

To report or not to report?

Extending Protection Motivation Theory to Vulnerability Discovery and Disclosure

Andrew William Green, Ph.D.

DeJarvis Oliver, Ph.D.

Amy B. Woszczyński, Ph.D.



**KENNESAW STATE
UNIVERSITY**
COLES COLLEGE OF BUSINESS
*Department of Information Systems
and Security*

Introduction

- Cybercriminals are motivated by financial gain from exploiting vulnerabilities, highlighting the urgent need for vulnerability discovery and remediation.
- Vulnerability researchers play a crucial role in identifying vulnerabilities, but they face a dilemma in deciding whether and how to report their findings.
- Vulnerability disclosure policies (VDPs) offer a potential solution by providing a safe and structured reporting mechanism.
- However, the adoption of VDPs by organizations remains limited, leaving researchers uncertain about potential legal repercussions and organizational responses.



Introduction

- Protection Motivation Theory (PMT) is proposed as a framework for understanding vulnerability researchers' decision-making processes.
- This study aims to adapt PMT to the context of vulnerability disclosure, exploring how factors like fear, rewards, and efficacy influence reporting intentions.
- The study will examine the influence of both personal and organizational threat appraisals on researchers' willingness to report.
- By understanding these factors, the study seeks to contribute to the development of effective VDPs and promote a culture of trust between organizations and vulnerability researchers.



Background

Laws, Regulation, and Retaliation

- Current US laws regarding cybersecurity, especially the CFAA and DMCA, are viewed by researchers as restrictive and inhibiting good-faith vulnerability research.
- Vulnerability researchers face risks of retaliation, including lawsuits and criminal charges, when reporting findings, especially concerning intellectual property.
- The US DOJ has attempted to clarify guidelines, but concerns remain about the definition of good-faith research and potential for civil claims.

Vulnerability Disclosure Policies

- VDPs offer a potential solution by providing a structured reporting mechanism and potential protections for researchers.
- However, VDP adoption remains limited, and the effectiveness of safe harbor provisions can vary.

Background

Protection Motivation Theory (PMT)

- PMT is a model that explains how fear appeals, threat appraisals, and coping appraisals influence behavior.
- It has been used in information security to promote employee compliance with cybersecurity guidelines.

Vulnerability Discovery and Disclosure (VDD) Model

- The VDD model adapts PMT to the context of vulnerability disclosure, focusing on how fear, rewards, and efficacy influence reporting intentions.
- It explores both personal and organizational threat appraisals and how they impact researchers' willingness to report.



Methodology

Expert Panel Review

- An expert panel consisting of two experienced vulnerability researchers and two cybersecurity academics was consulted to refine the survey instrument before distribution.

Power, Sample Size, and Effect Size

- Using effect sizes from prior studies, a sample size of 30-130 respondents was estimated to be sufficient for detecting effects.
- A target sample size of around 100 respondents was set.

Survey Distribution

- The Vulnerability Discovery and Disclosure (VDD) survey was disseminated using a 7-point Likert scale in Qualtrics.
- Survey items were modified from previously established scales where possible, but the survey was primarily exploratory.



Data Analysis

Invalid Data Resolution

- Survey bots were detected based on suspicious response patterns and timestamps.
- Data validation measures were implemented, including attention checks, completion rates, response times, and email validation.
- The final sample size after cleaning was 196 participants.

Respondents

- Respondents were US-based vulnerability researchers with diverse educational backgrounds, primarily holding 4-year degrees.
- The majority of respondents were White, male, and had an average age of 32.4 years with 7.1 years of experience in the field.
- The sample's representativeness was evaluated by comparing it to national statistics, revealing potential limitations in terms of race and ethnicity representation.



Data Analysis

Analytical Approach

- Harman's single-factor approach was used to test for common method bias (CMB), which was not found to be a significant issue.
- Principal components analysis (PCA) was employed for exploratory analysis and dimension reduction.

Principal Components Analysis

- PCA with varimax rotation resulted in 11 components explaining 74.613% of the total variance, exceeding the recommended threshold.
- Items were retained or dropped based on loadings, communalities, and Cronbach's alpha values, ensuring reliability and validity.
- Threat appraisals, coping appraisals, fear, and protection motivation intentions were analyzed separately, leading to the identification of a higher-order efficacy construct.



Results and Discussion

Threats

- The study found that vulnerability researchers do consider the potential harm to the organization (PSE-O) when deciding whether to report a vulnerability.
- This is a novel finding, as previous PMT research has primarily focused on personal threat appraisals (PSE-R).
- The results suggest that organizational threat appraisals are a significant factor in vulnerability disclosure decision-making.

Fear

- The study emphasizes the importance of reducing fear among vulnerability researchers to encourage reporting.
- Well-crafted VDPs, coordinated vulnerability disclosures, and safe harbor provisions can help alleviate fear and promote a culture of trust.
- Organizations should adopt a cooperative approach and consider offering bug bounties to further incentivize reporting.



Results and Discussion

Adaptive Rewards

- Adaptive rewards, such as recognition and bug bounties, are crucial for encouraging vulnerability disclosure.
- Organizations should clearly outline these rewards in their VDPs to attract and motivate researchers.
- The study suggests that well-defined VDPs can provide a sense of safety and increase the likelihood of reporting.

Efficacy

- The study found that self-efficacy and response efficacy combine to form a higher-order construct of perceived efficacy.
- This suggests that vulnerability researchers need to believe in their ability to report effectively and that their reports will be taken seriously.
- Organizations can enhance perceived efficacy by providing clear guidelines, points of contact, and assurances of protection.



Conclusion

Overall Conclusion

- This exploratory study analyzed how vulnerability researchers decide whether to disclose vulnerabilities, creating the VDD model based on modified PMT.
- The VDD survey was refined to 68 items through a rigorous process.

Theoretical Contributions

- Efficacy emerged as a higher-order construct, suggesting future research on providing instructions and policies to increase researchers' disclosure likelihood.
- The study introduced organizational perspectives (PSE-O, PVU-O), which were retained in the PCA analysis, indicating their importance in decision-making.

Conclusion

Practical Contributions

- Organizations should reduce fear through well-crafted VDPs, outlining clear reporting processes and protection measures.
- Adaptive rewards and a sense of safety can encourage reporting, benefiting organizations by identifying vulnerabilities early.
- User-friendly VDPs, written in clear language, are crucial for fostering positive collaborations with vulnerability researchers.

Limitations and Future Research

- The study used self-reports, which may have limitations despite efforts to minimize them.
- The non-probabilistic sample and the survey bot attack, although addressed, are limitations.
- Future research should explore ways to block survey bots, conduct qualitative studies on researchers' experiences, and gather data from organizational employees involved in VDPs.

