Barriers to a Cybersecurity Career: Analysis across Career Stage and Gender

Completed paper

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ABSTRACT

The demand for cybersecurity professionals is high—especially for women. We investigate barriers to a cybersecurity career based on career stages defined by Super (1957) and gender. Different concerns about a cybersecurity career between girls and adult women include a lack of awareness among young adult women. Both adult women and young adult women are concerned that they will be underestimated in a male-dominated field. Mid-career women are also concerned about being harassed in a male-dominated field. We offer some suggestions for improvement.

Keywords

Cybersecurity career choices, gender differences, career stages

INTRODUCTION

Cybersecurity professionals are currently one of the most hotly desired employees, with over 140,000 available positions in the United States (U.S. Bureau of Labor Statistics, 2022). The high cost associated with cybersecurity breaches drives this demand. A report from Splunk (2022) indicated that 49% of the security leaders surveyed suffered a data breach in the past two years.

An IBM survey (2021) found that the global average total data breach cost was $4.24 million. The number of women in the cybersecurity workforce limits how many cybersecurity professionals are available (Harmon & Walden, 2021). With the high demand for cybersecurity professionals, finding ways to get more women in the field is a great opportunity.

Theoretical foundations of women in cybersecurity careers are uncommon. However, cybersecurity has closely related fields such as information systems, computer science, and information technology. The literature from these fields focuses on adult women who have already picked a career. Youth often make career choices, so we want to study the whole career lifecycle. Girls' educational preparation is important in career development (Trauth & Connolly, 2021). While there has been much progress in women entering into technology-related careers, there is still a need for more research and interventions (Gorbacheva, Beekhuyzen, vom Brocke, & Becker, 2019). For example, men are still more likely to be promoted in technology-related careers than women (Langer, Gopal, & Bapna, 2020). Accordingly, our research questions focus on how cybersecurity career intentions evolve over life stages and how they differ by gender.

RQ1. How do cybersecurity career intentions differ across life stages?

RQ2. How do cybersecurity career intentions differ between genders?

LITERATURE REVIEW

Three main research areas inform the research questions: cybersecurity career development, gender differences, and career stages.

Cybersecurity Career Development

Career development is a complex concept with things that increase, decrease, and establish career perceptions. Researchers have studied these perceptions in information systems and related literature.

Information system professionals are often drawn to the field because of possibilities for achievement (Woodruff, 1980), advancement (Couger, 1988), computer self-efficacy (Heinze & Hu, 2009), interest in the work (Couger, 1988), and job prospects (Heinze & Hu, 2009). They often continue their work efforts because of job satisfaction and job involvement, the affective reaction, and motivation of a job (Igbaria, Parasuraman, & Badawy, 1994). They are happiest when their career orientation matches their current job setting (i.e., they are in a job position that matches their technical, managerial, or security career goals) (Igbaria et al., 1994). Company-provided tools and orientation can further increase job satisfaction (McMurtrey, Grover, Teng, & Lightner, 2002). When professionals engage in communities of practice, they have increased job-hopping and promotion opportunities (Huang & Zhang, 2014).

Information system professionals also become exhausted with their careers when they perceive that the workload is too high, fairness is low, and a lack of control over their careers (Armstrong, Brooks, & Riemenschneider, 2015). Race and gender can also be factors in career satisfaction where minorities feel they receive less career support and technical training (Igbaria & Wormley, 1992). Lack of role clarity and inconsistent performance metrics are found frequently in the careers of information system professionals (Applegate & Elam, 1992). The constant need to keep up with changing technology (Tsai, Compeau, & Haggerty, 2007) leads those that are less technologically oriented to change to other career paths (such as management) (Joia & Mangia, 2017).

Communicating with youth before entering the workforce and universities can increase interest in information systems (Cale, Mawhinney, & Callaghan, 1991). Many youth decide on a career involving computers before they leave high school (Helps, Jackson, & Romney, 2005). Running youth camps also helps increase interest in information systems careers (Choudhury, Lopes, & Arthur, 2010). Many companies and researchers have made efforts to increase participation in information systems careers, especially among women.

Gender Differences in Cybersecurity Careers

Beyond the difficulties of staying in the constantly evolving career of information systems, women see other difficulties not seen by men, including discrimination, exclusion from social events, and fewer advancement opportunities (Armstrong, Riemenschneider, & Giddens, 2018). Armstrong et al. (2018) performed a literature review of publications that cited a stage model proposed by Ahuja (2002). They found five main barriers for women in information systems careers: social expectations, work-family conflict, lack of role models, information networks, and lack of mentors. Trauth et al. (2009) focused on what they felt were most impactful: work-life balance, organizational climate, and mentoring. Kirton and Robertson (2018) saw that women often feel uncomfortable in male-dominated fields such as information systems and that stereotyping, sexism, and a lack of informal sponsorship (such as mentoring) can reduce women's desire to remain in their careers. Stereotypes, such as the analyst is a people person and the programmer is a machine person are often self-fulfilling (Brooke, 1995). Suseno and Abbot (2021) also discuss that women are more motivated by prosocial activities than men, which may limit their work industries. Trauth and colleagues have developed the individual differences theory of gender and IT (IDTGIT) to help explain women in the information systems workforce. In a recent paper discussing data collection with women over forty years, Trauth and Connolly (2021) show that

these factors have remained constant factors in career decisions: demand for information systems workers, gender laws and policies, cultural acceptance, educational opportunities, and father's increased role in childcare. Quesenberry and Trauth (2009) identified various career anchors for women in information system careers: lifestyle integration, organizational security, technical competence, challenge/variety, managerial competence, autonomy/independence, entrepreneurship/creativity, service/dedication, geographical security, and identity. Serenko and Turel (2021) identify social norms and implicit gender identity as factors in selecting a college major. Annabi and Lebovitz (2018) identified legitimacy concerns and uncertainty about their career role as other barriers.

Creating communities of practice for women has shown to increase information systems career selection (Panteli, 2012). Reid et al. (2010) showed that organizations can build healthier work environments by teaching employees not to discriminate and providing educational opportunities to women to increase their expertise. They showed that men often think gender issues are structural while women think gender issues are individual.

Super's Career Stages

Super's Career Stages are a group of attitudes, motivations, and behaviors that occur over a person's life (Salomone, 1996; Smart & Peterson, 1997; Super, 1957). Super (1957) related these stages to the person developing their self-concept often regarding their vocation. While initially the stages were presented sequentially, Super (Super, 1980) later explained that people can revisit stages multiple times.

Before elaborating on Super's career stages, there is another stage model that researchers have used to study women's choice in following an information system career, Ahuja's model of the social and structural determinants of women's careers in information technology (Ahuja, 2002).

Ahuja proposed three stages in information technology careers: choice, persistence, and advancement. While previous researchers have measured (Armstrong et al., 2018) Ahuja's model, researchers more broadly use Super's stage model. Super's model has more stages than Ahuja's, and more researchers have applied Super's model to children and youth. Ahuja defined the choice stage as beginning in college. We feel Super's stages will provide a more nuanced lens through which to study cybersecurity careers.

Super presented five stages: growth, exploration, establishment, maintenance, and disengagement (Super, 1953). These stages roughly followed the age of a person, with growth in the preteen years to disengagement with retirement (Giannantonio & Hurley-Hanson, 2006).

The growth stage is typically found in children from birth to 14 years old (Salomone, 1996). This stage is when a person is first introduced to occupations, stereotypes, and social norms (Giannantonio & Hurley-Hanson, 2006). This stage is often the first place that gender differences appear, where people think about what is expected of their gender (Giannantonio & Hurley-Hanson, 2006). Researchers have observed these differences in 7th-grade students (about 12 years old) and their parents (Usinger, 2005). Sources for career preferences in this stage come from media, parents, friends, teachers, and perceived stereotypes (Giannantonio & Hurley-Hanson, 2006). Often the physical attractiveness of professionals in the career determines the attractiveness of the career itself (Giannantonio & Hurley-Hanson, 2006). Based on these career preferences, we hypothesize:

H1. Compared to other stages, people in the growth stage will more highly rate barriers in cybersecurity from a) media, b) parents, c) friends, and d) teachers.

Females are not often portrayed in cybersecurity roles, and "nerds" are often portrayed as loner males. Also, parents are more likely to encourage females towards the arts than science,

technology, engineering, or math (Rogers, Boyack, Cook, & Allen, 2021; Starr & Simpkins, 2021). We hypothesize that:

H2. Compared to males, females in the growth stage will more highly rate barriers in cybersecurity from a) media, b) stereotypes, and c) parents.

The exploration stage is typically found in children from 15 years to adults 24 years old (Salomone, 1996). People in the exploration stage discover more accurate information about careers and begin to match their interests and identity with careers (Giannantonio & Hurley-Hanson, 2006; Super, 1957). They are also influenced by their part-time or full-time work and recruitment material (Giannantonio & Hurley-Hanson, 2006). Stereotypes reinforced by recruiters, career counselors, friends, teachers, and family members are still present in the exploration stage. Therefore, we hypothesize:

H3. Compared to other stages, people in the exploration stage will more highly rate barriers in cybersecurity from a) a lack of interest, b) parents, c) friends, and d) teachers.

During the exploration stage, people visualize stereotypes in the courses they take. Computing courses are often full of "nerdy" males. Females can feel out of place or even harassed in such classes (Kirton & Robertson, 2018). They will notice a lack of mentors in the field. This stage is also where females start to feel they need to follow a career that is for females, i.e., ones that are creative, collaborative, expressive, or communicative (Suseno & Abbott, 2021). This is also a stage where some females feel they are not supposed to have a career but be stay-at-home mothers (Jemini-Gashi, Duraku, & Kelmendi, 2021).

H4. Compared to males, females in the exploration stage will more highly rate barriers in cybersecurity from a) a sense of not belonging in computer courses, b) stereotypes, and c) lack of role models, d) lack of peers interested in cybersecurity, and ideas that cybersecurity is not a e) creative, f) collaborative, g) expressive, and h) communicative career.

The establishment stage is typically found in adults from 25 to 44 years old (Salomone, 1996). Workers in the establishment stage are establishing a stable work environment with promotion and growth potential (Giannantonio & Hurley-Hanson, 2006). They are aligning their self-identity with their work identity and may alter appearance and behavior to match what they think will get them promoted. As they are already in a career, it is less likely that they will be looking for new careers and will be looking for careers that provide them the most progression opportunities. They will be looking for peers and role models as examples of what they can achieve (Gibson, 2004).

H5. Compared to other stages, people in the establishment stage will more highly rate barriers in cybersecurity from a) a lack of role models, b) already having a career choice, and c) lack of opportunities for promotion.

Because those in the establishment stage are looking for role models and peers at high levels of achievement, females will be looking in the work environment for female role models and mentors. They will be turned off by male-dominated fields where they may feel underestimated (Kirton & Robertson, 2018).

H6. Compared to males, females in the establishment stage will more highly rate barriers in cybersecurity from a) a lack of role models, b) feeling of being underestimated, and c) feeling uncomfortable in a male-dominated field.

The maintenance stage is typically found in adults from 45 to 64 years old (Salomone, 1996). In this stage, people's self-identity begins to be seen beyond career identity (Giannantonio & Hurley-Hanson, 2006). They increasingly consider leaving their current career or company for a better fit and evaluate whether their previous career choices match their current self-concept. Age norms begin to be a factor in some careers (Lawrence, 1988). Cultural differences may arise between generations, especially in careers with a younger workforce, such as cybersecurity. Friends, mentors, and coworkers leaving the company can create feelings of isolation and job

dissatisfaction (Giannantonio & Hurley-Hanson, 2006). As people age in their careers, they become more interested in more prosocial endeavors such as mentoring (Schein, 1996).

H7. Compared to other stages, people in the maintenance stage will more highly rate barriers in cybersecurity from a) a lack of peers, b) too late to learn something new, c) not being able to have enough influence in cybersecurity, d) a lack of social impact, e) few opportunities to be a role model, and f) cultural differences in cybersecurity.

Like males, females in this stage will have more of a self-concept independent of their work identity. They will desire more flexibility than men as they often desire more time with family. They will also continue to see a lack of female peers.

H8. Compared to males, females in the maintenance stage will more highly rate barriers in cybersecurity from a) a lack of peers and b) wanting more flexibility.

The disengagement stage is typically found in adults 65 and older (Salomone, 1996). At this point, self-identity is more important than career identity (Giannantonio & Hurley-Hanson, 2006). People spend more time traveling and with family than in previous stages. As this stage is for people who have exited or are about to exit their career, they will not want to keep up with technology changes. Differences between males and females will be less apparent in career choices in this stage.

H9. Compared to other stages, people in the disengagement stage will more highly rate barriers in cybersecurity from having to keep up with technology.

We summarize our hypotheses in Table 1.

	Males and females	Females over males
Growth: Tween	1a) media, 1b) parents, 1c) friends, and 1d) teachers	2a) media, 2b) stereotypes, and 2c) parents
Exploration: ages 15-24	3a) a lack of interest, 3b) parents, 3c) friends, and 3d) teachers	4a) a sense of not belonging in computer courses, 4b) stereotypes, and 4c) lack of role models, 4d) lack of peers interested in cybersecurity, and ideas that cybersecurity is not a 4e) creative, 4f) collaborative, 4g) expressive, and 4h) communicative career
Establishment: ages 25-44	5a) a lack of role models, 5b) already having a career choice, and 5c) lack of opportunities for promotion	6a) a lack of role models, 6b) feeling of being underestimated, and 6c) feeling uncomfortable in a male-dominated field
Maintenance: ages 45-64	7a) a lack of peers, 7b) too late to learn something new, 7c) not being able to have enough influence in cybersecurity, 7d) a lack of social impact, 7e) few opportunities to be a role model, and 7f) cultural differences in cybersecurity	8a) a lack of peers, and 8b) wanting more flexibility
Disengagement: ages 65+	9) having to keep up with technology	–

Table 1. Hypothesized barriers

METHODOLOGY

To test our hypotheses, we ran a survey of four different populations. A survey design allowed us to capture the barriers to entering a cybersecurity career at different ages and career stages.

Demographics

We gathered data from four populations to obtain a range of ages and career choices. We sampled students from two different universities in the same state in the United States. One of the universities was private (n=94), and the other was public (n=19). Students were given extra credit

in the courses for participation. University students have often selected a career but are not in their career yet, and they make a good population for the Adult Exploration career stage.

The second sample came from recruitment efforts on Amazon's Mechanical Turk (n=152). We recruited English-speaking participants from the United States to take a survey about career choices. MTurk workers are suitable to sample from when 1) samples are appropriate to the theory, 2) qualifications are set, 3) sample sizes are appropriate, 4) compensation rates are strong, 5) controls are in place to stop automation and misrepresentation, 6) job postings are clear, 7) progress is monitored, 8) data is screened, 9) compensation is based on screening, and 10) details are reported (Aguinis, Villamor, & Ramani, 2021). Since careers are relevant to most people (even an MTurk career), the MTurk sample should fit within our theory. We set qualifications of English speaking and in the United States. We collected data until we had at least 30 participants in all adult career stages except disengagement, which is not as relevant to career choices (Smart & Peterson, 1997). We paid participants $3 for the survey that took, on average, 7 minutes ($25/hour). We were targeting a $20/hour pay rate which is strong in most of the United States. We prevented ballot stuffing and removed participants that took the survey too quickly (less than a minute). Of the 158 participants that completed the survey, we kept 152. We recruited MTurk participants by stating, "We are conducting an academic survey about career choices (10-20 minutes)." We monitored progress, screened data, and paid only upon qualified responses. Finally, we are reporting the details.

The third sample came from a capture-the-flag (CTF) event we hosted for the middle and high schools in the state (predominantly students 12-18 years old). CTF events are common in cybersecurity, and CTF participants are presented with challenges such as cracking passwords or finding a flag (unique keyword) hidden in a vulnerable program. Twenty schools and 583 youth

participated in the event. CTF participants were told about the research survey and offered prizes (a Raspberry Pi and Amazon gift cards) to be raffled off. Eighty-seven students participated in the CTF. This sample provided us with youth that are still selecting a career.

The final sample came from participants of cybersecurity youth camps hosted by the university since 2016. From 2016 through 2019, the university hosted a girls-only cybersecurity camp every summer. In 2021 the university hosted a girls' cybersecurity camp and a boys' cybersecurity camp. Five hundred thirty people have attended at least one of the camps. The camp attendees and their parents were contacted and told that if the camp attendees took the survey, they would be entered into a drawing for one of two Nintendo Switches. Sixty-eight camp attendees took the survey (12.83%). This sample provided us with people selecting careers that did not take a college path.

From the four samples, we gathered complete data from 420 participants. 179 (42.6%) of the participants were female, and 223 (53.1%) were male (see Table 2). We gathered data from males and females so that we could make comparisons between the two. If we only collected data from females, we would not be able to tell if our results were unique to females.

Sample	**Female**	**Male**	**Did not identify**	**Non-binary**	***Total***
College students	45	66	1	1	*113*
MTurk	68	84	0	0	*152*
Youth CTF	17	55	14	1	*87*
Previous camp attendees	49	18	1	0	*68*
Total	*179*	*223*	*16*	*2*	*420*

Table 2. Sample statistics by gender

We explored the career stages by age (see Table 3), as the career stages often follow age groups (Giannantonio & Hurley-Hanson, 2006), and how much participants identify with a career stage,

as career stages can be revisited later in life (Super, 1980). Previous research has measured career stage by age, organizational tenure, position tenure, and professional tenure (Lynn, Cao, & Horn, 1996). We defined seven career stages using Super's original stages and splitting growth by age 11 and exploration by age 18. Our seven stages are *Growth*: *Tween* for ages 11-14, *Exploration*: *Teen* for ages 15-18, *Exploration*: *Adult* for ages 19-24, *Establishment* for ages 25-44, *Maintenance* for ages 45-64, and *Disengagement* for those 65 and older. One person did not provide their age.

Age Stage	**Female**	**Male**	**Didn't identify**	**Non-binary**	***Total***
Growth: Tween	22	34	7	1	*64*
Exploration: 15-18	35	39	6	0	*80*
Exploration: 19-24	50	62	1	1	*114*
Establishment: 25-44	50	69	1	0	*120*
Maintenance: 45-64	17	16	0	0	*33*
Disengagement: 65+	5	3	0	0	*8*
Total	*179*	*223*	*15*	*2*	*419*

Table 3. Sample statistics by career stage based on age

Career Stages

We presented the participants with some statements to identify their career stage (see Table 4) because some literature (Super, 1980) suggests that self-identified stages might provide additional insight. We asked the participants to agree or disagree (Likert-like 5-point scale) with statements targeting the main theoretical concepts of each career stage. We averaged the participants' responses to the statements per stage. We identified the top career stage of each participant by finding the stage with the highest average. Table 5 shows the number of participants that identify with a particular career stage by gender. The number is lower here as some participants did not

answer all the survey items needed to establish career stage identity. While it may seem odd that disengagement has a high number of participants, we note that many in our sample do not have a job. This is the likely explanation for the difference in 8 people being classified into the disengagement group by age, but 112 people self-classifying into this group. When we asked about their current job title, 233 of 420 (55.5%) provided one.

Please indicate how much you agree or disagree with the following statements.
If you don't understand a statement, just skip it.

Statement	**Stage**
I am beginning to develop my self-identity	Growth
I am beginning to be introduced to career choices	Growth
I match my interests with my career	Exploration
I have had contact with people working in various careers	Exploration
I am concerned with career advancement	Establishment
I am trying to establish a stable work environment	Establishment
My professional appearance is important	Establishment
I am concerned with maintaining my self-identity	Maintenance
Having friends in my work is important in my career choices	Maintenance
My self-identity is distinct from my career	Disengagement

Table 4. Statements to identify career stages

Self-identified Career Stage	Female	Male	Didn't identify	Non-binary	*Total*
Growth	24	31	3	0	*58*
Exploration	52	38	5	1	*96*
Establishment	33	49	3	0	*85*
Maintenance	20	42	1	0	*63*
Disengagement	50	62	4	1	*117*
Total	*179*	*222*	*16*	*2*	*419*

Table 5. Self-identified career stage by gender

Career Barriers

The survey continued by asking participants about cybersecurity-related career barriers (Appendix A, Table A1). These barriers came from the literature previously examined. We asked participants why they would not pick cybersecurity as a career on a Likert-like scale with five points (not at all important, slightly important, moderately important, very important, and extremely important).

We present some summary statistics in Appendix A about the top and bottom barriers by age-based career stages (Figure A1), self-identified career stages (Figure A2), and gender (Figure A3). We see that a lack of capability, having a career set, and thinking cybersecurity is not creative are commonly identified as top barriers to a cybersecurity career across many ages, career stages, and genders. Parents are not seen as a barrier.

ANALYSIS

To test our hypotheses, we used four multinomial logistic regressions. The first two multinomial logistic regressions tested how well each career barrier predicted the career stage based on age and self-identification, respectively. The second two multinomial logistic regressions tested how well each career barrier predicted the combination of career stage based on age and gender and the

combination of self-identified career stage and gender, respectively. We used multinomial logistic regressions as they help predict membership in more than two categories (Field, Miles, & Field, 2012). In multinomial logistic regressions, tests are performed against a reference group. Since the establishment stage is typically the goal of educational institutions, we chose it as the baseline.

We only report on the significant results. Appendix B contains the full output. As we are making many comparisons, we show the results with and without a statistical correction. A Bonferroni correction is intended to reduce the likelihood of making a type I error but also increases the likelihood of making a type II error (Field et al., 2012). Instead of a p-value of < 0.05 a Bonferroni correction with 1,044 comparisons looks for a p-value of < 0.00004789. Many consider that correction too harsh, so Holm's and others recommended a stepped approach, reducing the p-value necessary for significance for every accepted test, starting with the one with the smallest p-value (Field et al., 2012).

We conducted four analyses to examine the differences between the establishment phase and hypotheses based on either age-based career stage or self-identified career stage. Please see Tables A2 – A5 in Appendix A for the complete results. The first analysis tested for differences in career barriers for each career stage based on age (see Table 6) for the most significant findings. A second analysis tested for differences in career barriers for each career stage based on the career stage individuals identified most with. However, no significant results were found. The third analysis tested for differences in career barriers for each career stage based on age and gender (see Table 7). The fourth analysis tested for differences in career barriers for each career stage based on the career stage individuals identified most with and gender (see Table 8).

	Career stage	**Direction compared to establishment stage**	**p-value**	**Traditional significance < 0.05 * < 0.01 ** < 0.001*** **	**Significant with Holm's correction?**
It is too late for me to learn something new	Exploration teen	Less than	0.00132	***	Yes
I don't even know what a cybersecurity career is	Exploration adult	Greater than	0.00019	***	Yes
My parents don't approve of cybersecurity as a career for me	Exploration adult	Less than	0.00099	***	Yes

Table 6. Significant results from analysis based on age.

	Career stage/ Gender	**Direction compared to establishment stage**	**p-value**	**Traditional significance < 0.05 * < 0.01 ** < 0.001*** **	**Significant with Holm's correction?**
There are too few teachers like me in cybersecurity	Establishment female	Less than	0.00183	**	Yes
I will feel underestimated in a male-dominated field	Exploration adult female	Greater than	0.00019	***	Yes
It is too late for me to learn something new	Exploration teen female	Less than	0.00086	***	Yes
I don't even know what a cybersecurity career is	Exploration adult female	Greater than	0.00036	***	Yes
	Exploration adult male	Greater than	0.00035	***	Yes
My parents don't approve of cybersecurity as a career for me	Exploration adult female	Less than	0.00005	***	Yes

Table 7. Significant results from analysis based on age and gender.

	Career stage/ Gender	**Direction compared to establishment stage**	**p-value**	**Traditional significance < 0.05 * < 0.01 ** < 0.001*** **	**Significant with Holm's correction?**
I am more interested in careers where I can communicate	Growth male	Less than	0.00056	***	Yes
I will feel underestimated in a male-dominated field	Exploration female	Greater than	0.00160	**	Yes
	Establishment female	Greater than	0.00047	***	Yes
I will feel harassed in a male-dominated field	Maintenance female	Greater than	0.00158	***	Yes

Table 8. Significant results from analysis based on self-identified career stage and gender.

Next, we list the significant results with Holm's correction. We will also show figures of the medians and the spread of the barriers in the significant results. Note that the figures do not entirely account for the covariates in the models.

1. *Teens in the exploration stage see "It is too late for me to learn something new" as less of a barrier than adults in the establishment stage.* (Figure 1)
2. *Female teens in the exploration stage see "It is too late for me to learn something new" as less of a barrier than male adults in the establishment stage.* (Figure 1)

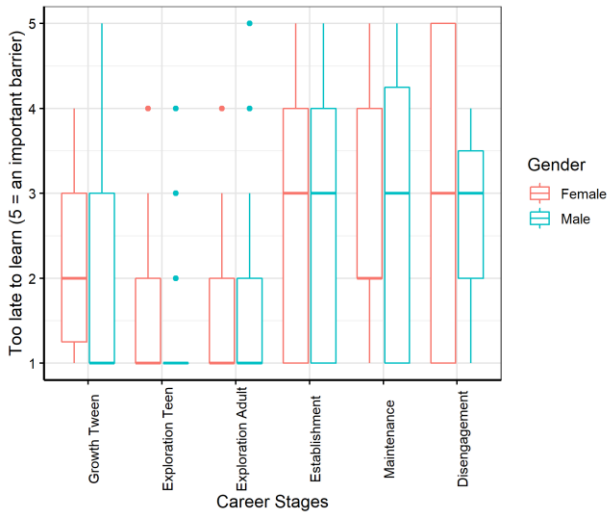

Figure 1. How much "too late to learn is a barrier" by career stage by age and gender

3. *Adults in the exploration stage see "I don't even know what a cybersecurity career is" as more of a barrier than adults in the establishment stage.* (Figure 2)
4. *Female adults and 5. male adults in the exploration stage see "I don't even know what a cybersecurity career is" as more of a barrier than male adults in the establishment stage.* (Figure 2)

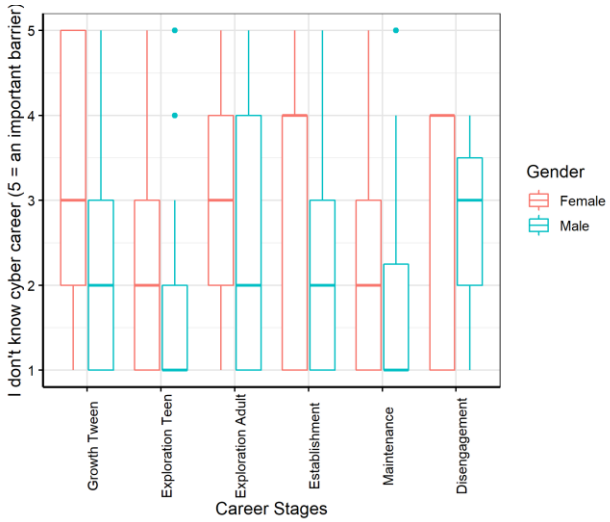

Figure 2. How much "I don't know what a cybersecurity career is" is a barrier by career stage by age and gender

5. *Adults in the exploration stage see "My parents don't approve of cybersecurity as a career for me" as less of a barrier than adults in the establishment stage.* (Figure 3)
6. *Female adults in the exploration stage see "My parents don't approve of cybersecurity as a career for me" as less of a barrier than male adults in the establishment stage.* (Figure 3)

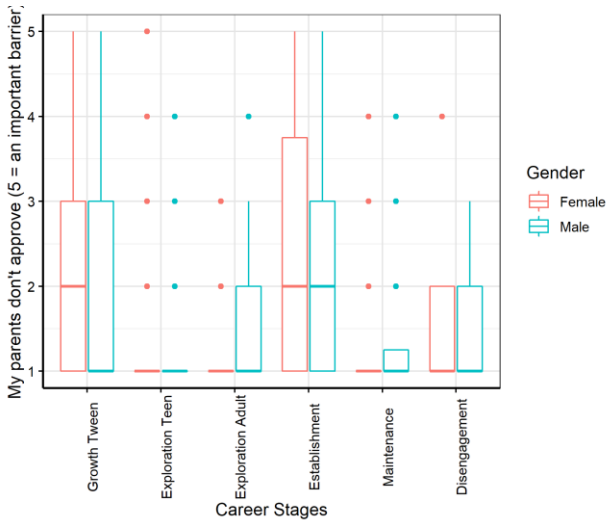

Figure 3. How much "my parents don't approve of a cybersecurity career" is a barrier by career stage by age and gender

7. *Female adults in the establishment stage see "There are too few teachers like me in cybersecurity" as less of a barrier than male adults in the establishment stage.* (Figure 4)

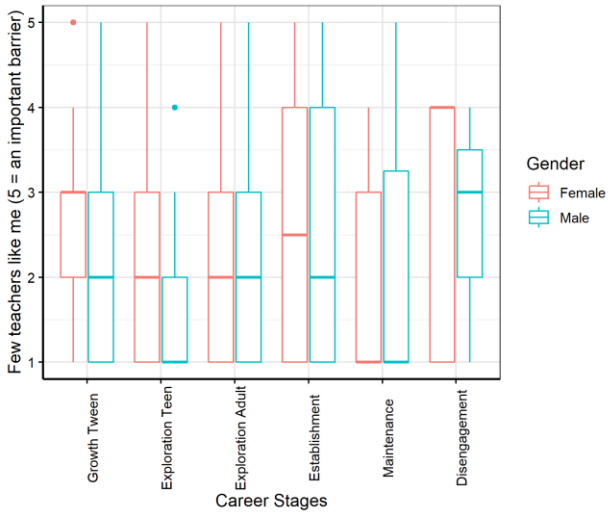

Figure 4. How much "there are few teachers like me" is a barrier by career stage by age and gender

8. *Female adults in the exploration stage see "I will feel underestimated in a male-dominated field" as more of a barrier than male adults in the establishment stage.* (Figure 5)

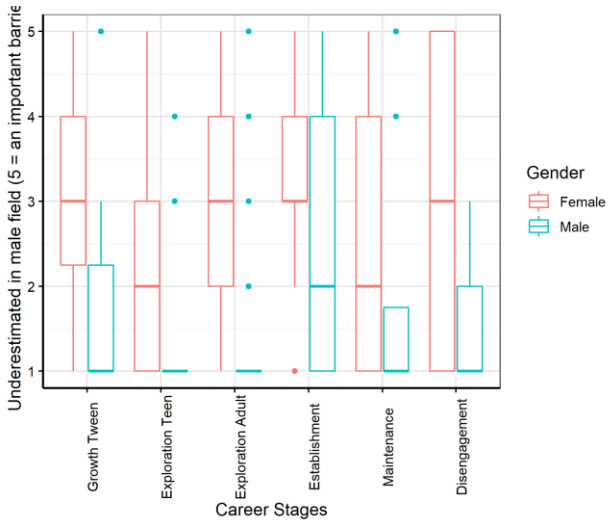

Figure 5. How much "I will feel underestimated in a male-dominated field" is a barrier by career stage by age and gender

9. *Females who identify with the exploration and 12. establishment stages see "I will feel underestimated in a male-dominated field" as more of a barrier than males who identify with the establishment stage.* (Figure 7)

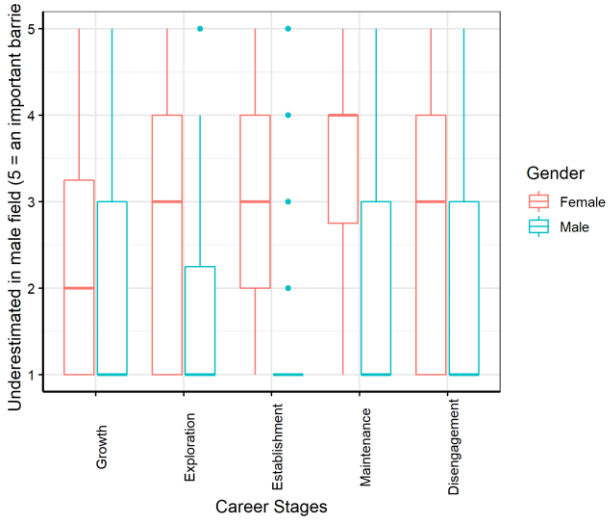

Figure 6. How much "I will feel underestimated in a male-dominated field" is a barrier by career stage by self-identified career stage and gender

10. *Females who identify with the maintenance stage see "I will feel harassed in a male-dominated field" as more of a barrier than males who identify with the establishment stage.* (Figure 8)

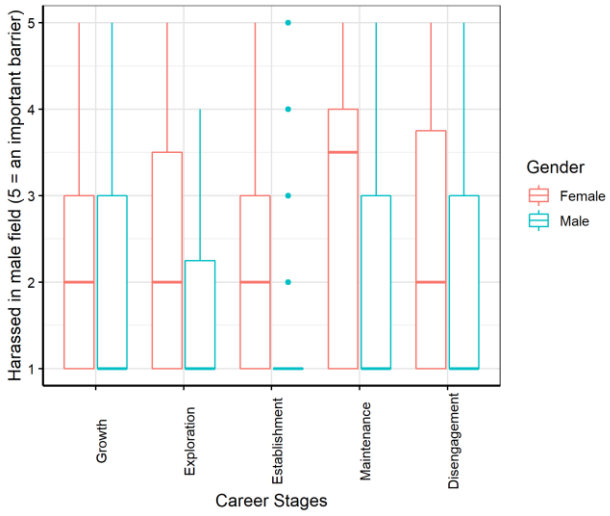

Figure 7. How much "I feel harassed in a male-dominated field" is a barrier by career stage by self-identified career stage and gender

DISCUSSION

Unsurprisingly, teens and female teens (15-18) were less concerned than adults (25-44) and male adults about "it's too late for me to learn something new." We expected (H7b) that "too late" might be a barrier for both males and females in the maintenance group (45-64), but that was not significant. An area for improvement regards "I don't even know what a cybersecurity career is." Young adults (19-24) across both genders, more than adults (25-44) were uncertain about cybersecurity as a career. Educational opportunities can remedy this.

On a positive note, parental approval is less of a barrier for young adults (19-24) and specifically young adult females than adults (25-44) or male adults. This was expected to be a concern for people of that age group (H3b). We also expected that young adult females would be concerned about the "lack of cybersecurity teachers like me" (H3d, H4c). However, we found that male adults responded with a higher rate of concern. Still, we think that more female teachers in cybersecurity will help as role models and mentors for young adult females.

Three of our findings confirm H6b that young female adults (19-24) and female adults (25-44) are concerned "I will feel underestimated in a male-dominated field." Females who identify in the maintenance career stage (but are not necessarily 45-64) are worried about being harassed in a male-dominated field. A two-pronged approach to fix this is to try to get more females into the field, making it no longer male-dominated. However, in the short term, we must figure out how to reduce the feeling. This would be a good area for future research.

Limitations

The questions that helped determine the "disengagement" career stage may have been more confusing than helpful. While eight people in our samples fell into that category based on age, 112

people self-identified as such. Similarly, 62 people identified as maintenance stage, but only 33 were grouped based on age. Based on these differences, perhaps the self-identification process was unclear and may have caused subjects to choose the wrong category.

It is also possible that educational settings or practices confound gender or age differences. Future research should attempt to separate the two variables.

Implications for research

It would be helpful to understand better why females are underestimated in this male-dominated field and what could be done to reduce that problem. Are there long-standing stereotypes at play or a few seminal examples that pervade the whole career space? Is there a critical mass tipping point at which gender becomes a non-issue in this field?

Implications for practice

There is a need to improve communication to increase awareness of what a career in cybersecurity is. Cybersecurity camps for teens and young adults are a good step in the right direction. Partnerships between academia and industry and following up with close industry mentoring could make a difference. While less critical, increasing the number of female teachers would be helpful. The area of highest concern is that the cybersecurity industry as a whole needs to change the expectations and treatment of females. Harassment should not be tolerated. Culture change is difficult but essential.

CONCLUSION

There are some barriers for girls and women choosing careers in cybersecurity. Improvements can be made in the areas of career awareness. Cybersecurity professionals need to do a better job ensuring female employees are not underestimated or harassed. Partnerships between academia

and industry can provide the best outcomes in increasing the number of cybersecurity workers, especially female adults and young adults.

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