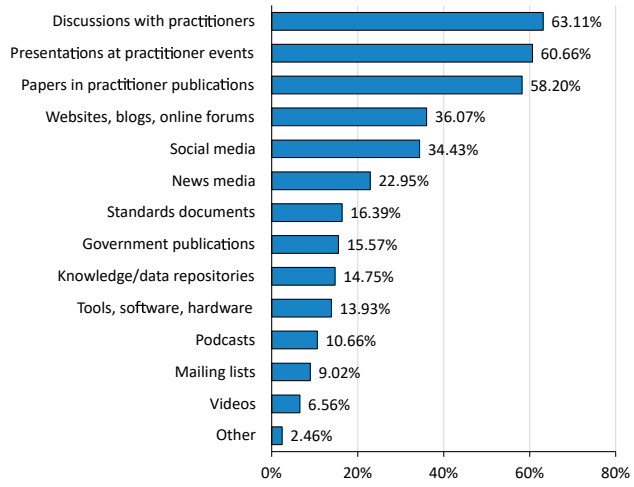

Figure 6: Channels through which research outputs are disseminated to practitioners (n = 124)

Over half selected discussions with practitioners, presentations at practitioner conferences, meetings, and events, and papers/articles in practitioner-focused publications. Two participants selecting "Other" indicated academic forums: *"publishing in academic places and hoping they'll see it" (R83).*

Practitioner impact and interest. Participants indicated how often they think their research directly impacts practice, yielding the following responses: 3% never, 9% rarely, 38% sometimes, 20% often, 14% always, and 16% do not know. Researchers also selected the extent to which they believe practitioners would be interested in having research outputs shared with them: 2% reported not interested, 16% slightly interested, 29% somewhat, 39% moderately, and 14% extremely.

Demographic differences. Academic participants were less likely to select the government publication channel compared to those from other organizations (Fisher's exact, p = 0.010, V = 0.29). Those conducting practitioner-focused research more often selected the following: presentations at practitioner forums (χ^2 = 9.93, V = 0.29); tools, software, and hardware (Fisher's exact, p = 0.003, V = 0.25); and knowledge/data repositories (Fisher's exact, p = 0.02, V = 0.21).

4.6 Barriers

Participants selected barriers encountered when engaging with practitioners. Because the challenges encountered during the dissemination phase may not apply to other research phases, we asked separate questions about barriers encountered before and during dissemination. Further, in an open-ended question, participants shared additional thoughts about practitioner interactions, with all comments related to barriers.

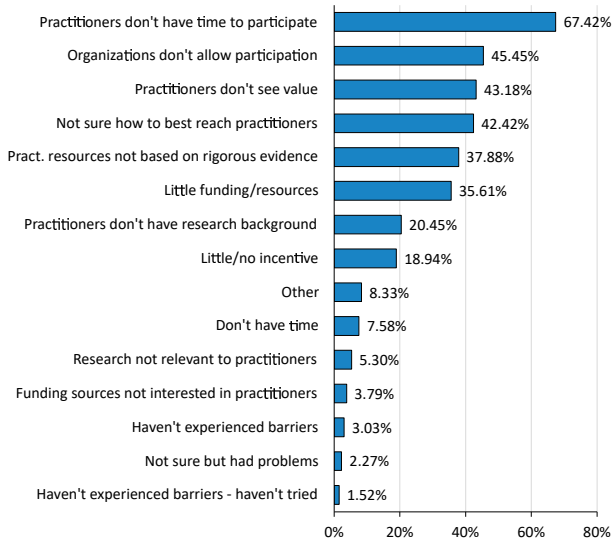

Figure 7: Barriers to consulting practitioners/practitioner resources during pre-dissemination research phases.

4.6.1 Pre-dissemination Barriers

Practitioners not having time was the most selected barrier at 67% (Fig. 7). No other barrier was chosen by a majority. Over 40% indicated that organizations do not allow practitioners to participate, practitioners do not see the value in participating, and they are not sure how to reach practitioners. Only 19% said they have little or no incentive to consult practitioners/practitioner resources, and just 8% said they do not have time. Among the write-in responses for "Other" barriers were: practitioners being wary or thinking they are being audited (3 participants); uncertainty about whether it is appropriate to cite practitioner resources; and inadequate financial incentives for practitioners to participate. Participants who had conducted practitioner-focused research less often selected little or no incentive (χ^2 = 8.78, V = 0.26) and more often selected practitioners not having time to participate (χ^2 = 4.18, V = 0.18) as compared to participants who had not.

4.6.2 Dissemination Barriers

Dissemination barriers varied, with no individual barrier selected by a majority (Fig. 8). The most selected was lack of interest or uptake from practitioners (41%). Over 30% said that there was little funding or resources, they were not sure where to disseminate results, there was little or no incentive, and that they were not sure how to translate research into content valuable to practitioners. Write-in responses for "Other" included: women's work not taken seriously in male-dominated fields; practitioners wanting validated, replicated, and quantifiable results; and a language barrier. Those who

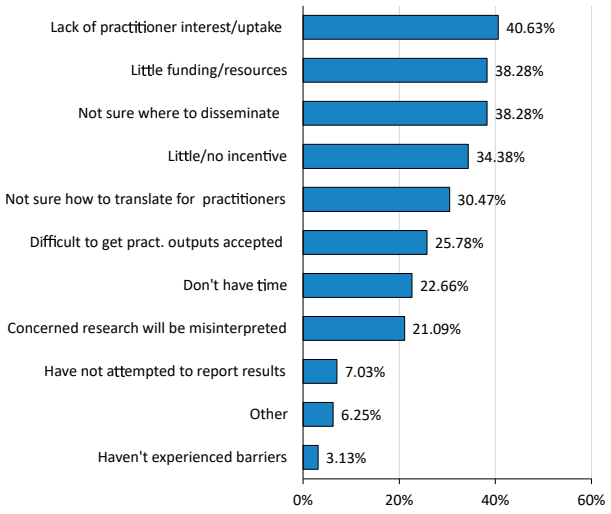

Figure 8: Barriers to producing or contributing to research outputs for practitioners.

had conducted practitioner-focused research were less likely to say there was little/no incentive ($\chi^2 = 4.30$, V= 0.18).

4.6.3 Qualitative Comments

We identified five main barriers in 30 open-ended responses.

Difficulty making connections. Twelve participants offered comments about not knowing how to reach practitioners. For example, an academic shared their frustration: *"I often reach out to practitioners to discuss study designs or disseminate results. Most of the time, I never hear back" (R47)*. Several expressed uncertainty about where to find practitioners who might benefit from their research: *"It's hard from the outside to know which people, at which organizations, might be interested in the specific area that you work on" (R59)*. Recruiting practitioners, as found in quantitative results, is a particular challenge *"even after offering compensation" (R103).* A lack of researcher or institutional name recognition may also hinder getting practitioners' attention: *"I believe they respond to requests from popular researchers but have no incentive in responding to a wider range of researchers" (R120).*

Several proposed ways to facilitate contact: *"It would be great to have a forum for collaborating – identifying practitioners with interests that overlap mine" (R112)*. R120 similarly suggested, *"having an organization or forum that enable academics to 'pitch' their projects to practitioners in the hopes of getting them to participate will revolutionize human centered security research."* A faculty member in Europe called upon research funding institutes to *"act as a facilitator between academia and industry" (R76).*

Divergent interests. Lack of practitioner interest in research may be due, in part, to conflicting interests and priorities of the two communities, mentioned by seven. Several expressed uncertainty about whether HCC research efforts are valued by practitioners. R81, a graduate student, said, *"In my opinion practitioners are focused on business/profit and not on effectivity of interventions, thus are not interested in HCI/security research."* Others commented that HCC research topics may not align with areas of practitioner interest. For example, R100 remarked, *"the issues the academic community values, e.g. privacy, are not necessarily valued by practitioners."*

Practitioner hesitance to share data. Four participants mentioned organizations being hesitant to share sensitive cybersecurity data. One stated, *"The most difficult challenge I face in working with practitioners is getting approval (from their organizations) to share security related data with external parties" (R27)*. An academic similarly commented, *"Practitioners are concerned of exposing their security loopholes" (R39)*. Another shared an example in which they were unable to address a discovered security issue because a business was reluctant to share data: *"We identified a vulnerability across a diverse pool of practitioner groups, but they were DISincentivized from communicating openly with us due to fears of opening themselves up to liability" (R24)*.

Lack of researcher incentives and time. Three commented on lack of incentive and time. While a graduate student felt researchers should *"talk more to people who actually do the things we just theoretically discuss" (R03)*, they lamented that in *"publish or perish academia, in which I hopefully gather multiple top tier conferences to graduate my PhD in a few years, I just don't have time to even think about doing additional projects or publications for practitioners."* A tenure-track faculty noted lack of institutional support: *"these [practitioner] publications do not contribute towards my academic promotion, so there is little incentive" (R116)*.

Presentation challenges. Nine participants cited difficulties presenting results in a way that is meaningful to practitioners. The sometimes abstract or non-generalizable nature of research findings poses challenges for researchers when trying to provide takeaways and recommendations. For example, R80, a North American academic researcher stated, *"As study results aren't always 'clean,' communicating the nuance of research findings to practitioners while providing useful, actionable insights can be challenging."* A European researcher commented that practitioners *"demand simple answers for very difficult questions" (R53)*. Researchers may further struggle to develop interpretations of research evidence actionable by practitioners since they do not understand the practitioner context. A participant with practitioner experience stated, *"I often see research in this space aimed at practitioners that don't understand their perspectives well, and present fairly naive/superficial results" (R59)*. Additionally, producing outputs in a style appropriate to the constraints and needs of practitioners can be non-trivial, as expressed by R92: *"I find that the challenge of writing for a different audience is difficult for fellow researchers without prior experience in industry."*

5 Discussion

Our study provides novel insights into the research-practice gap within the HCC field, specifically how researchers currently engage practitioners throughout the research life cycle and the challenges they encounter. In this section, we discuss limitations, revisit our research questions, provide practical recommendations, and suggest future research opportunities.

5.1 Limitations

We acknowledge several study limitations. There may be self-selection bias as those choosing to participate might have an interest in the survey topic and may not represent other researchers' views. Additionally, while we recruited researchers publishing in international conferences, most venues largely featured papers from North America and Europe, as reflected in participant demographics. Therefore, it is unclear if our results transfer to other regions since institutional incentives may differ [49]. Finally, our largely quantitative survey did not explore reasons behind responses. Using our study as a foundation, we recommend additional, qualitative research to further explore areas of interest identified in the survey as well as lessons learned in research-practice interactions and potential solutions.

5.2 Understanding Interactions

In this section, we discuss our findings in relation to our research questions as well as HCC-specific insights.

RQ1: Researchers see the value of engaging with practitioners but are often challenged in doing so. Our participants recognize that practitioners are key to their research making an impact (Fig. 1). The majority viewed connections with practitioners as at least somewhat important during most research activities and particularly so in activities at the beginning (e.g., identifying a new research topic) and end (e.g., targeting research outputs to practitioners) of the research life cycle. However, as our results illustrate, researchers are often highly challenged to connect with practitioners, so interactions may not actually happen.

RQ2: Dissemination channels do not always match practitioner preferences. Participants disseminate practitioner outputs via a variety of channels, most often through conversations with practitioners. In comparing these channels to those practitioners prefer [41], we see that while both communities favor presentations and articles in practitioner forums, there are substantial gaps for other channels. Compared to practitioner preferences, our participants more often share their results via researcher-practitioner discussions, social media, and news media. Researchers less often share their outputs via websites, standards documents, government publications, knowledge/data repositories, tools, podcasts, mailing lists, and videos. The differences indicate a current disconnect but also a roadmap for where researchers can invest more effort.

RQ3: Barriers differ across the life cycle. We uniquely identify researchers' challenges pre-dissemination, finding that these are often dependent on practitioner context (e.g., practitioner time, perception of research value, and organizational gate keeping) rather than issues on the researcher end. Conversely, barriers encountered during dissemination more often reflect issues in the research context that are similarly cited in existing literature (e.g., lack of resources, time, incentives, and translation knowledge [9, 38, 44, 47]). We extend this prior research by quantifying the frequency with which these barriers are encountered in HCC, finding none were selected by a majority. Further, lack of incentive and time, which are frequently cited as major challenges during knowledge translation and sharing [4, 17], were selected by a minority. Although our different results may be influenced by self-selection bias, they may also signify a shift towards HCC researchers becoming motivated to influence practice.

RQ4: The differences across demographic groups are likely due to access and opportunity. While we anticipated that participants with prior ***practitioner experience*** would interact more with practitioners and be more likely to see the importance in doing so, there were no statistically significant results to support this. Given this unexpected result, we suspect there may be other factors at play, for example, recency of practitioner experience or relevance to the research. Additionally, a potential lack of statistical power (described in 3.3.1) may also explain the lack of significant results. Divergences across ***organization types*** might be due to differing levels of access to practitioners. For example, industry and government participants may have ties to practitioners within their organizations, so would be more likely to consult them when identifying a research topic and have less need to use snowball recruitment. Differences among ***practitioner-focused research*** groups are likely due to the nature of the research; practitioner-focused research naturally necessitates more interactions. This was evident in differences consulting practitioners at the beginning of the research life cycle, dissemination of research outputs in ways preferred by practitioners [41], and incentive to engage practitioners. While these findings are not surprising, we see a missed opportunity for researchers not conducting practitioner-focused research since practitioners are often the designers of technologies that cause issues for end user populations and the ones to ultimately implement researchers' recommendations.

Domain-specific insights: Our results may reflect the distinctive characteristics of cybersecurity. In a contested field already challenged to prove return on investment [25, 63], cybersecurity practitioners may be reticent to embrace research not proven in an operational context or without concrete recommendations [25, 41, 53, 61]. Further, because many practitioners are technology-oriented, they may not value sociotech-

nical considerations [52,60]. Challenges of a constantly evolving, uncertain field result in practitioners being overworked and burnt out [27, 58], and, therefore, less willing to spend time reading or participating in research [7, 25, 41, 64]. Moreover, within an adversarial setting – not present in the related field of HCI – hesitance to disclose sensitive cybersecurity information and distrust of researchers [7, 25, 62] may lead to organizations not allowing their employees to participate.

We observe evidence of similar research-practice challenges within the adjacent domain of human-centered artificial intelligence (AI), which shares with cybersecurity characteristics of fast-paced change, focus on technology solutions, and sociotechnical entanglements [19, 42, 48, 73]. Research efforts on AI ethics (e.g., fairness and privacy) from the perspective of AI practitioners found some research-practice challenges similar to those in HCC, for example, reluctance to share sensitive data, lack of motivation to advocate for human element considerations (e.g., privacy) when return on investment is uncertain, lack of awareness of the severity of human-centric threats, and a disconnect between practitioner needs and solutions provided by researchers [42, 48, 73].

To overcome the disconnect, recommendations for AI researchers center on building trust through practitioner collaborations (e.g., conducting studies in real-world contexts), not just to understand current problems in practitioner processes but also to work towards fixing those [73] by providing tools, frameworks, checklists, and "integrative approaches that address awareness, motivation, and ability together" [48]. These recommendations can also apply to HCC in addressing the challenges found in prior HCC practitioner research [41] and our study. In turn, our research can contribute a researcher perspective, identifying advantageous points of researcher-practitioner interactions throughout the life cycle and researcher-specific challenges that may be applicable to human-centered AI. However, we see the need for more research to delve deeper into not just the commonalities, but also how the differences across and at the intersection of the two domains (e.g., the relative newness of AI implementations in practice vs. those in a more mature cybersecurity field) may impact research-practice challenges and solutions.

5.3 Practical Implications

We offer suggestions towards bridging the research-practice gap. While directly linked to our results, we recognize the need for further work to determine feasibility and acceptance of these for the research and practice communities.

5.3.1 For Researchers

Consider where additional practitioner engagement might be beneficial. Consulting practitioners/practitioner resources early and often during the research life cycle can help ensure that research is relevant to practitioner needs and context. While many participants saw the value of consulting practitioners at the beginning and end of the life cycle (Fig. 3), we suggest that, in some situations, there may be benefits to engaging practitioners during other activities. When conducting a literature review (4.1), despite possible researcher hesitance [68], the use of authoritative, credible practitioner resources (e.g., government publications, industry data breach reports, market analysis) could be helpful in identifying current cybersecurity issues and trends. In the study design phase (4.2), it might be valuable to ask practitioners representative of or familiar with users in the target study population for feedback on method appropriateness (e.g., whether an interview or focus group might be more acceptable to participants), survey instruments and design (e.g., feedback on technical accuracy/language, coverage of the topic, or completion time), or ways to recruit participants. While practitioners may not be well-versed in analysis (4.4), consulting them or practitioner resources during this activity may be helpful to better understand the context and meaning of data, for example, technical jargon and references in qualitative comments. These understandings can lead to the development of recommendations more relevant and actionable to practitioners.

Meet practitioners where they are. Some participants struggled with knowing where to disseminate outputs to practitioners (4.6.2, 4.6.3). We suggest they shift their efforts towards the information channels most preferred by practitioners (5.2). To accommodate researchers' time and resource constraints (4.6.2, 4.6.3), several channels require lower levels of effort, for example, being a guest on an established podcast or writing a short blog. These may also allow researchers to summarize key takeaways in their own words to avoid misinterpretation of results, an issue identified by researchers when interacting with news media [66]. Building a network of practitioners on social media (vs. posting to a following of mostly researchers) or joining mailing lists and forums that are frequented by practitioners can facilitate advertisement of outputs. Additionally, it may be beneficial to build relationships with science communicators, who are skilled in translating research information to practitioner terms and can share curated research evidence via channels practitioners prefer [18, 66].

Determine the best time to report. In addition to knowing where to disseminate results, knowing *when* may be just as important. Practitioners, who may not always trust or see value in research results [4, 41], might be more willing to act on conclusions originating from multiple studies, rather than from a single study. Therefore, we see a need for research synthesis reports, a model common within the medical profession [44].

Investigate ways to determine impact. Most participants were able to make a determination on how much impact their research has in practice (4.5), prompting us to wonder *how* researchers know this. Academic impact factors (e.g., H index) are not useful for measuring practitioner engagement. It may be difficult to determine if research is accessed, seen as

relevant, and implemented by practitioners. Therefore, we see value in future research that seeks to identify ways in which researchers gauge impact on practice and develop guidance on additional measures. These indicators of impact could provide encouragement to researchers, who, like our participants, may sometimes be disincentivized by institutional emphasis on research publications or are demotivated by a perception that practitioners are not interested in their work (4.6.2, 4.6.3).

5.3.2 For Intermediaries

While the above-mentioned strategies might help connect the two communities, they place the majority of the burden on researchers, who, as evidenced by our results, may lack the time, motivation, and skills to engage with practitioners or translate research into practitioner-friendly formats (4.6.1, 4.6.2, 4.6.3). Practitioners likewise struggle with similar issues (e.g., time, motivation) that keep them being more engaged with HCC research [41]. Therefore, it is important to explore solutions that alleviate undue burden on either community by enlisting the support of intermediary institutions and individuals.

Create space for research within practitioner forums. Our participants expressed challenges in knowing where to disseminate their findings and getting their outputs accepted to practitioner forums (4.6.2). To address these issues, intermediaries can feature HCC research in their events and publications. For example, conference sponsors could make a concerted effort to feature more research talks and offer grants to encourage researchers to attend. Cybersecurity organizations could invite researchers to present their work via channels that reach a broader practitioner audience, such as webinars or podcasts. Practitioner magazines and newsletters could include content featuring HCC research.

Instruct researchers on how to communicate to practitioners. To be able to effectively present research findings in the above-mentioned forums, researchers need to know how to create tailored, translational resources, ensuring outputs are actionable and prescriptive [10, 17, 20, 38, 61]. To develop these skills, which some participants indicated they lack (4.6.2, 4.6.3), educators of researchers can provide instruction on how to translate research findings to lay audiences for practical impact. Further, funding institutions can help researchers develop a business case and pitch to practitioners [50].

Establish evidence bridges. To reduce researchers' challenges (Fig. 4, 4.6), one proposed solution is the creation of *evidence bridges*, "professional individuals or organizations with a mandate to act as intermediaries between science and practice" [44]. These independent intermediaries synthesize and make accessible primary research in a format consumable by practitioners while providing a channel for practitioners to communicate their needs to researchers. These bridges are common in the medical field, for example, the American Cancer Society and Royal College of Physicians and Surgeons. To be successful, evidence bridges should have strong connections with and be trusted by both communities. A future investigation could help determine which current organizations, if any, may be best positioned to serve as evidence bridges. For example, we see a potential role for public research funding organizations (e.g., U.S. National Science Foundation, European Research Council) to assist their grantees in making impact in practice. Some universities have technology transfer organizations (e.g., [34]), which could be expanded to include the transition of research knowledge and recommendations. Additionally, since practitioners want HCC information from sources they trust or consider to be authoritative (e.g., standards documents and publications) [41], there may be a role for standards and government organizations to integrate HCC research insights in their technical publications.

Provide venues for researchers and practitioners to have meaningful interactions. While evidence bridges can be beneficial, not all communication should done via an intermediary. Compared to practitioner HCC interest ratings in a prior study [41], our participants underestimated practitioners' interest in receiving HCC information (4.5). They also expressed difficulty making connections with practitioners (4.3, 4.6.1, 4.6.2, 4.6.3). These findings indicate a communication gap and a need for improvement in relations. To facilitate dialogue, it is important to have venues where practitioners and researchers can meet to engage in meaningful discussion and begin to create connections for future interactions. These venues – perhaps organized by intermediaries – could move beyond one-way communication (presentation) formats towards a more interactive setting that allows for the mutual exchange of ideas and feedback. This exchange could shape future research, help researchers understand practitioner contexts, and provide practitioners with awareness of HCC.

6 Conclusion

Given the role of human error in cyber incidents, there is a critical need for practitioners to better address the human element. However, HCC research insights that could help advance their efforts may not be utilized, in part due to lack of access, relevance, and actionability, illustrating a research-practice gap [41]. Thus, informing researchers about how their efforts can better serve practitioner needs is key. Towards understanding and reducing the research-practice gap in HCC, we surveyed 133 HCC researchers on how they engage with practitioners. We extend existing knowledge by uniquely exploring the HCC researcher perspective and researcher-practitioner interactions across the entire research life cycle. We provide suggestions on facilitating integration of HCC research into practice by incorporating practitioner needs and context throughout the research process and enlisting intermediaries to connect the two communities.

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APPENDIX A: SURVEY INSTRUMENT

Terminology

Security *will be used as shorthand for cybersecurity.*

Human-centered security *(sometimes called "usable security") considers the human, social, and organizational factors related to security processes, technologies, products, policies, etc. It involves the relationships and interactions between people and cybersecurity, including people's perceptions, the challenges they encounter, and designing usable systems, products, and services that also result in improved security outcomes.*

Research *refers to human-centered security research you are currently conducting or have conducted in the past.*

Practitioners *are individuals who engage in a profession either directly related to security or significantly involving security considerations. Examples include, but are not limited to: Security practitioners – for example, administrators, analysts, architects, consultants, trainers whose primary job involves security IT practitioners - for example, system administrators, help desk staff, system and network architects Developers – for example, software and hardware developers who implement security features or mechanisms in their products Organizational leadership – for example, managers and executives Policy makers who include security considerations in their directives Educators and trainers who teach people about security.*

Practitioner resources *are those sources that are developed by or written for practitioners and are not published in research forums. Examples include industry reports and market surveys; technical white papers, standards, and guidelines; regulations and policies; and government reports.*

Information About You and Your Research

1) What is your current research position? If you are also a practitioner, you will have an opportunity to indicate that in the next question.

- □ Undergraduate student
- □ Graduate student
- □ Tenure-track faculty
- □ Non-tenure-track faculty
- □ Other type of researcher (non-faculty)
- □ Other (please specify)

2) Have you ever worked as a software/hardware developer, a security practitioner, or an IT practitioner?

- ◦ Yes, in the past
- ◦ Yes, and I currently still am a practitioner

- ◦ No

3) What kind of practitioner have you been? Select all that apply. *(Only asked if "Yes, in the past" or "Yes, and I currently still am a practitioner" was selected in Question 2)*

- □ Security practitioner
- □ IT practitioner
- □ Software or hardware developer
- □ Manager or executive
- □ Policy maker
- □ Educator/trainer
- □ Other (please specify)

4) How many years have you conducted human-centered security research?

- ◦ Less than 1
- ◦ 1-5
- ◦ 6-10
- ◦ 11-15
- ◦ 16-20
- ◦ More than 20 years

5) Which of the following best describes your current, primary organization/institution?

- ◦ Academic
- ◦ Private industry
- ◦ Non-profit
- ◦ Government
- ◦ Other (please specify)

6) In which region is your current organization?

- ◦ Africa
- ◦ Asia
- ◦ Europe
- ◦ North America
- ◦ Oceania
- ◦ South America
- ◦ Caribbean Islands
- ◦ Pacific Islands

7) Which type of funding has supported your human-centered security research? Select all that apply.

- □ Public funding from a government (international, national, or local) or other organization supported in part or in full by revenue generated by a government
- □ Private funding from a corporate organization or other organization not publicly funded
- □ Private funding from a corporate organization or other organization not publicly funded
- □ No specific funding
- □ I'm not sure
- □ Other (please specify)

8) What user populations have been the focus of your research? Select all that apply.

- □ General public end users
- □ Organizational end users (employees)
- □ Security practitioners
- □ Students
- □ IT practitioners
- □ Developers
- □ Organizational leadership
- □ Policy makers
- □ Educators/trainers
- □ Other (please specify)

9) Which populations could make use of or put into practice the implications and recommendations from your human-centered security research? Select all that apply.

- □ General public end users
- □ Organizational end users (employees)
- □ Students
- □ Security practitioners
- □ IT practitioners
- □ Developers
- □ Organizational leadership
- □ Policy makers
- □ Educators/trainers
- □ Other (please specify)

10) How often does your human-centered security research directly impact security practice?
Never - Rarely - Sometimes - Often - Always - Don't Know

Research Conceptualization

Remember: For the purposes of this survey, research refers to human-centered security research you are currently conducting or have conducted in the past. Practitioner resources are those sources that are developed by or written for practitioners and are not published in research forums (e.g., industry reports and market surveys; technical white papers, standards, and guidelines; regulations and policies; and government reports).

11) How often do you consult practitioners or practitioner resources when performing the following research activities?
Never - Rarely - Sometimes - Often - Always

Identifying a new research topic or problem

Developing research questions or hypotheses

Conducting a literature review

12) What do you think is the level of importance of consulting practitioners or practitioner resources when performing the following research activities?
Not Important - Slightly Important - Somewhat Important - Moderately Important - Extremely Important

Identifying a new research topic or problem

Developing research questions or hypotheses

Conducting a literature review

13) What is the level of challenge you have experienced when consulting practitioners or practitioner resources for the following research activities?
Not Challenging - Slightly Challenging - Somewhat Challenging - Moderately Challenging - Extremely Challenging - No Experience to Judge

Identifying a new research topic or problem

Developing research questions or hypotheses

Conducting a literature review

Study Design

14) How often do you consult practitioners or practitioner resources when performing the following study design activities for your human-centered security research?
Never - Rarely - Sometimes - Often - Always

Deciding which research methodology is most appropriate

Developing and piloting research instruments (such as surveys and interview protocols) and experiments

Developing a plan for sampling/recruiting research participants

15) What do you think is the level of importance of consulting practitioners or practitioner resources when performing the following study design activities?
Not Important - Slightly Important - Somewhat Important - Moderately Important - Extremely Important

Deciding which research methodology is most appropriate

Developing and piloting research instruments (such as surveys and interview protocols) and experiments

Developing a plan for sampling/recruiting research participants

16) What is the level of challenge you have experienced when consulting practitioners or practitioner resources for the following study design activities?
Not Challenging - Slightly Challenging - Somewhat Challenging - Moderately Challenging - Extremely Challenging - No Experience to Judge

Deciding which research methodology is most appropriate

Developing and piloting research instruments (such as surveys and interview protocols) and experiments

Developing a plan for sampling/recruiting research participants

Participant Recruitment

17) Have you conducted research for which you recruited practitioners as participants? Select all that apply.

- □ Yes, for surveys
- □ Yes, for interviews
- □ Yes, for focus groups or workshops
- □ Yes, for an experiment
- □ Yes, for another purpose
- □ No

18) In what ways have you attempted to recruit practitioners? Select all that apply. *(Only asked if "No" was NOT selected in Question 17)*

- □ Professional contacts
- □ Snowballing
- □ Online forums
- □ Mailing lists
- □ Social media (for example, Twitter, Instagram, Reddit, Facebook)
- □ Flyers
- □ Online advertisements (for example, Craigslist)
- □ Research panels or crowdsourcing platforms (for example, Mechanical Turk, Prolific, Qualtrics?)
- □ Other (please specify)

19) What is the level of challenge you have experienced when recruiting practitioners for your research? *(Only asked if "No" was NOT selected in Question 17)*
Not Challenging - Slightly Challenging - Somewhat Challenging - Moderately Challenging - Extremely Challenging

Data Analysis

20) How often do you consult practitioners or practitioner resources when performing the following data analysis activities for your human-centered security research?
Never - Rarely - Sometimes - Often - Always

Analyzing data (for example, statistical analysis or qualitative data coding)

Developing implications, recommendations, or solutions based on research results

21) What do you think is the level of importance of consulting practitioners or practitioner resources when performing the following data analysis activities?
Not Important - Slightly Important - Somewhat Important - Moderately Important - Extremely Important

Analyzing data (for example, statistical analysis or qualitative data coding)

Developing implications, recommendations, or solutions based on research results

22) What is the level of challenge you have experienced when consulting practitioners or practitioner resources for the following data analysis activities?
Not Challenging - Slightly Challenging - Somewhat Challenging - Moderately Challenging - Extremely Challenging - No Experience to Judge

Analyzing data (for example, statistical analysis or qualitative data coding)

Developing implications, recommendations, or solutions based on research results

23) Thinking about your research conceptualization, recruitment, design, and analysis activities, what barriers, if any, have you encountered when attempting to consult practitioners or practitioner resources? Select all that apply.

- □ There is little or no incentive for me to consult these.
- □ My research is not relevant to practitioners.
- □ Practitioner problems aren't of interest to my funding sources.
- □ There is little funding or resources to do this.
- □ I don't have time.
- □ Practitioners don't have time to participate.
- □ Practitioners don't see the value in participating.
- □ Practitioners' organizations don't permit them to participate.
- □ I'm not sure how to best reach practitioners.
- □ Practitioner resources may not be based on rigorously gathered evidence.
- □ Practitioners don't have a research background, so their help would be limited.
- □ I'm not sure, but I've had problems.
- □ I haven't experienced any barriers, even though I've consulted practitioners and practitioner resources.
- □ I haven't experienced any barriers because I haven't tried to consult practitioners or practitioner resources.
- □ Other (please specify)

Research Dissemination

24) How often are your research outputs (e.g., papers/articles, presentations, blogs, tools) targeted at practitioners?
Never - Rarely - Sometimes - Often - Always - I do not produce or have not yet produced research outputs

25) In what ways have you disseminated your practitioner-focused research outputs? Select all that apply. *(Only asked if "Never" and "I do not produce or have not yet produced research outputs" were NOT selected in Question 24)*

- □ Discussions with practitioners
- □ Papers/articles in practitioner-focused publications
- □ Presentations at practitioner-focused conferences, meetings, or other events
- □ Podcasts
- □ News media
- □ Videos
- □ Websites, blogs, other online forums
- □ Social media
- □ Mailing lists
- □ Tools or other software or hardware
- □ Knowledge and data repositories
- □ Government publications
- □ Standard documents
- □ Other (please specify)

26) What do you think is the level of importance of producing or contributing to research outputs targeted at practitioners?
Not Important - Slightly Important - Somewhat Important - Moderately Important - Extremely Important

27) In your opinion, what is the extent to which practitioners would be interested in having research outputs shared with them?
Not Interested at All - Slightly Interested - Somewhat Interested - Moderately Interested - Extremely Interested

28) What is the level of challenge you have experienced when producing or contributing to research outputs targeted at practitioners?

Not Challenging - Slightly Challenging - Somewhat Challenging - Moderately Challenging - Extremely Challenging - No Experience to Judge

29) What barriers, if any, do you encounter when producing or contributing to research outputs targeted at practitioners? Select all that apply.

- □ There is little or no incentive for me develop research outputs for practitioners.
- □ There is little funding or resources to do this.
- □ I don't have time.
- □ I am concerned that my research will be misinterpreted.
- □ I'm not sure how to translate research topics into content valuable to practitioners.
- □ I'm not sure where to disseminate my research results.
- □ It is difficult to get my article/presentation accepted to practitioner-focused publications and forums.
- □ Lack of interest or uptake from practitioners
- □ I haven't experienced any barriers.
- □ I have not attempted to report results to practitioners.
- □ Other (please specify)

30) Please share any other thoughts you have regarding interactions with practitioners in human-centered security research.

APPENDIX B: CONFERENCES USED FOR RECRUITMENT

- Symposium on Usable Privacy and Security (SOUPS) 2020 – 2022
- IEEE Symposium on Security and Privacy 2020-2022
- USENIX Security Symposium 2020 – 2022
- ACM Conference on Human Factors in Computing Systems (CHI) 2020 - 2023
- Symposium on Usable Security (USEC) 2021 – 2022
- European Workshop on Usable Security (EuroUSEC) 2020 - 2022
- AsiaUSEC 2020

- Socio-technical Aspects in Security Workshop 2020 – 2021
- Human-Computer Interaction for Cybersecurity, Privacy, and Trust (affiliated conference at International Conference on Human-Computer Interaction) 2020 - 2022
- Human Aspects of Information Security and Assurance (HAISA) 2020 - 2022