Examining Barriers to Entry: Disparate Gender Representation in Cybersecurity Within Sub-Saharan Africa

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Abstract: Globally, women are underrepresented in the fields of Science, Technology, Engineering and Mathematics (STEM). In Sub-Saharan Africa (SSA), this underrepresentation is even more prevalent, as fewer women pursue STEM careers in SSA when compared to the global norm. Cybersecurity is a critical subsection of STEM; one that is widely accepted as a field with enormous growth potential, yet only a small proportion of these jobs belong to women. Despite attempts to narrow the gender gap in cybersecurity, persistent factors still contribute to this disparity. Within this field, developing countries struggle with the same issues that impact their more developed counterparts. Issues that impact both SSA and the global participation of women in cyber-security include lacking representation and awareness as well as retention problems. Further, issues such as harassment, gender bias and the idea that cybersecurity is a "man's world" are also contributing factors. A slew of other factors is also at play in SSA; this includes issues of low school attendance by girls, restricted educational opportunities, and other systemic challenges. Girls and women are less likely to complete lower and secondary education, which has a ripple effect – fewer women reach higher education in SSA when compared to global trends. Generally, higher or tertiary education is necessary to join the cybersecurity workforce. Research exploring the challenges women in SSA face when trying to enter the cybersecurity field is limited. This paper presents an overview of the most persistent challenges faced in SSA and globally. It highlights the current skill shortage in the cybersecurity field that is exasperated by global challenges, including issues unique to the region. Educational pathways available to girls and women are explored, as well as the issues leading to widespread skill shortages within SSA. Programs striving to increase the participation of women in cybersecurity are discussed. Lastly, some suggestions to remediate this pervasive issue are also provided.

Keywords: Women in STEM, Cybersecurity, Representation, Minorities, Gender equality, Sub-Saharan Africa

1. Introduction

Though women[1] are underrepresented in Science, Technology, Engineering and Mathematics (STEM) fields globally, sub-Saharan Africa (SSA) is lagging even worse behind (Dube, 2015). Numerous factors contribute to this issue; this includes educational issues (school attendance, educational opportunities), issues faced when entering the workplace (inclusivity issues in recruitment, delayed career advancement) and finally systemic issues (gender bias and discrimination). School-attendance statistics indicate that young girls are being left behind, and limited educational pathways and programmes further exasperate the pervasive, systemic challenges (UNESCO, 2021).

The worldwide disparity in gender representation is alarming, as STEM fields are often referred to as jobs of the future (U.S. Bureau of Labor Statistics, 2021). Yet, a substantial portion of the population is still struggling to break through the barriers to entry. Cybersecurity roles require candidates with specialised skill sets, of which STEM backgrounds are a quintessential element. Within SSA, school-attendance is much lower than in other regions, with a knock-on effect resulting in fewer individuals being educated in STEM-related fields. Subsequently, fewer cybersecurity professionals are being produced. The International Information System Security Certification Consortium (ISC[2]) published that women in the global cybersecurity workforce remains at only 25% (ISC2, 2021). Considering the reduced number of cybersecurity professionals trained in SSA, compounded with a global underrepresentation of women in the field, women in Africa are left in a particularly unfortunate situation.

It is imperative to highlight the critical issues of low rates of female participation in the field of cybersecurity. To understand how this disparate situation has arisen, it is important to determine which factors are at play globally, as well as within the context of the African continent. In this paper, the pertinent factors perpetuating the gender gap in cybersecurity are discussed. Figure 1 illustrates the factors specific to SSA, as well as global factors, that lead to fewer women in cybersecurity.

[1] Gender theory has attempted to make important developments toward being more inclusive, rather than perpetuating the male/female binary. While this study acknowledges these important advancements in gender theory, differing gender expressions have not been considered within this study, due to a lack of reliable data regarding these topics.

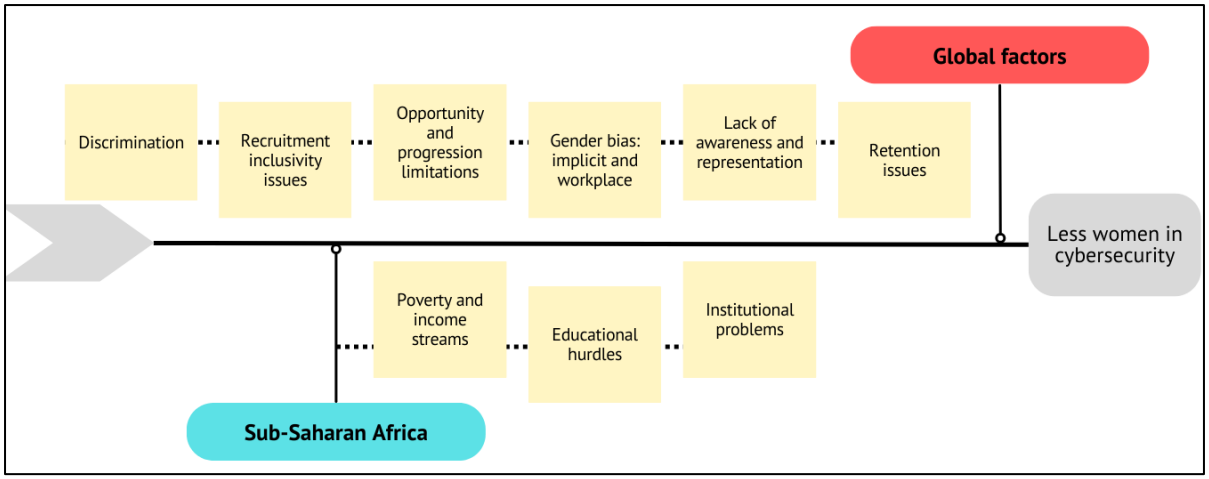

Figure 1: Leading Factors Contributing to low Rates of Women Entering Cybersecurity Domain

Section 2 examines the factors affecting the global cybersecurity gender gap, as summarised within the above figure. In Section 3, the factors exasperating the issue within SSA are considered. Finally, Section 4 provides some recommendations to help combat disparate gender representation.

2. Global Cybersecurity Landscape

While the cybersecurity threat landscape continues to grow at a rapid rate, the participation of women in cybersecurity has not increased accordingly. At a global level, several factors influence the slow introduction and retention of women within cybersecurity fields.

2.1 Discrimination

In the workplace, unfavourable attitudes toward women can create a toxic working environment. The fields of IT and cybersecurity can be affected by cultures hostile to women (Poster, 2018). Examples of this discriminatory behaviour are rife at cybersecurity conferences. While staying up to date regarding new security threats is imperative to a cybersecurity professional, these conferences do not present a safe space for women. Dominated by male attendees, women can be outnumbered 100 to 1 in attendance. Blackhat and Defcon are held in Las Vegas annually; it has been reported that some female attendees have experienced demeaning and objectifying interactions and have even been asked if they were secretaries or sex workers. Some have even indicated that they were sexually harassed at these events (Poster, 2018). This type of behaviour demonstrates the recurring attitude that women do not have the aptitude to operate in the cybersecurity domain; they were assumed to form part of the supporting staff. Furthermore, Poster shows that more than half of the women in cybersecurity around the world (51%) indicated that they have experienced gender discrimination, compared with 15% of male respondents. From unwarranted advances to name-calling, women are facing discrimination in many cybersecurity spaces.

2.2 Inclusivity Issues in Recruitment Practices

Most careers in cybersecurity start off in various other sectors, with skills being learned on the job (Frost & Sullivan, 2017). However, many hiring managers and HR still view individuals with backgrounds in computer science, engineering, and other STEM fields as the most qualified cybersecurity candidates, often ignoring those with degrees in other areas (Maiget, 2022). This is concerning, as more men have degrees in STEM fields relating to computer science and engineering than women (Hill, Corbett, & St. Rose, 2010). Skills gained in other sectors can help broaden cybersecurity teams and can also aid decision-making, risk-management, or analytics. Current recruitment practices hinder the inclusion of women due to insistence on existing experience in the field (Tarun, 2019). Job listings and hiring practices need to be cognisant of avoiding gendered terminology; Tarun presents studies that have found that almost twice as many male-gendered terms were found within job advertisements related to cybersecurity job openings.

2.3 Issues in Opportunity and Progression

Women may not enjoy the same access to Information and Communications Technology (ICT) as their male counterparts. The International Telecommunication Union (ITU) reports that, globally, 48% of women are using the Internet, as compared to 58% of men (ITU, 2019). In some areas around the world, the gender gap is almost

nullified with regions like Europe and the Soviet Union making great strides to close this gap. However, in Asia, the Middle East and particularly Africa, the gender gap has grown between 2013 and 2019 (Brown & Pytlak, 2020). Numerous factors play a role in influencing the ability of women to gain access to ICT, a crucial building-block in eventually joining cybersecurity fields. This may include geographical location, race, educational background, financial status, culture, and ethnicity. This shines a spotlight on the disparity and discrimination that women face in gaining meaningful access to critical resources for upliftment into the ICT field. Women may also face challenges in finding mentors for professional advancement (Bagchi-Sen, Rao, Upadhyaya, & Chai, 2010). Researchers Bagchi-Sen *et al*. highlight other factors such as work-family conflict, social expectations for women and early career barriers; These barriers include a lack of effective training, hindering their ability for career advancement.

Once women are employed within cybersecurity fields, they often face progression and retention issues. Women can be paid up to 21% less than men for comparable work (Fearn, 2020). Women may also struggle to advance or obtain training, essential in cybersecurity fields. Women may face more challenges in obtaining the advertised positions and later for career advancement due to various stereotypes and inclusivity practices.

2.4 Gender Bias: Implicit and Workplace

Cybersecurity firms are often perceived as "An Old Boys Club." Toxic working environments often impact women the most, where biases can result in prejudices against different demographics. Implicit and workplace bias is prevalent – women are often unfairly judged to be less competent than their male counterparts. Women also tend to be seen as less likeable as they are performing a "masculine job," some studies have found (Hill, Corbett, & St. Rose, 2010).

Women in STEM are most likely to encounter gender disparities at work. Study respondents have indicated that discrimination they have experienced includes being treated as incompetent, experiencing repeated, small slights at work, and receiving less support from senior leaders, compared to their male counterparts (Funk & Parker, 2018).

Within the workplace, performance support bias is often encountered. Employers, managers, and colleagues may provide support and resources more freely to men instead of women. Performance review and reward biases, even in merit-based evaluations, are often skewed in favour of men over women. The entire cycle of job application can be riddled with biases; from job descriptions, interview questions, and the attitudes of hiring managers. Microaggressions, such as being talked over in the workplace, affect women disproportionately (Reiners, 2022)

For working mothers, inequalities are even worse. The outbreak of COVID-19 exasperated the global cybersecurity skills challenge. Women's ability to continue working in cybersecurity fields at previous rates was affected at a time where the cybersecurity industry cannot afford to lose any more members, male and female alike (Budge J. , 2022). Working mothers are also much more likely to encounter pregnancy discrimination and unfair stereotyping (Reiners, 2022). Reiners further indicates that workplace gender bias can be reduced in several ways, such as enforcing or reviewing anti-discrimination and bias policies, identifying bias in recruiting practices and implementing regular gender bias training.

2.5 Awareness and Representation

To encourage the participation of women in cybersecurity, sectors should collaborate to raise representation and awareness. Primary school teachers and parents are amongst the most fundamental influencers in girl's interest in technology and cybersecurity. A study by CompTIA found that, while 27% of middle-school girls in the US may have considered careers in technology, this dropped to 18% by high-school (CompTIA, 2016). They found that 69% of girls who do not consider careers in technology attribute this to not knowing what these jobs involve. 53% indicated that further information and awareness would encourage them to pursue technology-related careers. Awareness, early exposure, and education are fundamental to increasing girls' confidence and interest in technology. Remediation could include supporting cybersecurity education in primary schools, offering internships during higher education and pairing women that have just started out in the field with mentors (Lingelbach, 2018).

Within cybersecurity firms, women are unequally represented in corresponding roles. A study found that in the US, 14% of Fortune 500 companies had female Chief Information Security Officers (CISO) in 2020. Lacking representation of women in the cybersecurity space can negatively impact the cybersecurity industry. Differing viewpoints and perspectives from women, who are commonly underrepresented, are critical in addressing

cyber-risks (Kshetri & Chhetri, 2022). Getting younger girls interested in technology by using inclusive methods may address issues of lacking awareness and representation in the long run. This is further discussed in Section 4.

2.6 Retention

The retention rate of women in cybersecurity is significantly lower than that of men. The study by Willis-Ford found that perceived barriers to the retention of women in cybersecurity roles include lacking mentorship, perceived hostile working environments and impostor phenomenon issue (Willis-Ford, 2018).

A study by Hill *et al.* investigating retention issues found that women who left STEM-related jobs cited family-related reasons more than men. Further, women in STEM are more likely to have a partner in STEM-related fields; if this partner is a man, their career will often be giver priority (Hill, Corbett, & St. Rose, 2015). The worldwide cybersecurity skills shortage remains and is further exasperated by the global COVID pandemic. Cybersecurity also faced a hidden epidemic impacting women's ability to continue working at pre-pandemic level, as many took on a disproportionate number of childcare responsibilities (Budge J. , 2022). Since lockdown was imposed in many nations, women were now faced with simultaneously managing work requirements and childcare duties.

Women have reported to be disproportionately impacted by the pandemic. For example, one in four women reported job losses due to a lack of childcare, which was double the rate of male job losses (Maiget, 2022). For women with, or without childcare responsibilities, retention rates must be improved. Issues concerning environments that are perceived as hostile to women must also be addressed.

3. The Sub-Saharan African Cybersecurity Landscape

Severe skill shortage, particularly in STEM, is a challenge to achieving sustainable and comprehensive economic growth in Africa (Kayode, 2018). In SSA, a gender imbalance across all educational levels has been documented. Contrary to countries with relatively higher levels of income, women are less likely to pursue higher education in countries with lower levels of income. The highest gender disparities are found in low-income countries (Huyer, 2015).

3.1 Poverty and Income Streams

The only region in the world that has had a recent increase in the percentage of children-out-of-school, is SSA; between the years 2018 and 2020, the figure rose from 35.9% to 36.6% (Brixi & Rawlings, 2022). Leading factors contributing to lower school attendance is twofold – long travelling distances to school, as well as insecurity in terms of getting to school. While urban areas have the largest concentration of schools, rural areas do not have enough schools to serve all the students fairly and with ease. In certain political climates, parents have indicated that they are unwilling to send girls to school if it is too large a distance from home, as they fear for their safety; worries include the dangers of kidnapping, rape, molestation, and other forms of abuse.

Further, SSA is home to the largest population of poor individuals in the world, which has proven to decrease the number of children attending school. Studies have indicated that poverty weighs more on girls than on boys, where net school attendance has the greatest disparity among poorer households; If all children in a family cannot be sent to school due to economic restraints, boys will most likely be given precedence over girls (Ombati & Ombati, 2012).

3.2 Education in SSA

Largely because of poverty within SSA, education in SSA is one of the most prevalent hurdles to joining the cybersecurity workforce. Most cybersecurity occupations require a higher-level education, such as a diploma, bachelors equivalent or postgraduate degree; about 88% of cybersecurity job postings require a bachelor's degree (or higher) as well as at least 3 years of job experience (Markow, Bittle, & Liu, 2019). SSA is lagging compared to the rest of the world in the completion of primary school, let alone obtaining higher education (Bennell, 2021).

While women outnumber men in university enrolment in some SSA countries, they are less likely to major in STEM at tertiary levels (Hammond, Matulevich, Beegle, & Kumaraswamy). Other countries in SSA have low rates of postsecondary educational attainment for men and women alike, with women being even less likely to be enrolled in university programmes.

In terms of educational attainment, it was found within the Gender Gap Report that SSA ranks the lowest globally; the region has an average gender gap of 0.689 between men and women when regarding the education attainment subindex (World Economic Forum, 2022). This subindex describes the gap between women's and men's access to education. It factors in the ratios of women to men within primary-, secondary- and tertiary-level education. A score of 1 indicates gender parity, and 0 complete disparity. SSA ranks sixth out of the eight global regions on the gender gap scale. This regards factors such as economic participation, health, political empowerment, and educational attainment. SSA suffers from these gender gaps in many ways, particularly with gender gaps in the workforce posing a significant and emerging crisis (World Economic Forum, 2022).

Further, the number of people enrolling in tertiary education in SSA is much lower, compared with the global average, as seen in Figure 2. Only 8,2% of women in SSA enrolled in tertiary education; note that this figure does not indicate if the schooling was completed. This is a distressingly low enrolment rate, compared with the global average excluding SSA. Lacking education for both men and women in SSA is a leading factor to lower participation rates in cyber security careers.

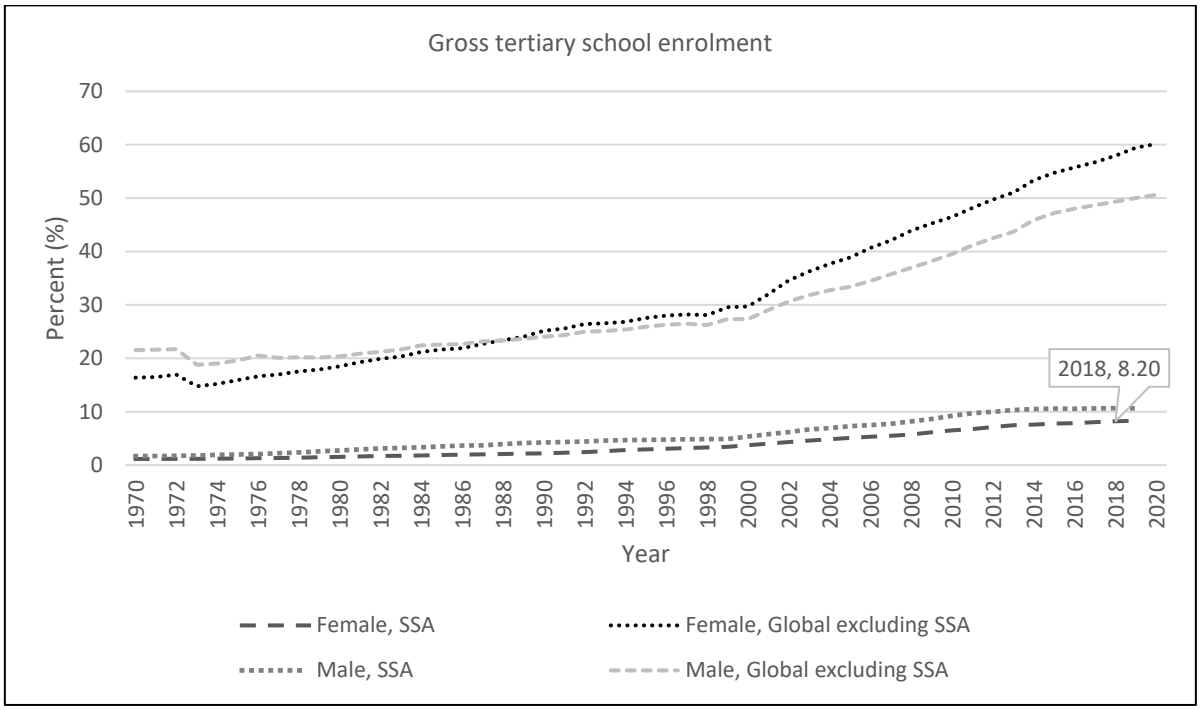

Figure 2: Gross tertiary School Enrolment, SSA and Globally (UNESCO Institute for Statistics, 2022)

Within SSA, women are less likely than men to study STEM- or information security-related programmes, as illustrated in Figure 3.

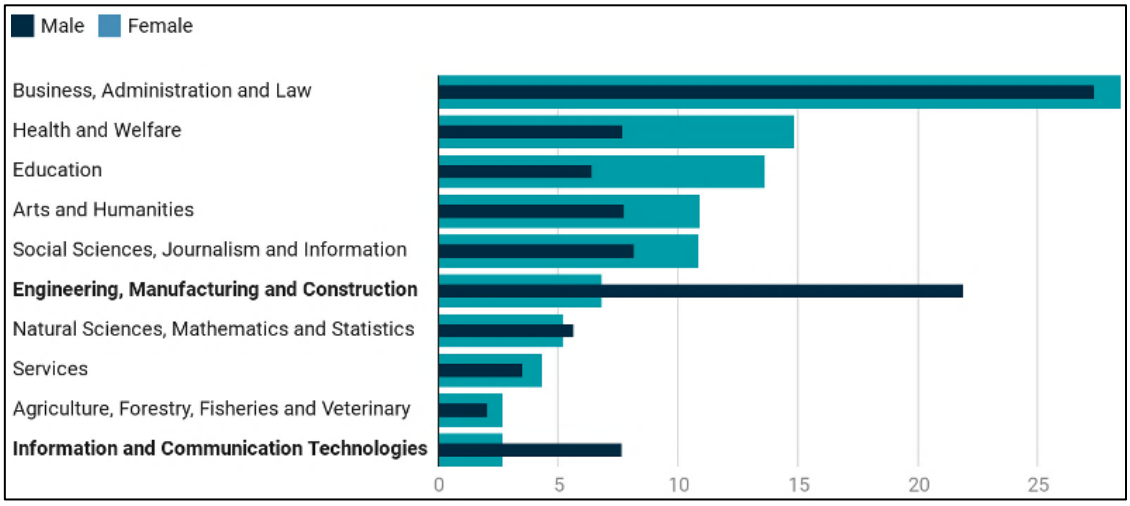

Figure 3: Student Enrolment per Career Program (%) (Santos & Rubiano-Matulevich, 2019)

The disparate representation of women in STEM programmes has been linked to lacking information regarding the possible opportunities to be found within the field. Biased gender norms, often starting during childhood and other psychosocial factors explain these dynamics further (Santos & Rubiano-Matulevich, 2019).

3.3 Institutional Problems

Educational gender inequality in SSA can also be linked to patrilineal systems, where property is passed on by the male lineage within a family; these systems are common in some areas of SSA and are likely to produce gender discrimination in favour of boys (Baten, de Haas, Elisabeth, & Meier zu Selhausen, 2021).

Regarding some traditional and religious practices within SSA, early marriage and teenage pregnancy can also negatively impact the progression of females within the workplace. Early marriage practices, whilst illegal, are still a barrier to educational attainment because of possible early engagement in parental duties. Teenage pregnancies significantly contribute to high-school drop-out rates. Many schools in SSA allow the expulsion of pregnant girls, at the expense of their education (Ombati & Ombati, 2012). Adolescent pregnancy is persistently high in SSA, linked to various sociocultural, environmental, and economic factors within the region; young girls are disadvantaged because of this (Yakubu & Salisu, 2018).

If women manage to enter the workforce in SSA, various issues are yet again at play. Institutional power relations within the region are often underpinned by patriarchal, capitalist, and neo-colonial values (Liani, Nyamongo, Pulford, & Tolhurst, 2021). Participants within the study by Liani *et al.* indicated various institutional problems faced by many women within SSA. This includes

- Research and educational funding uncertainties, coupled to race and gender,
- Insufficient social resources and a lack of mentor opportunities,
- Inflexibility of work culture and policies,
- Pressure and negative stereotypes or attitudes at work toward “career women”,
- Gender bias at the workplace, particularly for younger women who are “likely to go on maternity leave”, making them “useless” to the organisation,
- Sexual harassment, bullying and intimidation and insufficient awareness of harassment policies at work.

Considering the slew of factors women in SSA face to enter a STEM workforce, it is unsurprising how few women are participating within the cybersecurity workforce.

4. Closing the gap

To address the scarcity of women in cybersecurity, various groups must address the lack of opportunities afforded to women. Critical stakeholders, such as government, industry and academia must implement strategies to address the myriad issues deterring women from entering this workplace (Burrell & Nobles, 2018).

While global perspectives and recommendations to close the gender workforce gap certainly apply within the SSA-context, further steps may be required to address the gender disparity. Within SSA, the most prominent hurdle that must be overcome is increasing female participation in higher education. A sizeable challenge remains in accessing equitable, quality education for adolescent girls. Further policymaking and interaction with various stakeholders must continue to attempt to close the educational attainment gap (UNESCO, 2022).

A leaky pipeline of women in cybersecurity has been discussed; women are not well-enough retained in cybersecurity environments. Various considerations can be made to retain or recruit a more diverse workplace. To improve and encourage female workforce participation within cybersecurity, the ISC^2 Cybersecurity Workforce Study has indicated that the top investments to address for women are (ISC2, 2021):

- Invest in training,
- Providing more flexible working conditions,
- Invest in certifications,
- Invest in diversity, equity, and inclusion initiatives,
- Hire for attitude and aptitude and train for technical skills,
- Provide well-defined career paths,
- Encourage women and minorities to pursue STEM degrees in college,
- Establish organisation diversity goals,
- Establish mentorship programs,

- Address promotion gaps if they exist within an institution.

All these initiatives can help promote women pursuing cybersecurity careers and thus contribute to the global cybersecurity workforce. Because of the family responsibilities that many women undertake, another key initiative would be the provision of flexible working conditions. The ISC^2 Cybersecurity Workforce Study also shows that such a provision would help to diversify cybersecurity (ISC2, 2021). Flexible working conditions would afford women the opportunity to organise scheduling, work times and environment to still handle family responsibilities, if necessary. Strict onsite requirements with set hours disempower both men and women to be able to tackle family-related matters. Recent studies have found that women, much more than men, must adjust their careers for family-related matters and experience significant career interruptions as a result (Schaeffer, 2022).

Further, numerous initiatives to provide mentoring and training of young, female cybersecurity talent can help address this shortage. Many universities, non-profit organisations and professional bodies have initiatives to foster mentor and mentee relationships. Within SSA, "Women in Cyber" is an initiative targeting women residing in East Africa, offering training and assistance. These initiatives can address issues of lacking role models, as well as provide women with critical skills needed to enter the cybersecurity workforce.

It is essential that cybersecurity becomes more receptive welcoming women. A key contributing factor is the usage of real-world applications and exposure to industry. One of the solutions in this domain could be learning factories. To support investment in training, learning factories can provide much-needed skill improvements. Learning factories can be run by organisations to provide learning activities, real-world applications, information sharing and skills development. It affords graduates, workers, and new employees the opportunity to be exposed to key activities that will support their career growth and development. A learning factory can assist with action- and practice-based learning to strengthen the learner's ability to apply themselves within a practical environment.

Other techniques that should be adopted to help recognize the efforts of women include (Poster, 2018) (Maigret, 2022):

- *Acknowledge the contributions of women*. The list of women contributing to STEM is much longer than the public may believe. Raising awareness of the invaluable contributions women have made to STEM and cybersecurity is crucial to promoting the participation of women in cyber. Contributions are often overlooked and under-appreciated (Austin, 2022). For example, during the Second World War, it was not public knowledge that around 10,000 women carried out message decryption. Furthermore, there have been various female scientists like Hedy Lamarr and Elizabeth Smith Friedman, who invented encryption methodologies that were applied in various military equipment at the time.
- *Recognize diverse expertise*. Both men and women can bring diverse skillsets to a team. Diverse teams with differing viewpoints tend to be more creative and resilient.
- *Encourage young women to pursue STEM-related degrees and careers from an early age*. Parents and teachers must encourage young girls to consider these fields, as there are ample opportunities within the ever-expanding STEM disciplines.
- *Create mentorship programs at various levels*. These can be introduced as early as primary school to provide successful models for girls; and can be implemented at any level of development, even for junior professionals.
- *Dismantle bias in hiring practices and train all employees equally*. Workplaces should not just afford these opportunities to executives; all employees should feel involved, valued, and respected.
- *Prioritise creating and supporting leadership positions for more women***.** Active leadership promotion for women so that women can also gain experience concerning project and management responsibilities.

5. Conclusion

The pervasive and systemic challenges faced by women in SSA and within a global context have brought about a gender-asymmetric workplace within the cybersecurity field. While women in SSA face the same barriers to entry, some unique experiences further exasperate their situation. Issues of gender bias, discriminatory recruitment practices and delays in opportunity and progression influence gender representation in cybersecurity negatively. Additionally, within SSA, widespread poverty, a lack of educational pathways and other institutional problems further disadvantage women's participation in STEM fields. Techniques to close this

gender gap have been outlined; however, without active support from various stakeholders, this gap may persist. Holistic programs must be developed to help balance the gender disparity in cybersecurity, both in SSA and globally.

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