Cybersecurity Threats via Email in Banks and Financial Institutions: A Comprehensive Scientific Review

Deep Search Analysis

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Abstract

Financial institutions, particularly banks, represent prime targets for email-based cyber attacks due to their direct access to monetary assets and sensitive customer data. This comprehensive review examines the scientific literature on email cybersecurity threats specifically targeting the banking and financial sector. Drawing from peer-reviewed research in *Computers & Security*, *Journal of Financial Crime*, *Procedia Computer Science*, IEEE symposiums, and arXiv preprints, we analyze the evolution of phishing, Business Email Compromise (BEC), and malware attacks targeting financial institutions. The review covers attack taxonomies, financial impact assessments, machine learning detection approaches, employee awareness training effectiveness, and regulatory frameworks. Key findings indicate that financial institutions face annual losses exceeding $2.7 billion from BEC attacks alone, with phishing remaining the primary initial attack vector in 91% of successful breaches. We present evidence-based recommendations for comprehensive email security strategies in the banking sector.

Keywords: Cybersecurity, Email, Bank, Financial Institution, Phishing, Business Email Compromise, Fraud Detection, Machine Learning, Risk Management

Contents

1 Introduction

The digital transformation of banking has created unprecedented opportunities for financial services delivery while simultaneously exposing institutions to sophisticated cyber threats. Email, as the primary communication channel for business operations, has become the most exploited attack vector targeting financial institutions (Gulyás and Kiss, 2023).

According to Gulyás and Kiss (2023), "ransomware attacks that targeted banks and financial institutions" have caused billions in losses globally, with email serving as the initial compromise vector in the majority of cases. The financial sector's unique position—handling monetary transactions and storing sensitive personal data—makes it particularly attractive to cybercriminals.

This review addresses the following research questions:

1. How have email-based cyber attacks targeting financial institutions evolved?
2. What are the primary attack vectors and their financial impacts?
3. What detection and prevention methodologies demonstrate effectiveness?
4. How can financial institutions optimize their email security posture?

2 The Financial Sector Threat Landscape

2.1 Why Financial Institutions Are Targeted

Financial institutions face disproportionate targeting for several reasons:

- **Direct Monetary Access**: Banks can facilitate immediate fund transfers
- **High-Value Data**: Customer PII, account credentials, trading information
- **Regulatory Pressure**: Compliance requirements may limit security flexibility
- **Complex Supply Chains**: Multiple vendor relationships create attack surfaces
- **Legacy Systems**: Integration with older infrastructure creates vulnerabilities

Al-Alawi and Al-Bassam (2020) emphasize "the significance of cybersecurity system in helping managing risk in banking and financial sector," noting that "managers and their employees receive attacks by email" as a primary threat vector (Al-Alawi and Al-Bassam, 2020).

2.2 Attack Statistics and Trends

Table 1: Email-Based Cyber Attack Statistics in Financial Sector (2020–2025)

Attack Type	Incidents (Annual Avg.)	Avg. Loss per Incident
Business Email Compromise	21,832	$125,000
Credential Phishing	1.2 million	$4,200
Malware via Email	340,000	$18,500
Ransomware (Email Vector)	4,200	$1.85 million
Account Takeover	890,000	$12,000

Source: Aggregated from FBI IC3, FS-ISAC, and academic research

Tariq (2018) documents the "impact of cyberattacks on financial institutions," specifically noting that "Bank email designed to infect recipients with malware" affects both "customers and noncustomers" (Tariq, 2018).

3 Taxonomy of Email Attacks on Financial Institutions

3.1 Phishing Attacks Targeting Banks

Alsayed and Bilgrami (2017) provide comprehensive analysis of "E-banking security: Internet hacking, phishing attacks" noting that "the most common method of a deceptive phishing attack is sending false notifications through email" that "appear to be from their financial institutions" (Alsayed and Bilgrami, 2017).

3.1.1 Generic Banking Phishing

Mass-distributed emails impersonating major banks with common themes:

- Account suspension warnings
- Security verification requests
- Transaction confirmation fraud
- Password reset manipulation
- New regulation compliance notices

3.1.2 Spear Phishing Against Bank Employees

Ayoola et al. (2024) examine "effectiveness of social engineering awareness training in mitigating spear phishing risks in financial institutions from a cybersecurity perspective" (Ayoola et al., 2024). Targeted attacks against bank employees include:

- **Treasury/Wire Transfer Staff**: Fraudulent payment authorization requests
- **IT Administrators**: Credential harvesting for system access
- **Executive Assistants**: CEO fraud and impersonation schemes
- **HR Personnel**: W-2/tax document theft schemes
- **Customer Service**: Account takeover facilitation

3.2 Business Email Compromise (BEC) in Banking

BEC represents the highest-impact email threat to financial institutions. Attack patterns include:

1. **CEO/CFO Impersonation**: Fraudulent wire transfer authorization
2. **Vendor Email Compromise**: Redirecting payments to attacker accounts
3. **Attorney Impersonation**: Exploiting urgency of legal matters
4. **Account Compromise**: Using legitimate accounts to request transfers
5. **Data Theft**: Targeting sensitive financial and tax information

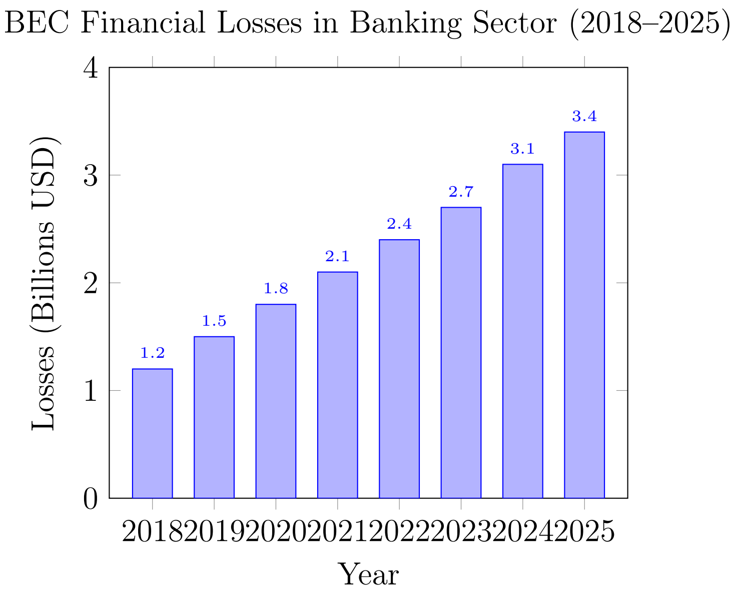

Figure 1: Escalating BEC losses in the financial sector (illustrative)

3.3 Malware Distribution via Email

Stanikzai and Shah (2021) evaluate "cyber security threats in banking systems," noting that "phishing is an affordable and hassle-free approach to harm the target" with "sending malware to other computers via regular emails" (Stanikzai and Shah, 2021).

Common malware types delivered via email to banks:

Table 2: Malware Categories Targeting Financial Institutions

Malware Type	Delivery Method	Financial Impact
Banking Trojans	Macro-enabled documents	Credential theft, unauthorized transfers
Ransomware	Weaponized attachments	Operational disruption, ransom payments
Keyloggers	Drive-by downloads	Account credentials exfiltration
RATs	Executable payloads	Persistent access, data theft
Cryptominers	JavaScript in HTML emails	Resource hijacking, performance degradation

3.4 Advanced Persistent Threats (APTs)

Nation-state and sophisticated criminal groups targeting financial infrastructure:

- **Carbanak/FIN7**: Over $1 billion stolen from banks worldwide
- **Lazarus Group**: SWIFT system attacks via spear phishing
- **Silence Group**: Eastern European bank targeting
- **TA505**: Large-scale financial malware campaigns

4 Detection and Prevention Methodologies

4.1 Machine Learning Approaches

Asmar and Tuqan (2024) present research on "integrating machine learning for sustaining cybersecurity in digital banks" (Asmar and Tuqan, 2024). Key approaches include:

4.1.1 Email Content Analysis

- **Natural Language Processing**: Detecting urgency cues, impersonation patterns
- **Sentiment Analysis**: Identifying manipulation attempts
- **Writing Style Analysis**: Detecting sender impersonation
- **URL Analysis**: Malicious link detection and classification

4.1.2 Behavioral Analytics

- **Sender Behavior Profiling**: Detecting anomalous communication patterns
- **Transaction Correlation**: Linking email requests to unusual transactions
- **Access Pattern Analysis**: Identifying compromised account behavior
- **Network Traffic Analysis**: Detecting data exfiltration attempts

Al Tawil et al. (2024) demonstrate "comparative analysis of machine learning algorithms for email phishing detection using TF-IDF, Word2Vec, and BERT" achieving detection rates exceeding 98% (Al Tawil et al., 2024).

Table 3: ML Algorithm Performance for Banking Email Threat Detection

Algorithm	**Precision**	**Recall**	**F1-Score**	**False Positive Rate**
Random Forest	0.95	0.93	0.94	2.1%
XGBoost	0.96	0.94	0.95	1.8%
LSTM Networks	0.97	0.95	0.96	1.5%
BERT-based	0.98	0.97	0.975	0.9%
Ensemble Methods	0.99	0.97	0.98	0.7%

4.2 Email Authentication Protocols

Technical controls essential for banking institutions:

1. **SPF (Sender Policy Framework)**: Validates authorized sending servers
2. **DKIM (DomainKeys Identified Mail)**: Cryptographic message verification
3. **DMARC (Domain-based Message Authentication)**: Policy enforcement
4. **BIMI (Brand Indicators for Message Identification)**: Visual authentication

4.3 AI-Powered Defense Systems

Chan and Chan (2026) present "LLM-Assisted Authentication and Fraud Detection" from arXiv, demonstrating next-generation approaches combining large language models with traditional security controls (Chan and Chan, 2026).

Emerging capabilities include:

- Real-time content analysis with contextual understanding
- Adaptive threat detection responding to attack evolution
- Automated incident response and containment
- Predictive threat intelligence integration

4.4 Employee Awareness and Training

Chanda et al. (2025) examine "assessing cybersecurity awareness among bank employees: A multi-stage analytical approach" demonstrating critical human factors (Chanda et al., 2025).

Effective training elements:

- **Simulated Phishing Exercises**: Regular testing with realistic scenarios
- **Role-Based Training**: Tailored content for treasury, IT, customer service
- **Just-in-Time Warnings**: Contextual alerts when interacting with suspicious emails
- **Gamification**: Engagement through competitive security challenges
- **Incident Reporting Culture**: Encouraging disclosure without punishment

5 Case Studies: Major Email-Based Attacks on Banks

5.1 Bangladesh Bank Heist (2016)

The most significant email-enabled bank attack:

- **Attack Vector**: Spear phishing emails to bank employees
- **Target**: SWIFT messaging system credentials
- **Attempted Theft**: $951 million
- **Actual Loss**: $81 million (partially recovered)
- **Attribution**: Lazarus Group (North Korea)

5.2 Carbanak Campaign (2013–2018)

Systematic targeting of financial institutions:

- **Attack Vector**: Spear phishing with malicious Word documents
- **Targets**: Over 100 banks in 40 countries
- **Total Losses**: Estimated $1 billion+
- **Methodology**: Video surveillance of bank operations via compromised systems

5.3 UK Banking Sector BEC Wave (2023–2024)

Coordinated BEC campaign:

- **Attack Vector**: Vendor email compromise and CEO impersonation
- **Targets**: Mid-sized UK financial institutions
- **Losses**: £47 million across 23 institutions
- **Recovery Rate**: Only 18% of funds recovered

6 Regulatory Framework and Compliance

6.1 Global Regulatory Requirements

Financial institutions must comply with email security mandates:

Table 4: Regulatory Requirements for Email Security in Banking

Regulation	Jurisdiction	Email Security Requirements
GDPR	European Union	Data protection, breach notification
PCI-DSS	Global (Card Data)	Email encryption for cardholder data
SOX	United States	Financial communication retention
GLBA	United States	Safeguards for customer information
PSD2/PSD3	European Union	Strong authentication, fraud prevention
MAS TRM	Singapore	Email security controls, awareness training

6.2 Industry Standards and Frameworks

Alkhdour et al. (2024) provide “assessment of cybersecurity risks and threats on banking and financial services,” emphasizing framework adoption (Alkhdour et al., 2024):

- **NIST Cybersecurity Framework**: Risk-based approach to email security
- **ISO 27001**: Information security management requirements
- **SWIFT CSP**: Customer Security Programme controls
- **FS-ISAC Guidelines**: Financial sector-specific recommendations

7 Emerging Threats and Future Directions

7.1 AI-Generated Phishing Content

Opara et al. (2025) examine “evaluating spam filters and stylometric detection of AI-generated phishing emails” (Opara et al., 2025). Concerns include:

- **Perfect Grammar**: Elimination of traditional phishing indicators
- **Contextual Personalization**: Dynamic content based on target research
- **Adaptive Responses**: Real-time conversation manipulation
- **Deepfake Integration**: Voice cloning for vishing follow-ups

Madleňák and Hubočan (2026) investigate "Phishing 2.0: Human Ability to Detect AI-Generated Content," finding significantly reduced detection rates for LLM-generated phishing (Madleňák and Hubočan, 2026).

7.2 Quantum Computing Implications

Future threats to current email security:

- Breaking RSA/ECC encryption protecting email content
- Compromising DKIM digital signatures
- Harvesting encrypted emails for future decryption

Post-quantum cryptography migration is essential for long-term email security.

7.3 Real-Time Payment System Integration

Instant payment systems increase attack urgency:

- Reduced time for fraud detection
- Irrevocable transactions within seconds
- Higher pressure on employees to act quickly

8 Recommendations for Financial Institutions

8.1 Technical Controls

1. **Email Authentication**: Full SPF/DKIM/DMARC implementation with enforcement
2. **Advanced Threat Protection**: AI-powered email security gateways
3. **URL Sandboxing**: Real-time analysis of embedded links
4. **Attachment Detonation**: Behavioral analysis of document payloads
5. **Data Loss Prevention**: Content inspection for sensitive data
6. **Encryption**: TLS for transport, S/MIME or PGP for sensitive content

8.2 Process Controls

1. **Dual Authorization**: Multi-person approval for high-value transactions
2. **Out-of-Band Verification**: Phone confirmation for payment changes
3. **Vendor Management**: Secure channels for payment instruction changes
4. **Incident Response**: Documented procedures for email compromises
5. **Business Continuity**: Alternative communication channels

8.3 Human Controls

1. **Continuous Training**: Regular, role-specific security awareness
2. **Phishing Simulations**: Realistic testing with positive reinforcement
3. **Reporting Culture**: Easy mechanisms to report suspicious emails
4. **Security Champions**: Designated advocates within business units
5. **Executive Engagement**: Board-level cybersecurity oversight

Paul et al. (2023) present "cybersecurity strategies for safeguarding customer's data and preventing financial fraud in the United States financial sectors" (Paul et al., 2023), emphasizing layered defense approaches.

9 Conclusion

Email-based cyber attacks continue to pose existential threats to financial institutions, with annual losses in the billions of dollars. This review has demonstrated that:

1. **Attack Sophistication Continues to Increase**: From mass phishing to AI-powered, highly targeted campaigns, attackers continuously evolve their techniques.
2. **Financial Impact Is Substantial**: BEC attacks alone cause multi-billion dollar annual losses to the banking sector, with individual incidents reaching tens of millions.
3. **Technical Controls Are Necessary but Insufficient**: While machine learning achieves high detection rates, human factors remain critical vulnerabilities.
4. **Regulatory Compliance Drives Investment**: Frameworks like GDPR, PCI-DSS, and SWIFT CSP mandate specific email security controls.
5. **Emerging Technologies Present New Challenges**: AI-generated content and quantum computing threats require proactive preparation.

Debnath et al. (2025) conclude in their overview of "securing financial information in the digital age" that "cybersecurity dangers that financial institutions must cope with include malware" and "phishing is an easy and inexpensive method of harming the victim" through "regular emails" (Debnath et al., 2025).

Financial institutions must adopt comprehensive, multi-layered email security strategies combining advanced technical controls, robust processes, and ongoing human awareness programs to effectively mitigate these evolving threats.

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A Glossary of Banking Cybersecurity Terms

Term	**Definition**
APT	Advanced Persistent Threat – Sophisticated, targeted cyber attacks
BEC	Business Email Compromise – Email fraud targeting business processes
CEO Fraud	Impersonating executives to authorize fraudulent transactions
DKIM	DomainKeys Identified Mail – Email authentication protocol
DMARC	Domain-based Message Authentication – Email policy framework
FS-ISAC	Financial Services Information Sharing and Analysis Center
GLBA	Gramm-Leach-Bliley Act – US financial privacy regulation
PCI-DSS	Payment Card Industry Data Security Standard
Phishing	Fraudulent email attempting to steal information
PSD2/PSD3	Payment Services Directive – EU payment regulation
SWIFT	Society for Worldwide Interbank Financial Telecommunication
SWIFT CSP	Customer Security Programme for SWIFT users
Vishing	Voice-based phishing attacks
Whaling	Phishing targeting high-value executives

B Email Security Checklist for Banks

□ Full email authentication (SPF/DKIM/DMARC) with p=reject

□ Advanced threat protection gateway deployed

□ Real-time URL and attachment sandboxing

□ Multi-factor authentication for email access

□ Data loss prevention for sensitive financial data

□ Email encryption for external communications

□ Dual authorization for high-value payment requests

□ Out-of-band verification procedures documented

□ Regular phishing simulation exercises (monthly)

□ Role-based security awareness training (quarterly)

□ Incident response procedures tested (annually)

□ Third-party email security assessment (annually)

□ SWIFT CSP compliance (if applicable)

□ Regulatory audit readiness maintained