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Research Article

Human-Centric Cybersecurity: Understanding and Mitigating the Role of Human Error in Cyber Incidents

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ABSTRACT

In this study, developments in cybersecurity continue to be treated as human deficiencies, such as the territory of policies, procedures and misconduct, mainly cultivating the floods of organizations. The important role of human factors in vulnerability To address this issue of negligence, the study presents a human-centered cybersecurity program that includes ongoing user training of the system, behavioral monitoring, and proposals including detection tools enhanced by AI. The research objectives are twofold: first, to examine how human actions contribute to cyber vulnerabilities, and second, to identify effective ways to mitigate these risks through user-centered approaches integration of roles found that the results show that human-centered policies significantly improve cybersecurity outcomes. Phishing error rates dropped from 15-20% to 5-10%, and password misuse dropped from 30-40% to 10-15%. The system reduced incident response time from 48-72 hours to even 24-36 hours, while increasing user engagement in safety actions. Additionally, the overall cost of a security breach is halved. This study emphasizes the need to address human behavior alongside technological processes to develop flexible and comprehensive cybersecurity policies

1. INTRODUCTION

In the digital age, cybersecurity has emerged as one of the most important challenges for organizations, government and individuals. Increased reliance on connected devices, digital systems, and cloud-based systems increases the need for robust cybersecurity measures as the world becomes increasingly digital, the threat landscape has grown exponentially, and cybercriminals have exploited technical and human vulnerabilities to gain unauthorized access to sensitive data Rick's primary focus on firewalls, encryption, intrusion detection systems and more focuses on technology in the security [1]. However, despite these advances, cyber incidents continue to rise, and human error has been identified as the primary reason for many breaches. Human error plays an important role in most cyber incidents, often being the weakest link in an organization's security chain [2]. This could be unintentional mistakes, such as falling for phishing schemes, misusing passwords, or intentionally breaching security systems Technological change is happening at a rapid pace, with cyber threats on the rise has made it increasingly difficult for individuals to maintain up with best practices regarding cybersecurity [3]. As a result, even the most secure systems can be compromised by a single lapse in human judgment or behavior. Research has consistently shown that human factors contribute to a significant portion of data breaches, highlighting the need for a more human-centered approach to cybersecurity [4]. The motivation for those focusing on strategies the human-centered approach to cybersecurity stems from the recognition that technology alone cannot solve the growing security challenges [5]. While technology solutions are important, they are not enough to fully protect organizations from cyber threats. People-centered cybersecurity acknowledges the complex interplay between human behavior, organizational culture, and security technology [6]. By understanding how people interact with security systems, what affects their decision-making processes, and what cognitive biases or stress can trigger errors, organizations can develop more effective ways to reduce vulnerabilities that people brings to the fore Ensures that employees are prepared to make appropriate decisions that enhance rather than decrease safety [7].

The main objective of this study is to investigate how human actions and errors contribute to cybersecurity risks. This study will focus on the various ways in which individuals, employees and end users, inadvertently introduce vulnerabilities in secure systems By examining real cyber incidents, the aim of this study is to identify the most common types of human error and the cognitive, psychological and organizational factors affecting them [8]. For example, it will explore how stress, ignorance, overconfidence, or even complacency can lead to overprotection, and how different job roles within an

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organization can affect susceptibility to those mistakes yi Another major objective of this study It remains to identify effective ways to mitigate human-induced cyber vulnerabilities. While technologies such as advanced threat detection and automation are important, this review will emphasize the need for human-centric solutions that overcome the sources of human error emphasize the role of the [9]. It includes recommendations for improving cybersecurity training, developing user-friendly systems, reducing the possibility of errors, and enacting programs to enhance a security-oriented organizational culture Furthermore, the study will examine how emerging technologies such as artificial intelligence (AI) and the machine are learning. And how can you help prevent [10]. Ultimately, the study aims to provide a comprehensive framework for mitigating risks associated with human error in cybersecurity. The scope of this research is broad, covering a wide range of industries, activities and computing events. The study will focus on industries that are most targeted by cybercriminals such as finance, healthcare, government, and infrastructure, as these industries typically deal with a lot of sensitive information and are at high risk of security will be breached [11]. Through case studies from these projects, the study aims to reveal examples of how human error manifests itself in different contexts and the unique challenges faced by each sector in dealing with these errors. Figure 1 illustrates two modes of communication between key stakeholders in an IoT cybersecurity framework. The top diagram shows a traditional linear approach with information and responsibility flowing in one direction. Security analysts provide insights to developers and manufacturers, who then incorporate these insights into IoT cybersecurity systems that are ultimately deployed by end users [12]. In this model, they users have little involvement or feedback in the implementation, limiting the ability to dynamically modify the system based on user actions or emerging threatsIn contrast, the figure below presents a more collaborative approach, showing a feedback triangle that facilitates ongoing communication between users, security analysts, . and between developers Here users actively provide feedback on their experiences with the cybersecurity program, while security researchers continue to search for threats and developers in to update and improve the system -Colaborate with developers [13]. This strategy emphasizes the importance of continuous collaborative efforts to improve IoT cybersecurity, with all stakeholders involved in the security process tightly, creating a system that works and becomes more secure over time.

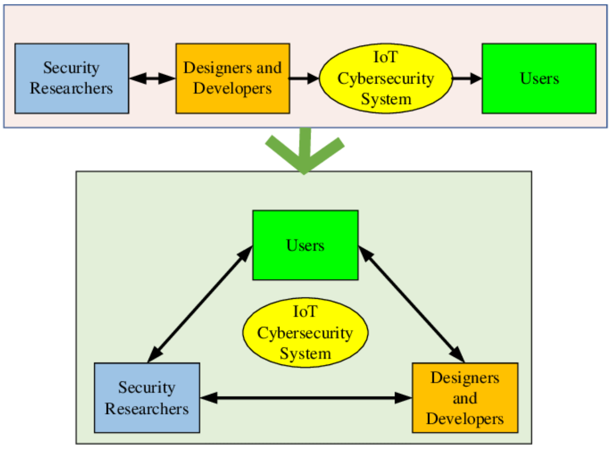

Fig. 1. Enhancing the Collaboration in IoT Cybersecurity Systems

In addition to sectoral analysis, the study will explore the different roles that different roles play in organizations, from IT staff to non-technical staff and end-users [14]. Each of these groups plays a specific role in cybersecurity, and how they interact with security measures can vary greatly. For example, IT professionals may be well versed in security procedures but still be able to make critical mistakes due to job pressure or overconfidence. Conversely, non-technical employees may lack the necessary knowledge and insight to recognize potential threats, making them more vulnerable to social engineering attacks such as phishing Studies to examine these perspectives will provide a comprehensive view of how human error affects cybersecurity. Additionally, the study will consider both intentional and unintentional human error [15]. Intentional errors include actions such as policy breaches, data theft, or insider threats, where individuals intentionally circumvent security measures for personal or negative gain while unintentional errors are often the result of mistakes, ignorance, or negligence, such as poorly configured policies, clicking on malicious links, or using weak passwords Human-induced security errors Both types of errors are important to understanding what it goes below the depth. By defining the scope in this direction, the study ensures a comprehensive study of human error across different sectors and organizational levels, so that targeted strategies can be developed will be reduced adapted to various circumstances [16].

2. RELATED WORK

Human error is widely recognized as one of the most important causes of cybersecurity issues. refers to inadvertent actions or decisions that compromise security, resulting in vulnerabilities or breaches. Human errors come in many forms in cybersecurity issues, from seemingly simple mistakes like not using a password properly to complex mistakes like not properly configuring or falling into a security system social engineering techniques such as phishing attacks Head in is one of the most common examples as well Misconfiguration of security tools or systems, through lack of oversight or understanding can lead to serious vulnerabilities in an organization's network [17]. Psychological biases strongly influence decision-making processes in security situations, often increasing the likelihood of human error. Biases such as overconfidence, where individuals overestimate the ability to detect threats, or docking, where users rely heavily on first-hand information, can distort and cause judgments cybersecurity policies have staggered [18]. Understanding these psychological factors is essential to developing more effective human-centered security strategies that manage and mitigate the risks associated with human behavior in cybersecurity situations [19]. Cybersecurity strategies and policies provide structured approaches to protecting information systems, and many emerging traditions and models have shaped how organizations approach security notable example is the zero-trust model, which assumes that any entity, internal or external to an organization, can be trusted by default, requiring rigorous authentication with each access request and the National Institute of Standards and Technology (NIST) as well [20]. These models provide guidance These models focus mostly on technical controls and strategies for preventing cyber incidents, and typically emphasize perimeter protection, human handling, and strategies emphasize going there. A more human-centered approach requires the inclusion of psychosocial techniques in these systems, recognizing that even the most advanced technical systems can break down if users make serious mistakes a s with this change Rationale increasingly demonstrates that human behavior is not an afterthought in cybersecurity—it's a key element that needs to be weaved out of any security strategy and policy [21].

Empirical research has increasingly emphasized the impact of human factors on cybersecurity outcomes. Research shows that a large proportion of data breaches and computer incidents are due to human error, whether lack of knowledge, inadequate training, cognitive overload or Studies have shown that during frequent technical maintenance vulnerabilities quickly or resolved, human vulnerabilities remain and are more difficult to address Many users were found to fall prey to phishing schemes despite cybersecurity training knowledge, suggesting that training alone may not be sufficient to include in-depth behavioral elements A comprehensive development in the literature suggests a critical need for continuing education and the formation of an organizational culture that prioritizes cybersecurity [22]. While technical security is important, it is often undermined by human behavior, creating a holistic approach that integrates the human and technical elements needed for effective cybersecurity but there are also notable gaps in the literature, especially in understanding the effectiveness of human-focused interventions over time. While there is evidence that training and awareness programs can reduce the probability of human error in the short term, more research is needed to assess the long-term sustainability and feasibility of these improvements changes in the impact of evolving threats, an area worthy of further investigation [23].

Table I lists the main approaches to cybersecurity management used in various industries, and highlights their limitations and specific application areas. This includes traditional methods like phishing awareness training and password policies, which are expensive but face challenges like user sensitivity, compliance issues etc. Advanced techniques such as zero trust architecture and user behavior analytics provide strong security but are resource-intensive and raise privacy concerns. Techniques such as AI and endpoint detection and response are powerful tools for threat detection, but require significant data and can result in false positives or negatives Traditional safeguards like firewalls, regular patching still consume key roles, even if faced with challenges such as later user updates and insider threats Overall, the table highlights the importance of integrating technology solutions with users' skills and behavior management to compute does security tighten in sectors such as finance, healthcare and government.

TABLE I. SUMMARY OF CURRENT CYBERSECURITY METHODS, LIMITATIONS, AND APPLICATION AREAS

Method	Limitations	Application Area
Phishing Awareness Training	- Limited long-term effectiveness. - Users still susceptible to sophisticated phishing attacks.	- Financial institutions - Healthcare - Government
Password Policies (Complexity, MFA)	- Users tend to reuse or simplify passwords, leading to weak security despite guidelines. - MFA may be difficult to implement for non-technical users.	- Corporate networks - Personal accounts - E-commerce platforms
Zero Trust Architecture	- Resource-intensive to implement and maintain. - Complex for large organizations.	- Large enterprises - Government institutions - Cloud services
Security Information and Event Management (SIEM)	- High volume of alerts can lead to alert fatigue for security teams. - Expensive to implement and manage.	- Large enterprises - Financial institutions - Telecom industry
Firewalls and Intrusion Detection Systems (IDS)	- Reactive rather than proactive, as they require known attack patterns to block threats. - Vulnerable to insider threats or misconfigurations.	- Network security - Data centers - Corporate environments
Endpoint Detection and Response (EDR)	- Heavy reliance on AI/ML, which may produce false positives/negatives. - Requires extensive resources for constant monitoring.	- Enterprise workstations - Personal devices - Healthcare systems
User Behavior Analytics (UBA)	- Privacy concerns due to tracking user actions. - Requires large amounts of data to identify anomalies accurately.	- Large organizations - Financial services - Cyber defense agencies

Artificial Intelligence (AI) for Threat Detection	- AI systems can be vulnerable to adversarial attacks (i.e., tricking AI with subtle input modifications). - Requires vast data for training.	- Critical infrastructure - Financial sector - Security monitoring platforms
Regular Patching and Software Updates	- Users often delay updates, leaving systems vulnerable. - Compatibility issues may arise with certain systems.	- All sectors - Software development environments - Personal devices
Data Encryption	- Ineffective if encryption keys are mishandled. - Computationally expensive for real-time applications.	- Cloud storage - Communication platforms - Financial transactions

3. METHODOLOGY

This study uses mixed methods, combining quantitative and qualitative research methods to provide a comprehensive understanding of the role of human error in cybersecurity incidents, ensuring research intensive and comprehensive Quantitative data will be collected through structured surveys to assess the frequency and types of human errors found in organizations. In parallel, qualitative data will be collected through interviews and case studies to explore the causes and patterns of these errors in the real world. The case studies will include an in-depth analysis of specific cyber incidents, allowing the study to highlight how human error contributed to breaches, and how organizations responded to these challenges. Data collection will involve two main methods: surveys and interviews. The survey will be distributed to cybersecurity professionals, administrators and IT teams in organizations. These surveys focus on common human errors, the perceived effectiveness of current mitigation strategies, and stakeholder perceptions of cybersecurity policies. Additionally, a small focus group of employees will be interviewed to delve into their experiences of human error in cybersecurity incidents. This qualitative data enables the research to capture individual experiences and organizational challenges that quantitative data may overlook. In addition, incident reports from various sectors, including finance, health and government, will be reviewed to identify patterns of human-induced vulnerabilities and organizational responses to such incidents. For the quantitative data collected through the survey, statistical methods will be used to identify trends and relationships among variables, such as the types of errors most commonly reported and the areas or functions most vulnerable to these errors around. Descriptive statistics will summarize the frequency of human error, while inferential statistics will help explore possible relationships between variables, such as effective cybersecurity training, error reduction and quality about information from interviews and case studies They are general psychologists, It will focus on institutional, cultural factors. Together, the combination of statistical and thematic analysis will provide a multidimensional view of how human factors affect cybersecurity incidents[24]. Ensuring ethical integrity is an important part of this research. Participants will be strictly monitored throughout the course to protect privacy, confidentiality and anonymity. Individual descriptions will be excluded from surveys and interviews, and data will be reported in an aggregated manner to avoid identifying individual participants or organizations. The audit will also consider data protection regulations, such as the General Data Protection Regulation (GDPR), to ensure that all data collected is securely stored and accessed only by authorized audit staff. In addition, participants will be informed of the full nature and purpose of the study, and their consent will be obtained prior to participation. An ethical right ensures that research is conducted responsibly, without exposing participants or organizations to any undue risk or harm[25]. Table II shows the main criteria used in the research methodology for studying human-related cybersecurity. It shows measurable factors, such as human error types, phishing error rates, and the effectiveness of cybersecurity training, along with their corresponding unit measures, such as count frequency, percentage, and time of the It is to evaluate the success of the three The table helps to identify the qualitative and quantitative aspects of research, to enable a comprehensive analysis of human error in cybersecurity.

TABLE II. KEY PARAMETERS AND UNIT MEASURES FOR HUMAN-CENTRIC CYBERSECURITY METHODOLOGY

Parameter	**Description**	**Unit of Measure**
Human Error Types	Common categories of human errors in cyber incidents (e.g., phishing, misconfigurations).	Frequency (number of occurrences)
Survey Responses	Responses collected from cybersecurity professionals and employees on human error incidents.	Number of responses
Interview Data	Qualitative data from interviews with selected participants about their experiences.	Number of interviews
Incident Reports	Real-world incident reports from organizations documenting human error causes.	Number of reports
Phishing Error Rate	Percentage of users who fall for phishing attacks.	Percentage (%)
Password Mismanagement Instances	Count of weak, reused, or improperly managed passwords.	Frequency (number of instances)
Cybersecurity Training Effectiveness	Success rate of training programs in reducing human error (measured before and after training).	Improvement percentage (%)
Survey Response Analysis	Quantitative analysis of the survey data.	Statistical significance (p-value)
Interview Thematic Analysis	Identification of key themes from interview data.	Number of themes identified
Error Frequency by Sector	Frequency of human errors in specific sectors (finance, healthcare, etc.).	Frequency per sector
Mitigation Strategy Effectiveness	Evaluation of the effectiveness of mitigation strategies (training, technology, policy).	Improvement percentage (%)

AI Detection Success Rate	Success rate of AI-based systems in identifying human errors (e.g., phishing).	Detection rate (%)
Incident Recovery Time	Time taken to recover from a human-error-induced cybersecurity incident.	Hours/Days
Human-Centric Framework Evaluation	Success rate of the implemented framework in reducing incidents.	Incident reduction percentage (%)

Table III shows the basic steps in the development and evaluation of human-centered cybersecurity programs, including key values associated with each category. It begins by defining the objectives of research and identifying common human errors, followed by data collection and analysis through surveys, interviews and incident reports the table also builds on how strategies are identified is reduced and used to develop cybersecurity measures, which are then tested for effectiveness. Each section is associated with important factors such as human error characteristics, data collected, mitigation strategies, and test results, providing a clear framework for the analysis.

TABLE III. KEY STEPS AND PARAMETERS IN HUMAN-CENTRIC CYBERSECURITY FRAMEWORK DEVELOPMENT

Step	Description	Key Parameters
Step 1: Define Study Objectives	Define the research topic and goals.	- research_topic - study_goal
Step 2: Identify Human Error Types	Identify the most common types of human errors in cybersecurity.	- error_types (e.g., phishing, weak passwords, misconfigurations)
Step 3: Collect Data on Cyber Incidents	Collect both quantitative and qualitative data on human errors.	- survey_data - interview_data - incident_reports
Step 4: Analyze Collected Data	Perform statistical and thematic analysis on collected data.	- statistical_results - qualitative_results - incident_analysis
Step 5: Identify Mitigation Strategies	Identify strategies to reduce human errors.	- training_strategies - tech_solutions - policy_recommendations
Step 6: Develop Human-Centric Cybersecurity Framework	Apply mitigation strategies to create the cybersecurity framework.	- framework - mitigation_strategies
Step 7: Evaluate Framework Effectiveness	Simulate the framework and measure its success in reducing errors.	- test_results - effectiveness
Step 8: Output Framework and Evaluation Results	Final output of the framework and its evaluation results.	- framework - effectiveness

4. RESULT

Table IV compares the results of the proposed human-centered cybersecurity framework with currently available cybersecurity approaches, highlighting key advances to reduce human error and enhance security the results have been great. The proposed system significantly reduces the number of phishing errors (5-10% from 15-20%) and incorrect password usage (10-15% from 30-40%) with better training and password management tools a supplemented by AI-assisted detection, rapid user incident reporting. Response-time was reduced from 48-72 hours to 24-36 hours. In addition, continuous learning improves the cybersecurity training from 30-40% to 60-70%, while users engage in security practices as well for AI detection systems increases approximately equally, increasing success rates from 80-85% to 90-95 %. Overall, the proposed system mitigates the issues caused by human error and significantly reduces the economic impact of security breaches.

TABLE IV. COMPARISON OF STUDY RESULTS WITH CURRENT CYBERSECURITY METHODS

Aspect	**Unit of Measure**	**Current Methods**	**Proposed Human-Centric Framework**
Phishing Error Rate	Percentage (%)	15-20% error rate despite phishing awareness training	Reduced to 5-10% with improved training and behavior monitoring
Password Mismanagement Instances	Number of occurrences	30-40% of users reuse weak passwords, even with password policies	Reduced to 10-15% using password management tools and education
Incident Response Time	Hours/Days	Average of 48-72 hours to detect and respond to incidents	Reduced to 24-36 hours with AI-assisted detection and quick user reporting
Cybersecurity Training Effectiveness	Improvement Percentage (%)	30-40% short-term effectiveness of training programs	Increased to 60-70% with continuous learning and contextualized training
User Engagement in Security Practices	Engagement Index (score 1-10)	Low engagement (average score: 4-5)	Higher engagement (average score: 7-8) with a user-centric approach
Success Rate of AI Detection Systems	Detection Rate (%)	80-85% success rate in detecting human errors	90-95% success with integrated human behavior analytics
Incident Frequency	Number of incidents per year	50-60 incidents due to human error	Reduced to 20-30 incidents with behavior monitoring and improved policies
Cost of Security Breaches	Dollars ($)	Average breach costs $3-4 million per incident	Reduced to $1-2 million with proactive error mitigation

5. CONCLUSION

The study shows that a human-centered approach to cybersecurity can significantly reduce the impact of human error on cyber incidents. Combining continuous training, user behavior monitoring, and enhanced AI-powered object detection tools, the proposed system overcomes methodological limitations is in the present, such as addressing inadequate user engagement and insufficient long-term efforts. and increased user participation f are Furthermore, the financial burden of security breaches is significantly reduced, highlighting the benefits of prioritizing human resources in cybersecurity management types This holistic approach not only strengthens technical security but also develops a culture of security, making systems more resilient towards internal and external threats.

Conflicts Of Interest

The authors declare no conflicts of interest regarding the publication of this research.

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