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QUANTITATIVE ASSESSMENT OF DATA PROTECTION PRACTICES IN U.S. REVENUE CYCLE MANAGEMENT

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Abstract

This study quantitatively assessed data protection practices in U.S. revenue cycle management (RCM) by applying an evidence-oriented measurement instrument and summarizing results as an overall RCM Data Protection Index (RCM-DPI) with five domain subscales. A cross-sectional, observational design was used, and data were obtained from 120 organizations representing provider-operated, outsourced vendor, and hybrid RCM operating models. The overall RCM-DPI averaged 67.4 (SD = 9.8; median = 68.1; range = 41.0–88.5), indicating mid-range protection maturity with meaningful variability. Subscale means were highest for workforce safeguards (74.2, SD = 8.6) and data security controls (70.8, SD = 10.1), while auditability and monitoring (62.7, SD = 12.7) and vendor oversight (60.3, SD = 13.4) showed lower central tendency and wider dispersion. The overall index correlated strongly with auditability and monitoring (r = 0.85), identity and access governance (r = 0.82), vendor oversight (r = 0.80), and data security controls (r = 0.77), and moderately with workforce safeguards (r = 0.69), supporting coherent index composition. Organizational descriptors were negatively associated with protection outcomes, including toolchain complexity (r = -0.36 overall; r = -0.41 for auditability) and outsourcing proportion (r = -0.33 overall; r = -0.44 for vendor oversight). In multivariable regression, governance cadence positively predicted the overall index (B = 3.12, p < .001), while outsourcing intensity (B = -2.76, p < .001), toolchain complexity (B = -2.21, p = .003), and clearinghouse concentration (B = -1.48, p = .034) predicted lower scores; size tier was not significant (p = .18). Model fit was R^2 = 0.49 (adjusted R^2 = 0.46). Subscale reliability ranged from 0.81 to 0.88, supporting measurement consistency.

Keywords

Revenue cycle management, data protection, cybersecurity, healthcare compliance, vendor risk.

INTRODUCTION

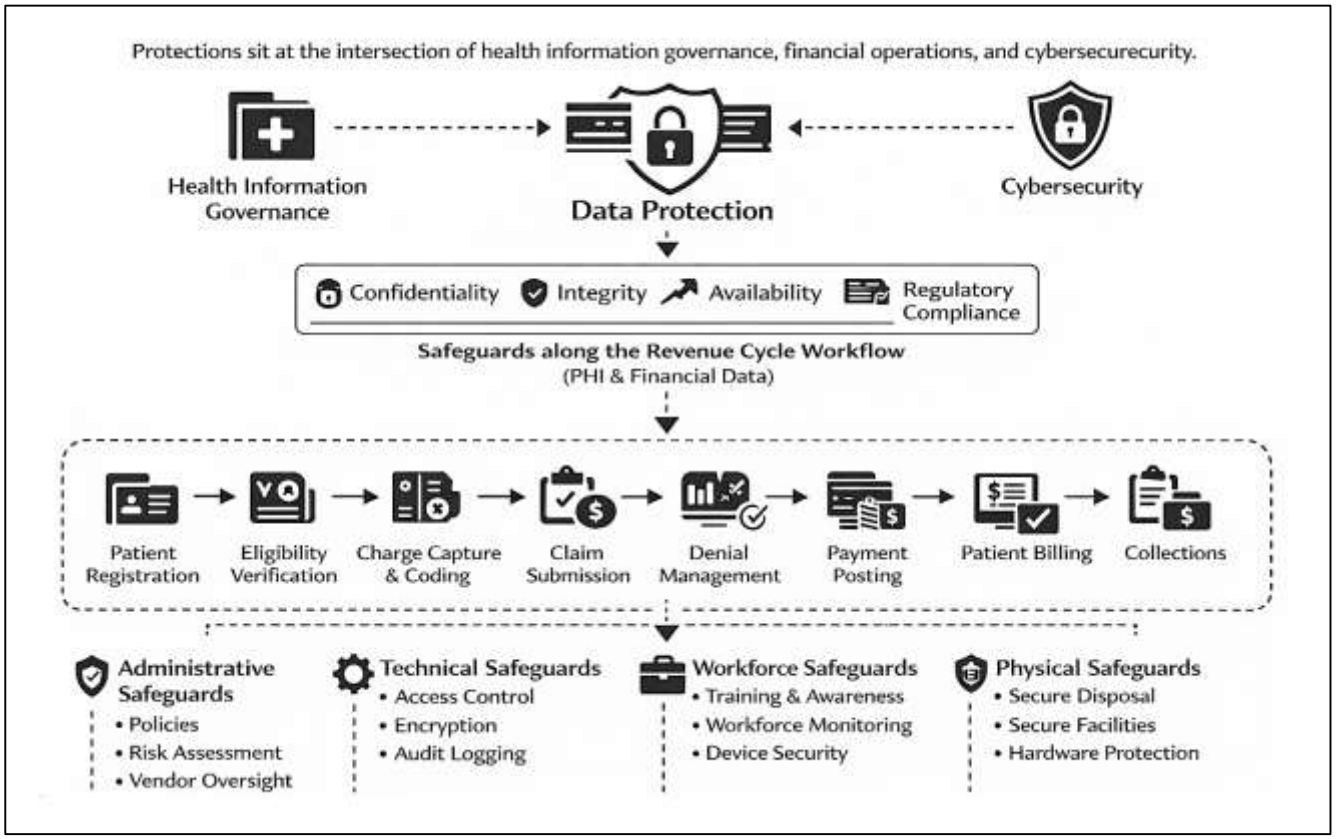
Data protection practices in U.S. revenue cycle management (RCM) sit at the intersection of health information governance, financial operations, and cybersecurity (Lindner et al., 2020). In definitional terms, data protection refers to the coordinated set of administrative, technical, and physical safeguards that preserve the confidentiality, integrity, and availability of sensitive information across its lifecycle, including collection, processing, storage, transmission, and disposal. In healthcare settings, the protected core commonly includes electronic protected health information and related personally identifiable information such as names, dates of birth, contact details, insurance identifiers, claim numbers, clinical and procedure codes, and payment records that appear throughout billing workflows. Revenue cycle management is the end-to-end set of processes that converts healthcare services into reimbursed claims and patient payments, typically including registration, eligibility verification, charge capture, coding, claim submission, denial management, payment posting, patient billing, and collections (Tarka, 2018). As RCM becomes increasingly digital, these datasets move through internal departments and external partners such as clearinghouses, billing vendors, coding services, and payment processors. Each handoff adds exposure points where unauthorized access, misconfiguration, or data leakage can occur. The international significance of this topic arises because the operational model behind RCM mirrors global patterns in digital health administration: distributed processing, vendor ecosystems, cloud services, remote workforces, and cross-border service delivery in administrative support functions. These characteristics make U.S. RCM a highly visible and analytically important case for evaluating how mature healthcare markets protect administrative health data at scale. A quantitative assessment can start from clear definitions of protected data elements, workflow boundaries, and safeguard categories, then translate them into measurable indicators such as access control coverage, authentication strength, encryption adoption, audit logging completeness, and vendor oversight practices (Bandalos & Finney, 2018). Establishing these foundational definitions is necessary because "data protection" in RCM is not a single technology or policy, but a set of operational controls embedded across people, processes, and platforms, each contributing differently to risk reduction and operational integrity.

The structure of RCM data flows makes protection both essential and measurable because revenue cycle operations rely on standardized transactions and high-frequency exchanges. Claims and remittance workflows routinely contain identifiers, diagnosis and procedure codes, dates of service, provider identifiers, and payment amounts (Arfan et al., 2021; Carpenter, 2018). In many organizations, the same data elements are copied into work queues, spreadsheets, exported reports, attachments, and external portals, creating multiple replicas that must each be protected (Jahid, 2021; Akbar & Farzana, 2021). Operational pressure to maintain throughput and minimize claim rejections can lead staff to prioritize speed and access convenience, which increases the importance of well-designed safeguards that do not require workarounds. In quantitative terms, RCM protection can be measured using observable control families such as role-based access configuration, least-privilege enforcement, multi-factor authentication deployment, secure transmission methods for files, encryption settings for databases and backups, and the integrity controls used to prevent or detect unauthorized modifications to billing data (Cho et al., 2022; Reza et al., 2021; Zobayer, 2021a). Workforce controls are also measurable, including training frequency, onboarding and offboarding discipline, separation of duties between billing, coding, and payment posting roles, and the presence of supervisory review for high-risk actions such as refund issuance or account adjustments (Zobayer, 2021b) . Because RCM often integrates multiple systems—practice management platforms, EHR billing modules, coding tools, denial management software, and clearinghouse connections—measurement should reflect both the internal environment and external interfaces (Ariful & Ara, 2022; Arman & Kamrul, 2022). Internationally, similar administrative health workflows exist under different payment models and regulatory regimes, so an evidence-based measurement approach developed for U.S. RCM can be interpreted in other contexts when framed around universal security concepts like confidentiality, integrity, availability, identity governance, and auditability (Kersten & Greve, 2022; Mesbaul & Farabe, 2022; Abdur & Haider, 2022).

Quantitative evaluation is further justified by the reality that healthcare organizations face persistent and evolving security threats that frequently target administrative systems and operational

dependencies. Billing environments are attractive because they combine identity-rich records with financial routing information and because disruption can quickly affect cash flow (Cataldo et al., 2021; Mushfequr & Praveen, 2022; Mortuza & Rauf, 2022). RCM operations also depend on email, file exchange mechanisms, portals, and networked servers, which are common pathways for credential compromise, malware delivery, unauthorized access, and data exfiltration (Abdul, 2023; Rakibul & Samia, 2022). When a revenue cycle function is disrupted, the effects are measurable in operational indicators such as delays in claim submission, increased denial rates due to incomplete documentation, backlogs in work queues, longer days in accounts receivable, and delayed patient billing. These operational realities connect naturally to a quantitative research design that assesses protection practices alongside indicators of resilience and control performance (Abdulla & Zaman, 2023; Arfan et al., 2023; Howard et al., 2020). For example, security monitoring maturity can be measured by log retention durations, alert response times, incident ticket volumes, and the frequency of tabletop exercises. Vulnerability management can be assessed through patch cadence, device inventory completeness, remediation time distributions, and the proportion of systems covered by endpoint detection tools (Amin & Mesbaul, 2023; Foysal & Aditya, 2023). Vendor risk practices can be measured through contract control clauses, due diligence completion rates, periodic access reviews, and evidence of third-party security attestations (Hamidur, 2023; Rashid et al., 2023). The international significance remains strong because cross-border service delivery in administrative functions can introduce data residency concerns, differences in subcontracting practices, and varying expectations for incident reporting (Borsboom et al., 2021; Musfiqur & Kamrul, 2023; Muzahidul & Mohaiminul, 2023). A rigorously defined quantitative framework helps compare organizations on consistent dimensions and identify patterns of protection strength or weakness across different organizational types.

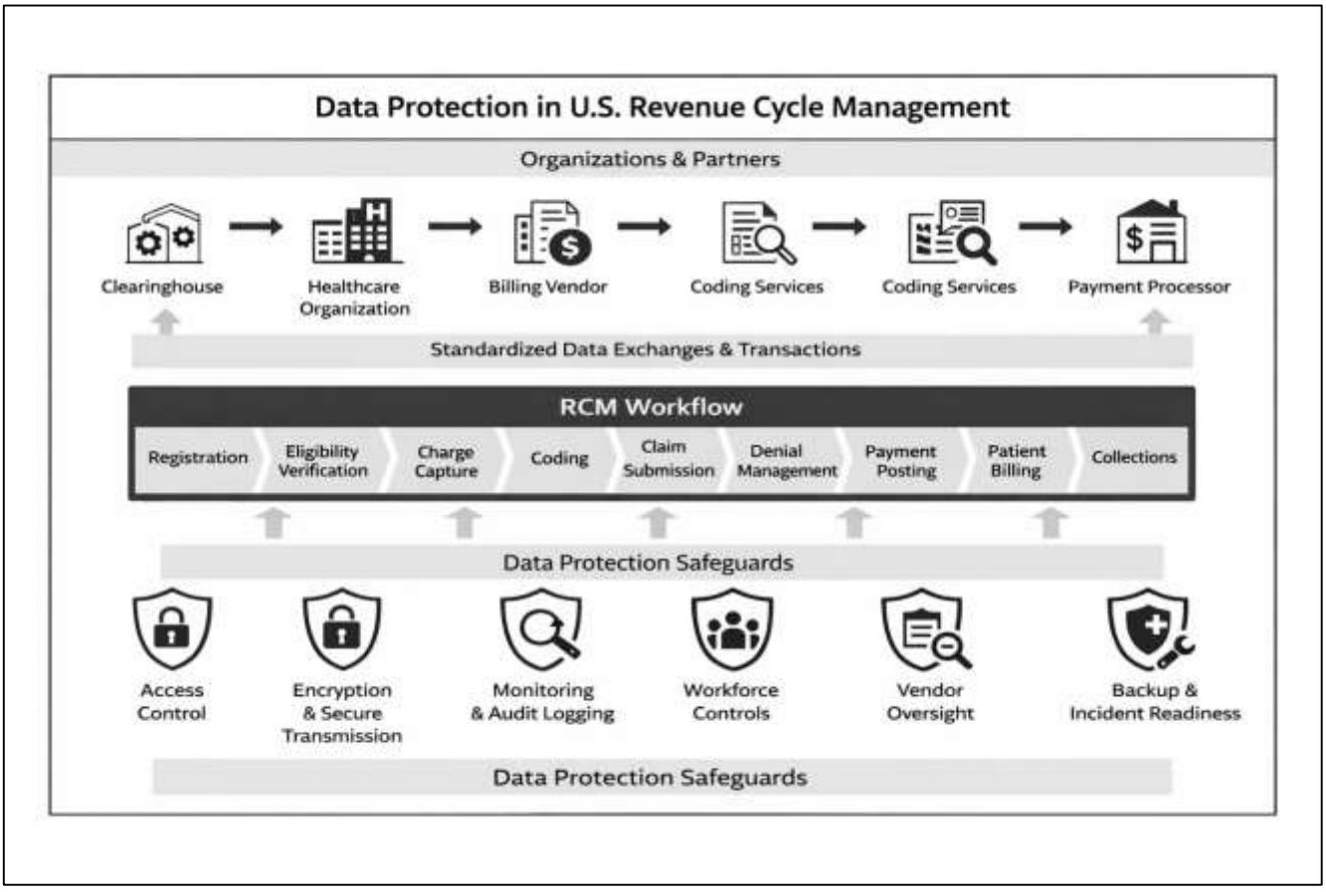
Figure 1: Quantitative Data Protection in RCM



Regulatory and governance expectations shape what "good protection" means in U.S. RCM, yet quantitative assessment is needed because compliance statements alone do not reveal implementation quality (Amin & Praveen, 2023; Hasan & Ashraful, 2023; Santoro et al., 2021). In practice, organizations can maintain policies that appear complete while controls remain partially implemented, inconsistently enforced, or poorly monitored. A revenue cycle department may have a policy that limits access to

minimum necessary data, yet permissions may be inherited from legacy role groups and remain broader than intended (Ibne & Kamrul, 2023; Mushfequr & Ashraful, 2023). An organization may require encryption, yet exports, backups, or data extracts used for analytics might be stored unencrypted in shared locations. A vendor relationship may include security language in contracts, yet day-to-day access provisioning for vendor staff may lack robust logging, time-bound entitlements, or periodic review. These gaps are empirically measurable (Madrid et al., 2018; Roy & Kamrul, 2023; Shaikh & Farabe, 2023). Quantitative designs can capture differences between "documented" and "operational" control states by assigning scores for evidence such as configuration settings, access review artifacts, audit log samples, training records, and incident response documentation (Haider & Hozyfa, 2023; Zobayer, 2023). This approach improves rigor because it treats protection practices as operational behaviors and system configurations rather than narrative claims. Internationally, governance measurement aligns with global best practices because many jurisdictions and standards emphasize risk-based controls, documented accountability, and continuous monitoring (Hozyfa & Mst. Shahrin, 2024; Hasan & Shah, 2024). When the research instrument is designed around measurable evidence categories—technical configurations, administrative routines, and physical safeguards—it becomes more transferable across settings while still being sensitive to U.S.-specific RCM workflows and outsourcing structures (Hasan & Zayadul, 2024; Muzahidul & Aditya, 2024; Hail et al., 2021).

Figure 2: RCM Data Protection Framework Overview



RCM is also distinct because it is a human-intensive environment where many tasks involve manual review, exception handling, and interaction with sensitive records across multiple stages (Hasan & Rakibul, 2024; Mominul, 2024). Eligibility verification, prior authorization support, denial follow-up, coding queries, and patient collections often require staff to access or share information through platforms that differ in security posture and logging capability (Mominul & Zaki, 2024; Pankaz Roy & Praveen, 2024; Wong et al., 2021). Remote work and distributed teams increase reliance on endpoints and identity controls, making authentication strength, device security coverage, and session management critical measurable areas (Rahman et al., 2024; Saba & Hasan, 2024). Many organizations

also rely on multiple billing applications and legacy systems that may not support modern security features uniformly, which creates measurable variability in control deployment. Quantitative assessment can examine the percentage of systems integrated into centralized identity management, the proportion of privileged accounts governed by strong controls, and the completeness of audit trails across the revenue cycle toolchain (Shaikat & Zaman, 2024; Sudipto & Hasan, 2024; Wong et al., 2021). It can also capture process maturity by measuring how frequently access rights are reviewed, how consistently users are assigned role-based permissions, how quickly terminated access is removed, and how often exception approvals occur (Haider & Praveen, 2024; Zobayer & Kumar, 2024). From an internal control perspective, revenue cycle operations involve financially material actions such as charge entry, write-offs, refund processing, and payment posting, which introduces integrity risks that overlap with cybersecurity concerns (Zulqarnain & Zayadul, 2024). Quantitative instruments can therefore include integrity-related indicators like approval workflows, reconciliation frequency, anomaly detection usage, and segregation of duties. The global significance of measuring these practices lies in the shared reality that administrative health functions everywhere increasingly rely on digital workflows and vendor ecosystems, and the same principles of identity governance, auditability, and secure data handling remain central regardless of payment model (Schoen & LaVenia, 2019).

A quantitative introduction also benefits from clarifying that "data protection practices" include both proactive safeguards and readiness capabilities. Proactive safeguards include access control, encryption, segmentation, secure transmission, hardening, patching, endpoint protection, and monitoring. Readiness capabilities include incident response planning, business continuity and disaster recovery, backup testing, restoration time objectives, and the operational ability to sustain revenue cycle functions under disruptive conditions (Jacobson et al., 2020). In RCM, continuity is tightly tied to cash flow and patient communication, so resilience indicators can be integrated into the assessment framework without shifting into outcomes or implications. For example, the research can measure the frequency of backup restore testing, the existence of offline backup strategies, documented recovery procedures for billing applications, and the proportion of revenue cycle tools covered by continuity plans. The presence and execution of tabletop exercises can be measured through frequency, scope, and documentation completeness (Hovenkamp-Hermelink et al., 2019). Data retention and disposal practices can be measured through retention schedules, secure destruction procedures, and controls on data extracts and archived claims files. Vendor-related resilience can be measured through contractual continuity obligations, incident notification procedures, and evidence of vendor testing. This measurement logic provides an internationally meaningful template because resilience, continuity, and incident readiness are widely recognized as core dimensions of security governance in critical service environments (Mansour et al., 2022).

In U.S. revenue cycle management, the combination of legally protected health information, financially actionable identifiers, high transaction velocity, and multi-organization processing chains creates a setting where the precision of quantitative measurement is especially valuable (Kalantar et al., 2020). RCM involves repeated data replication across systems, frequent external exchanges, and high volumes of user access events, all of which produce measurable traces that can be used to evaluate protection practice strength. A quantitative paper can therefore define an assessment model that converts protection practices into structured variables, such as an index of identity governance maturity, a composite score of encryption and secure transmission adoption, an auditability score based on log coverage and review cadence, and a vendor oversight score based on due diligence, access management, and monitoring artifacts (Mauerer et al., 2021). Such constructs allow systematic comparison across organizations, departments, or vendor types using consistent scoring rules, supporting statistical analysis of differences by size, system complexity, outsourcing depth, or toolchain diversity. Internationally, this approach is significant because the same methodological logic can be applied to other administrative health and insurance ecosystems, even where terminology differs, as long as measurement focuses on observable safeguards and operational routines. By grounding the introduction in clear definitions, workflow realities, and measurable protection dimensions, the study positions data protection in U.S. RCM as a quantifiable operational domain rather than an abstract compliance topic, providing a rigorous foundation for subsequent methodological development and analysis (Kineber et al., 2022).

The primary objective of the study titled "Quantitative Assessment of Data Protection Practices in U.S. Revenue Cycle Management" is to measure, score, and statistically describe the extent to which revenue cycle management (RCM) environments apply data protection controls across people, process, and technology layers that handle sensitive patient and financial information. This objective-oriented focus emphasizes the creation of a structured measurement model that converts real-world protection activities into quantifiable indicators that can be consistently captured across organizations and compared using numerical methods. Specifically, the study aims to operationalize "data protection practices" into measurable dimensions such as identity and access management discipline (role-based access configuration, least-privilege application, privileged account governance, and access review regularity), authentication strength (multi-factor coverage, session controls, and remote access safeguards), data security controls (encryption at rest and in transit, secure file transfer usage, backup protection, and data retention or disposal routines), auditability and monitoring (log completeness, retention duration, review cadence, alert handling procedures, and traceability of high-risk actions), workforce safeguards (training frequency, policy awareness, onboarding and offboarding rigor, separation of duties, and supervision of exceptions), and third-party oversight (vendor access provisioning, contractual security requirements, evidence of due diligence, and monitoring of clearinghouse or billing-platform connections). A central objective is to produce a composite protection score or index that summarizes these dimensions while still allowing subscale interpretation, enabling the study to report not only an overall level of protection adoption but also the specific areas where control deployment is strong, inconsistent, or absent within the RCM workflow. The study further objectives include assessing variability in protection practice scores across key organizational characteristics common in RCM contexts, such as organization type (provider-based revenue cycle departments versus outsourced billing entities), organization size, outsourcing intensity, platform diversity, and transaction volume tier, using statistical techniques that support group comparisons and relationship testing. By centering measurement precision, standardization of indicators, and numerical comparability, the study's objective is to establish an empirically grounded baseline description of data protection practices within U.S. RCM operations that is suitable for robust quantitative analysis.

LITERATURE REVIEW

The literature review for "Quantitative Assessment of Data Protection Practices in U.S. Revenue Cycle Management (RCM)" synthesizes research that explains how data protection controls are defined, implemented, measured, and validated in environments where healthcare administrative and financial data are processed at scale (Tamburri, 2020). Because RCM workflows handle high volumes of sensitive information through multiple systems and third-party intermediaries, the literature relevant to this topic spans healthcare information governance, cybersecurity control frameworks, privacy-preserving operational practices, and quantitative measurement approaches used to score organizational safeguards. This section organizes prior work around measurable constructs that can be translated into variables for statistical analysis, including access control maturity, authentication coverage, encryption and secure transmission adoption, audit logging and monitoring completeness, workforce behavior and training compliance, incident readiness and continuity practices, and third-party oversight in outsourced billing ecosystems (Cantiello et al., 2021). The review also emphasizes empirical studies that used surveys, audits, maturity models, or breach datasets to quantify security posture, identify determinants of control adoption, and examine variation across organizational types and sizes. Rather than treating data protection as a purely regulatory topic, the literature review positions it as an operational and measurable domain within revenue cycle processes, where the strength of safeguards can be represented through indices, subscale scores, compliance-rate metrics, and reliability-tested instruments. This framing supports the study's quantitative purpose by grounding variable selection, measurement design, and statistical testing strategies in established empirical traditions while keeping the focal unit of analysis tightly aligned with U.S. RCM workflows (Birnstill et al., 2018).

Unit of Analysis for RCM Data Protection

Revenue cycle management (RCM) has been widely described in the healthcare administration and informatics literature as a data-processing system rather than only a billing function, because it transforms clinical encounters into standardized financial transactions through repeatable stages that can be treated as measurable operational domains (Piechnicki et al., 2021). Across research streams on

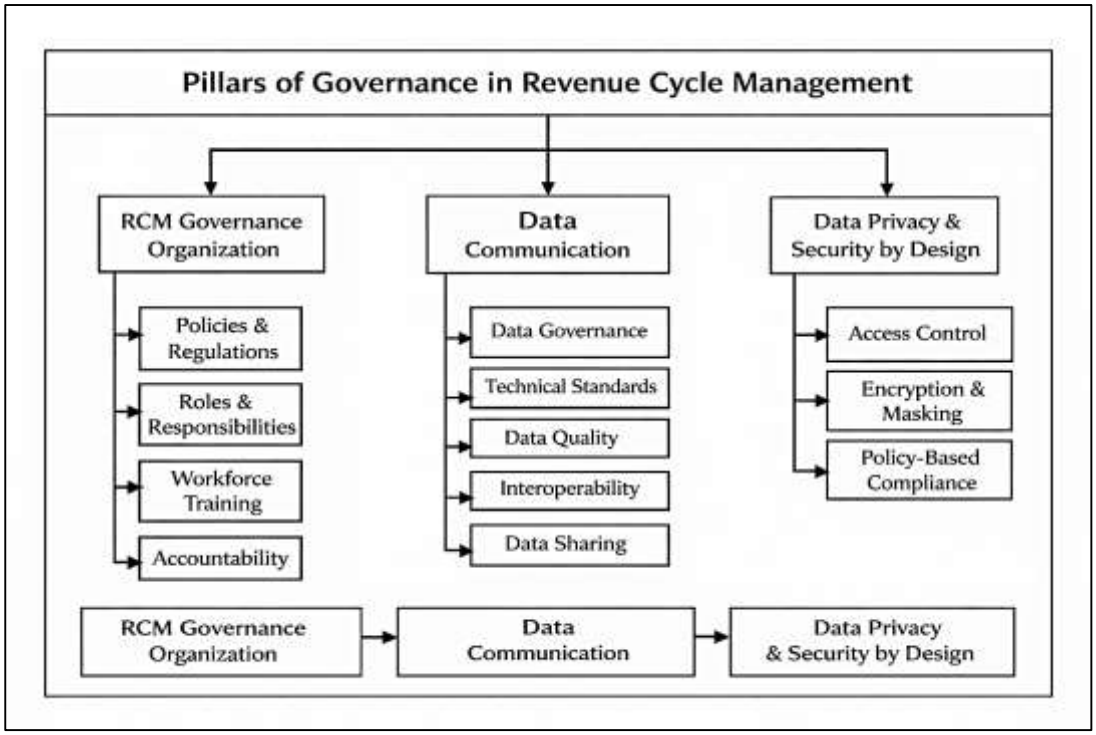
administrative simplification, health IT-enabled billing, and claims workflow optimization, authors consistently decomposed RCM into sequenced steps that include registration and demographic intake, insurance eligibility and benefits verification, clinical documentation alignment and coding, claim generation and submission, remittance processing and denial management, payment posting, and patient billing and collections. This staged framing supported measurement because each step handled distinct data objects and produced distinct transaction artifacts. Studies of EHR-enabled administration and associated workflow redesign highlighted that registration and eligibility stages concentrated identity fields and payer identifiers; coding stages concentrated diagnosis and procedure codes, modifiers, and documentation references; claims submission and clearinghouse exchange concentrated standardized claims segments and claim status data; remittance stages concentrated adjustment reason codes and payment records; patient billing stages concentrated statements, payment plans, and contact histories. Work on electronic data interchange and claims standardization emphasized that these objects moved across multiple interfaces, including practice management modules, coding tools, claim scrubbers, clearinghouse gateways, payer portals, and patient payment systems. Scholars examining interoperability and digitization, including research by Adler-Milstein and Jha, emphasized that expanded electronic exchange increased routinized data movement outside single applications, which increased the number of "touchpoints" where access, transmission, and storage controls mattered (Y.-J. Yang et al., 2020). Research on healthcare data breaches by Seh and colleagues, and empirical breach trend analyses by Jiang and collaborators, reinforced that operational systems used for administrative exchange remained frequent targets in broader healthcare incident patterns. Evidence from systematic reviews on healthcare cybersecurity behavior by Kruse and colleagues, along with investigations into organizational security program maturity in healthcare settings, also supported the idea that exposure accumulated across routine workflows rather than only at one endpoint. In this literature, the concept of "control exposure points" emerged naturally from operational decomposition, because exposure grew with the number of systems touched, the number of handoffs to internal teams or vendors, and the frequency of exports and extracts created for reconciliation, reporting, appeals, audits, and patient communication (Melani et al., 2018).

The literature also provided a consistent basis for defining data protection practices as measurable constructs by organizing safeguards into administrative, technical, and physical domains that mapped onto healthcare compliance expectations and cybersecurity control taxonomies (Ochella et al., 2022). Administrative safeguards appeared in research on governance and compliance as observable practices such as the existence and periodic review of policies, documented risk assessment routines, workforce training cadence, onboarding and offboarding procedures, incident reporting channels, and vendor oversight processes. Studies in information security governance, including work associated with Gordon and Loeb on security investment logic and later organizational security economics, supported the idea that management routines and resourcing decisions shaped measurable control deployment rather than simply formal compliance language. Technical safeguards were treated in many empirical and review studies as concrete implementations that could be assessed through system configuration and operational logs, including role-based access control design, least-privilege provisioning, multifactor authentication coverage, encryption usage for data at rest and in transit, secure file transfer practices, endpoint protections, patch routines, and logging and monitoring completeness. Research aligned with widely used control catalogs, including work that examined healthcare alignment with formal security frameworks, described how technical safeguards gained meaning only when tested through evidence such as account inventories, authentication logs, encryption settings, backup protections, and audit event records (Samhan, 2020). Physical safeguards were similarly described as measurable, particularly in studies of privacy incidents and operational security, through workstation protection, device controls, clean desk practices, secure disposal routines, and restrictions on printing or unattended displays in billing environments. A recurring methodological theme across the literature was the distinction between self-reported control presence and observable evidence, which influenced how researchers scored maturity. Several governance evaluation studies in healthcare treated policy existence as insufficient when not supported by verification artifacts. Breach-focused research, including analyses synthesized from multi-year incident datasets, reinforced this view because high breach frequency occurred even in highly regulated environments, implying that measurement

benefited from capturing operational execution rather than only stated intent. As a result, prior studies commonly used structured instruments that allowed categorical ratings (present or absent) while also enabling graded scoring (partial, consistent, or comprehensive implementation), often supported by documentation review or system-based verification (Shubinsky & Zamyshlaev, 2022).

Within U.S. settings, the literature consistently emphasized that the scope boundaries for evaluating RCM data protection required careful definition because revenue cycle operations rarely remained contained within a single organization or a single application (Shafiq et al., 2018). Research on healthcare outsourcing, billing service operations, and third-party access models described two dominant operating arrangements: provider-operated RCM units embedded within hospitals and physician groups, and outsourced billing services that performed coding, claim follow-up, denial resolution, and patient collections for multiple clients. This distinction mattered because studies on vendor governance and third-party risk repeatedly reported that access pathways and accountability structures changed when vendors handled claim workflows or maintained billing platforms. Work on business associate relationships and operational risk governance treated these environments as multi-entity ecosystems, where protection practices depended on identity management alignment, contract enforcement, shared incident handling expectations, and auditability across organizational boundaries (Jaquette et al., 2018). Another prominent theme in the literature was the standardized role of clearinghouses and transaction intermediaries as external dependencies in claims exchange. Research on claims processing architectures and electronic transaction routing described clearinghouses as common hubs for eligibility transactions, claim submission, claim status queries, remittance delivery, and attachment handling, which created high-frequency data flows that crossed administrative domains. Consequently, studies on healthcare cybersecurity and operational resilience treated external dependencies as part of the practical perimeter of protection, not merely a background feature of the industry. In this framing, scoping did not stop at the provider network, and measurement needed to include third-party portals, file exchange endpoints, and interface engines that moved RCM data. Empirical work that examined large-scale disruptions in claims processing ecosystems reinforced the systemic consequences of concentrated dependencies and the need to define them clearly when designing quantitative assessments (Von Schnurbein et al., 2020).

Figure 3: RCM Governance Framework Overview



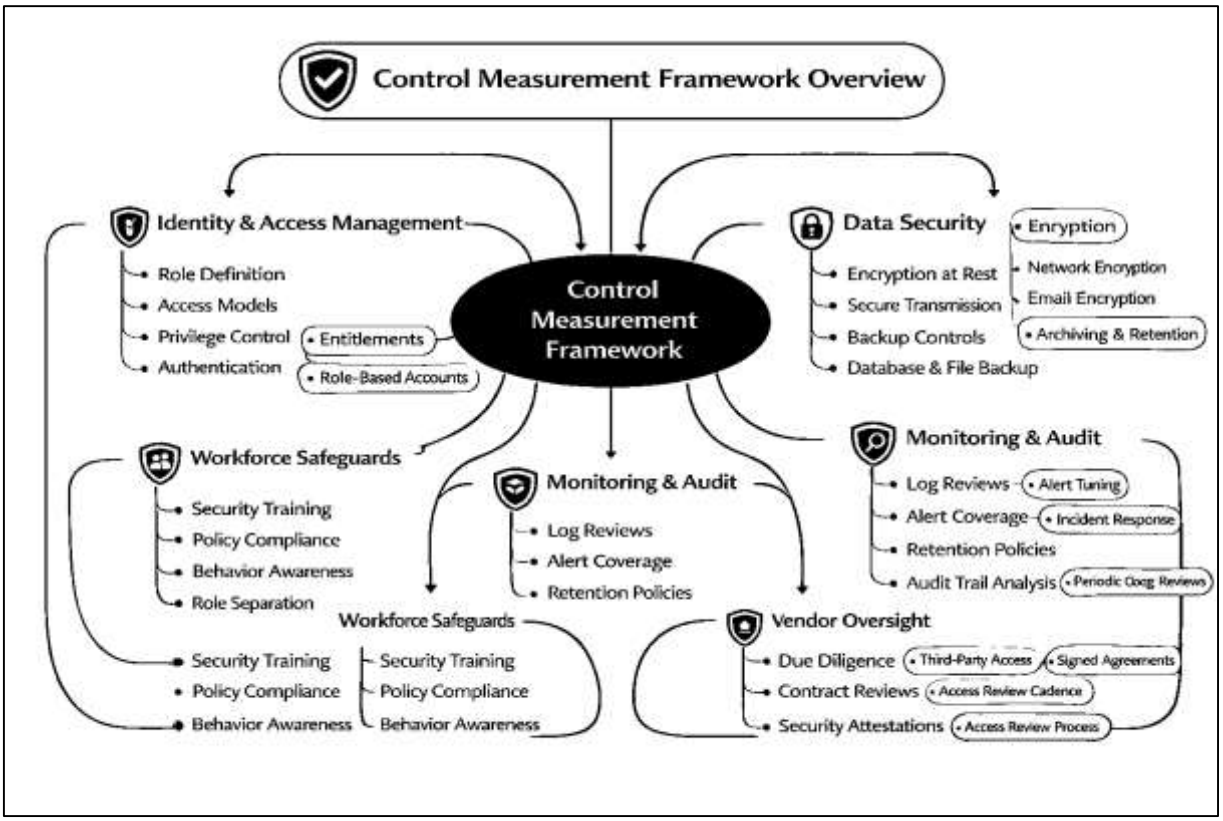
The literature also converged on practical inclusion rules for what counted as "RCM systems," because the revenue cycle toolchain often included overlapping platforms that blurred boundaries between clinical documentation, billing, analytics, and patient communications (Zhang et al., 2022). Studies on administrative digitization and revenue cycle technology adoption described core systems such as the billing platform or practice management system, coding tools that supported diagnosis and procedure selection, claim scrubbers that applied payer rules, remittance import and reconciliation tools that posted payments and adjustments, denial management modules that tracked appeals and work queues, patient payment portals that stored financial and contact artifacts, and reporting layers that generated extracts for financial close and payer audits. Research examining workflow complexity emphasized that secondary artifacts, such as spreadsheet exports, downloaded remittance files, uploaded attachments, and emailed documentation packets, became "shadow systems" that materially affected exposure even when not formally recognized as systems of record (Compare et al., 2019). Security behavior research in healthcare settings, including studies that focused on human factors and workaround behavior, reinforced the idea that informal data movement channels needed explicit scoping because they often bypassed centralized controls. In parallel, work on auditability and monitoring practices emphasized that logging coverage frequently varied across the toolchain, so system inclusion decisions affected what could be measured and compared. Across this body of work, a strong methodological implication emerged: a quantitative assessment of RCM data protection gained validity when it defined scope by functions and data objects rather than by application names alone, then documented where those functions occurred across platforms and partners (Ansari et al., 2019). This approach aligned with how prior researchers described operational domains and enabled consistent measurement across provider-operated and outsourced models, across different technology stacks, and across varying degrees of clearinghouse involvement, while keeping the unit of analysis anchored to the same essential RCM workflow stages and the same categories of sensitive administrative and financial health data.

Frameworks In Organizational Cybersecurity

Control-measurement frameworks in organizational cybersecurity research have frequently been organized as "control families" that function as practical maps for turning complex protection programs into measurable variables (Palia et al., 2021). Across healthcare security, information assurance, and governance scholarship, the most stable grouping pattern separates controls into identity and access management, data security, monitoring and audit, workforce safeguards, and vendor oversight, because each family captures a different mechanism by which risk is reduced in operational systems. Identity and access management has been treated as foundational in empirical and conceptual work by authors such as Saltzer and Schroeder, whose classic security principles emphasize least privilege and separation of privilege as design requirements that translate naturally into measurable indicators like role definition completeness, entitlement appropriateness, and privileged account constraints. Later applied security research in enterprise settings, including work discussed by Ferraiolo and Kuhn on role-based access control, reinforced the idea that role structure can be evaluated by the clarity of role catalogs, the alignment between job functions and permissions, and the degree to which privileged actions are isolated from routine accounts. Data security controls are commonly treated as a distinct family because encryption practices, secure transmission routines, and backup protections relate directly to the confidentiality and availability of information assets; studies from applied cryptography and information assurance traditions, including widely taught work by Schneier, have influenced the operationalization of encryption coverage as a measurable property rather than an abstract commitment (Figalist et al., 2021). Monitoring and audit are similarly recognized as a separate control domain in influential security engineering literature by Anderson and in governance-oriented discussions by scholars who focus on accountability and traceability, because logging coverage, retention practices, and alert handling are observable and can be assessed through system evidence. Workforce safeguards have been foregrounded in human factors and socio-technical security research, including work by Sasse and colleagues, which treats training completion, policy comprehension, and behavior under operational pressure as measurable determinants of control effectiveness. Vendor oversight appears as its own family in risk management and supply-chain security research, including perspectives associated with Shedden and governance-focused scholars,

because third-party dependencies create exposure channels that cannot be reduced through internal controls alone. This family approach is especially relevant to revenue cycle management environments, where the "control surface" extends across platforms, portals, file exchanges, and outsourced personnel (Ning et al., 2020). As a result, literature-based variable mapping often aligns each control family with concrete indicators: access models and privileged governance for identity controls, encryption and backups for data security, log and alert measures for monitoring, training and role separation measures for workforce, and due diligence and access review cadence measures for vendor oversight.

Figure 4: Cybersecurity Control Measurement Framework Overview



Security measurement literature has also relied heavily on maturity models and scoring systems to convert control families into interpretable quantitative summaries, and this body of work shows consistent tension between binary compliance scoring and graded maturity assessment. Binary scoring has been used in compliance-oriented auditing traditions because it offers clarity and simplicity, yet many studies in information security management argue that binary measures collapse meaningful variation and can mask partial implementation, inconsistent enforcement, or weak monitoring (Brnich et al., 2019). Governance and economics-oriented work often associated with Gordon and Loeb supports measuring security as a level of capability because investment decisions and risk reduction are rarely all-or-nothing outcomes. In parallel, many applied cybersecurity maturity approaches treat safeguards as layered capabilities that progress from informal and ad hoc practices to defined, managed, and continuously evaluated routines, which permits numerical scoring that captures the difference between policy existence and operational execution. Research syntheses in healthcare cybersecurity and digital health governance, including work by Appari and Johnson and later evidence summaries by Kruse and colleagues, have repeatedly emphasized that regulated environments still show major variability in real-world control deployment, which makes graded measurement more informative than simple pass–fail classifications. Measurement research often distinguishes between the maturity of control design, the maturity of control operation, and the maturity of control monitoring, because these represent different stages of capability and can be scored separately (Brnich et al., 2019). For revenue cycle management, this maturity perspective has been applied implicitly in workflow-based assessments that separate subscales by operational stage and system layer, rather than

reporting a single undifferentiated security number. Literature on healthcare digitization and interoperability associated with Adler-Milstein and collaborators supports this layered approach because RCM workflows frequently span multiple systems, and control strength differs across the toolchain even within a single organization. Studies analyzing breach patterns and disruption dynamics in healthcare administrative systems, including work by Seh and colleagues and large-scale trend analyses by Jiang and collaborators, add weight to scoring approaches that emphasize monitoring and resilience capabilities, since incidents are often detected through logs and managed through recovery processes rather than prevented solely through perimeter defenses (Ribeiro & Barbosa-Povoa, 2018). Across this research tradition, scoring systems are described as tools for comparability: they allow analysts to compare organizations, departments, or vendor models on consistent dimensions such as authentication coverage, encryption consistency, log completeness, training compliance, and third-party governance, while still preserving the detail needed to interpret where weaknesses cluster within RCM operations (Zorpas, 2020).

Instrument development research provides additional guidance on how quantitative control measurement tools are built, refined, and defended as valid representations of security practice rather than collections of convenient checklist items (Khaled et al., 2021). Across methodological writing on survey design, program evaluation, and organizational measurement, the dominant pattern begins with item generation, then moves through validation and reliability testing to demonstrate that the instrument measures what it claims to measure with acceptable consistency. In security and privacy contexts, item generation has often used three complementary sources: expert judgment, standards mapping, and literature-derived indicators. Expert panels appear frequently in healthcare informatics and security governance studies because practitioners can translate control language into operational behaviors that are observable in real organizations, especially in specialized domains like revenue cycle operations where generic cybersecurity items may miss critical data exchange behaviors. Standards mapping has been used to ensure coverage of core safeguard categories, while literature-derived indicators help anchor items in empirically studied risk mechanisms, such as credential misuse, email-based compromise, insecure file transfers, or poorly governed vendor access. Validation strategies in the measurement literature describe content validity as the degree to which items represent the construct domain, construct validity as the degree to which items behave as theoretically expected, and convergent validity as the alignment between the instrument and related measures (Damschroder et al., 2022). In organizational security research, construct validity is often supported when control-family subscales correlate in sensible ways with governance maturity markers, monitoring capabilities, or independently observed security outcomes, without reducing the instrument to a proxy for organization size or budget. Reliability strategies are treated as essential because control measurement instruments often combine items of different types, including policy evidence, configuration evidence, and behavior evidence. Methodological discussions in applied social science and psychometrics, along with security program evaluation literature, support using internal consistency checks for subscales, stability checks across time when repeated measurement is feasible, and interrater consistency when audits involve more than one assessor. Human factors research associated with Sasse and colleagues also emphasizes that measurement instruments must respect operational realities, because poorly designed items encourage socially desirable responses rather than accurate reporting, especially for topics like training compliance and policy adherence (Moullin et al., 2019). For RCM-focused assessment, the literature supports item phrasing that ties questions to concrete artifacts—access reviews, audit logs, configuration screenshots, vendor access lists, training completion records—so that measurement emphasizes observable evidence. This approach aligns with governance evaluation studies in healthcare that differentiate between documented controls and executed controls, and it matches the empirical breach literature's repeated finding that the presence of regulation does not automatically imply the presence of robust operational safeguards.

A final synthesis across these framework traditions shows that quantitative measurement of controls becomes stronger when control families, maturity scoring, and instrument design are integrated into a coherent model that respects workflow complexity and external dependency patterns common to revenue cycle management. In applied healthcare security scholarship, vendor and clearinghouse dependencies are frequently cited as reasons that internal controls alone cannot define the security

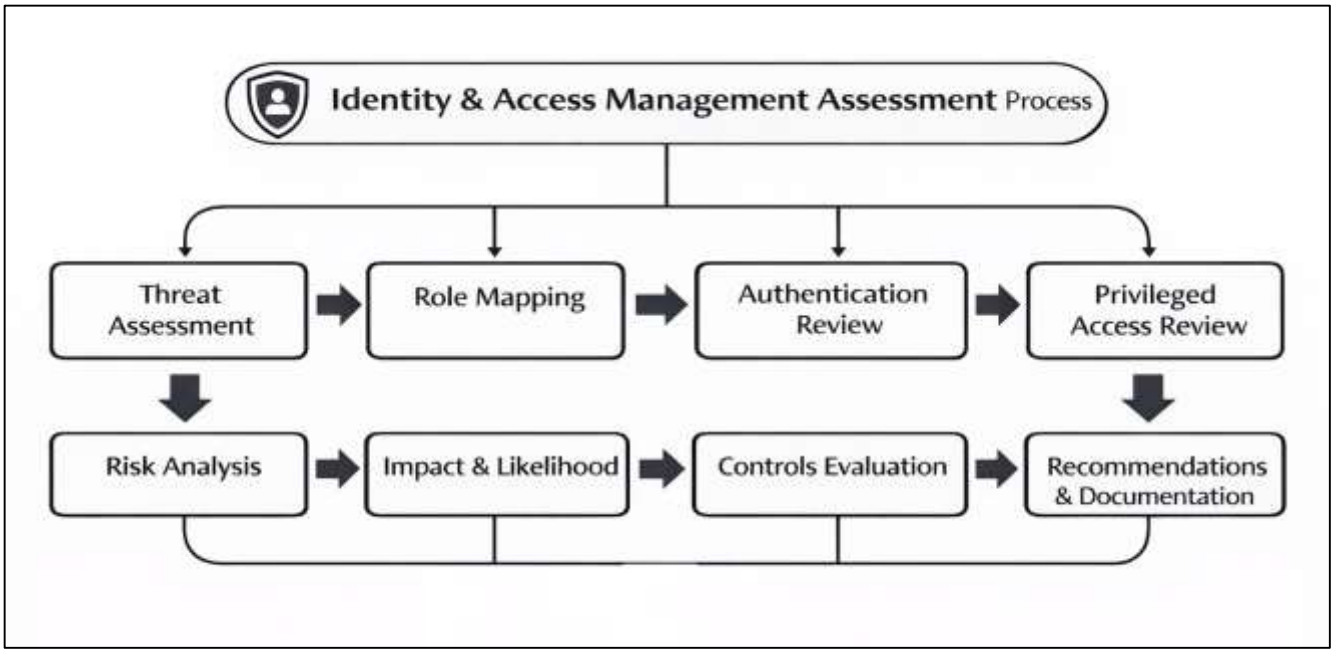
posture of an administrative workflow, because high-volume transactions and outsourced services extend the boundary of data processing into third-party platforms (Tobi & Kampen, 2018). Risk management literature on third-party governance highlights measurable practices such as due diligence completeness, contract control coverage, access review cadence, and evidence of enforcement mechanisms for remote access and authentication requirements. Interoperability and administrative digitization studies associated with Adler-Milstein and others reinforce that the modern administrative toolchain includes multiple systems and exchange layers, which creates uneven logging coverage and inconsistent application of encryption or authentication policies across components. Security operations research and breach trend analyses, including work by Verizon's research team and domain syntheses by Seh and colleagues, underscore the measurement importance of auditability and monitoring indicators, because timely detection and response frequently depend on log completeness and alert handling discipline. Human factors research led by Sasse and related scholars supports the inclusion of workforce measures such as training completion and policy comprehension, because technical controls are often bypassed in high-throughput environments when usability and workflow alignment are poor. Classical security principles described by Saltzer and Schroeder remain visible in modern control-family frameworks through their emphasis on least privilege, separation of duties, and economy of mechanism, which translate into measurable RCM-relevant indicators like entitlement minimization, privileged action isolation, and simplified access design (Presseau et al., 2019). RBAC concepts associated with Ferraiolo and Kuhn remain central to mapping job roles in billing, coding, denial management, and payment posting to permission sets that can be audited and compared. The security investment logic discussed by Gordon and Loeb provides an interpretive lens that supports measuring control maturity rather than only policy presence, since organizational decisions about monitoring, access governance, and vendor oversight produce observable capability differences. When these literature streams are synthesized for an RCM-focused quantitative design, they support a structured approach that measures control deployment across system layers and workflow stages, distinguishes documented intent from operational execution, and represents security posture through interpretable subscales aligned to control families (Talwar et al., 2020). This synthesis remains grounded in existing empirical and methodological traditions without shifting into forecasting or future-oriented claims, because it focuses on how prior studies have conceptualized, measured, validated, and compared cybersecurity and governance controls in complex administrative environments.

Management in Billing and Claims Operations

Identity and access management has been treated in the healthcare information security literature as the most immediate layer of protection for billing and claims operations because it governs who can view, create, modify, export, or transmit revenue-cycle data at every step of administrative processing (Derricks, 2021). Research across healthcare informatics, security governance, and audit practice has repeatedly framed revenue cycle management as a role-dense environment in which sensitive information is accessed frequently by staff with specialized tasks and time pressures. Within billing and claims operations, job functions commonly include registrars who initiate demographic and insurance records, coders who translate clinical documentation into standardized codes, billers who assemble and submit claims, denial specialists who interpret payer responses and manage appeals, payment posters who apply remittances and adjustments, supervisors who approve exceptions, and vendor users who support outsourced coding, billing, or platform maintenance. Studies examining administrative workflow complexity have highlighted that role boundaries blur when organizations run lean staffing models, centralize work queues, or cross-train employees to reduce backlogs, and these operational realities increase the importance of explicit role definition and access governance (Attaran, 2022). A consistent theme in the literature is that role-based access control becomes meaningful only when role catalogs match real job functions and are maintained as living artifacts rather than one-time implementation documents. In practical measurement terms, research on access governance and internal controls has encouraged the use of role mapping evidence that shows whether each revenue-cycle role has a defined permission set, whether permissions are aligned to the minimum needed for that role, and whether staff are assigned to roles consistently without ad hoc permission grants. Across multiple studies of security program maturity and healthcare compliance execution,

access risk has been linked to role conflicts, excessive privileges, and unmanaged exceptions that accumulate over time, especially in environments where urgent claim resolution incentivizes quick permission changes. The literature also points to the reality that billing and claims systems often include multiple connected applications, meaning role mapping must extend across the toolchain rather than focusing only on a single billing platform (Fraga-Lamas & Fernández-Caramés, 2019). As a result, identity and access management scholarship supports a measurement approach grounded in observable access structures, documented role definitions, and traceable assignment practices that reflect how revenue-cycle work is actually performed.

Figure 5: Identity Access Management Assessment Overview



A second stream of literature focusing on authentication and remote access has emphasized that billing and claims operations create distinctive access patterns that can strain traditional security controls. Healthcare administrative teams frequently log in at high volume throughout the day, move between multiple systems, and rely on shared task queues, which can normalize frequent session starts and reduce tolerance for friction (Kamel Boulos et al., 2018). Studies in organizational security and human factors have described how usability constraints and performance pressure increase the likelihood of unsafe workarounds, including attempts to reuse sessions, avoid additional login steps, or share access in tightly coupled workflows. In revenue-cycle contexts, the practical concern is not only whether an authentication control exists, but whether it covers the full set of systems that staff use for claims submission, status checks, remittance retrieval, denial management, and patient payment processing. Research on identity management maturity has therefore supported measuring authentication strength in terms of coverage across systems and consistency across access channels, including internal networks, remote access gateways, vendor portals, and cloud-based billing tools. Literature on remote work and distributed operations has further highlighted that administrative functions often rely on remote connectivity for outsourced billing staff, after-hours denial work, and vendor support, making remote access a frequent pathway for both legitimate operations and potential misuse. Across security operations studies and breach analyses, credential compromise and unauthorized remote access repeatedly emerge as common mechanisms that enable broader system intrusion, which underscores why authentication rigor is treated as a core determinant of overall protection posture (Gunduz & Das, 2020). Measurement approaches described in the literature commonly focus on whether multi-factor authentication is required for standard users and privileged users, whether remote access is restricted by conditional rules, and whether session management practices reduce exposure from unattended terminals in busy office environments. Studies of audit and monitoring practices complement this view by emphasizing that authentication controls are stronger when accompanied by session timeout

enforcement and event logging that can reconstruct access patterns during investigations. In billing operations specifically, high-frequency logins and multitasking across applications make it important to examine whether policies are implemented in ways that remain workable for staff, because controls that cannot be used reliably tend to be circumvented, leaving the organization with documented safeguards but weak operational reality (Stockburger et al., 2021).

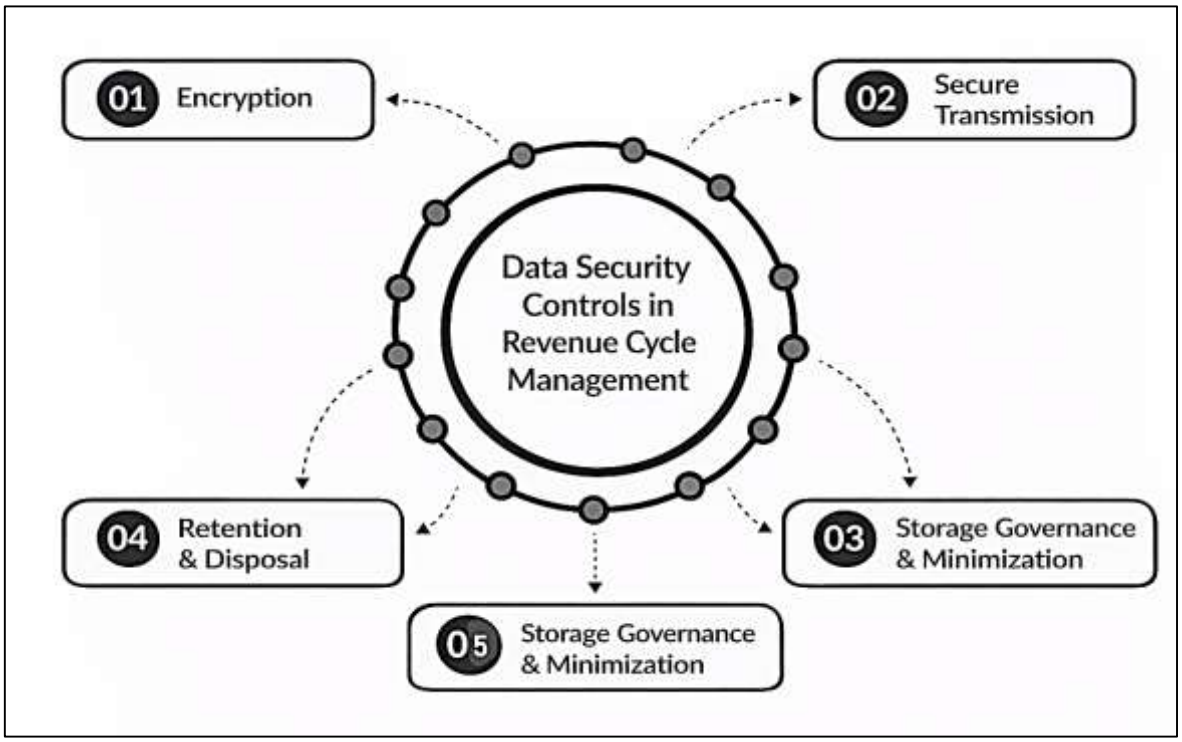
Privileged access governance has been singled out in the literature as a particularly sensitive element of revenue-cycle security because billing and claims systems contain functions that can materially change financial outcomes and data integrity. Research on internal controls, fraud risk, and healthcare revenue integrity has documented that certain actions—such as write-offs, refunds, adjustments, charge corrections, and payment postings—require elevated permissions and can be abused intentionally or misused accidentally if safeguards are weak (Zhu & Badr, 2018). Security governance studies have treated privileged access as a distinct risk domain because it concentrates power: a small number of accounts can perform high-impact actions, access broader datasets, and bypass ordinary workflow restrictions. In revenue-cycle settings, privileged access may include supervisors who approve exceptions, system administrators who manage configurations and integrations, and vendor personnel who maintain platforms or troubleshoot claim routing issues. The literature has commonly argued that privileged access must be constrained, justified, time-limited when possible, and heavily logged because it creates a direct route to both confidentiality loss and integrity compromise. Studies in auditing and compliance practice have reinforced that privileged accounts should be inventoried, reviewed regularly, and separated from routine user identities to reduce the likelihood that high-risk actions are performed casually or without oversight (C. Yang et al., 2020). Segregation of duties appears as a recurring theme in both security and accounting-oriented research because dividing responsibilities reduces opportunities for undetected errors or inappropriate transactions. In RCM operations, segregation principles often apply to preventing the same person from both initiating and approving a refund, both posting and reconciling payments without review, or both altering patient balances and controlling related reporting outputs. Research on program maturity has supported assessing segregation not only through policy statements but through the configuration of workflow approvals and the presence of enforced dual authorization for high-risk activities. The literature also notes that vendor involvement complicates privileged access because vendors often need elevated permissions to resolve issues quickly, and this operational need can lead to long-lived privileged accounts that persist beyond the original purpose. Across studies of third-party risk and healthcare cybersecurity, unmanaged vendor privilege has been treated as a common weakness when organizations rely heavily on outsourced support yet do not enforce strong access review cadence and deprovisioning discipline (Kuperberg, 2019).

Data Security Controls

Data security controls in revenue cycle management (RCM) environments are consistently described in the literature as the practical safeguards that protect sensitive administrative and financial health data during routine billing operations. RCM workflows generate and store identity attributes, insurance identifiers, claim artifacts, remittance details, adjustment histories, and payment records in multiple places, including primary billing databases, reporting environments, integration layers, file repositories, and end-user devices (Yang et al., 2020). Because revenue cycle work is continuous and transaction-heavy, data is frequently replicated into work queues, exported for reconciliation and audits, and staged for denial management or payer communications. This operational reality is central in prior research that treats healthcare administration as an information-processing system where exposure risk increases as data is duplicated and distributed across tools and teams. In this context, encryption is presented as a baseline protective control because it reduces the usability of data if storage media or systems are accessed without authorization. The literature emphasizes that encryption in RCM is not limited to the core billing database, because sensitive records may also reside in backups, archival repositories, analytics extracts, and locally downloaded files (Shukla et al., 2022). Studies on healthcare cybersecurity and organizational security programs frequently highlight that exposure occurs when encryption is unevenly applied across these storage locations, resulting in pockets of unprotected data even when the main system is secured. Similarly, endpoint devices used by billing, coding, denial, and payment teams become critical control points because they often handle

downloads, cached data, printed statements, and locally saved spreadsheets. Prior work also notes that administrative functions are vulnerable to "shadow storage," where operational convenience leads staff to keep duplicate datasets in shared drives or local folders for quick reference (Molinaro & Ruaro, 2022). The cumulative message across the literature is that encryption becomes meaningful in RCM only when it is consistently applied across the storage landscape that supports revenue cycle tasks, including databases, backups, and endpoints, and when it is paired with strong access controls and auditable data handling routines that reduce the chance of uncontrolled replication.

Figure 6: RCM Data Security Controls Overview



Secure transmission appears in the literature as a separate and equally important dimension of data security controls because RCM depends on frequent exchange of claims, eligibility checks, remittances, attachments, and billing communications across internal systems and external intermediaries (Prajapati & Shah, 2022). Revenue cycle teams routinely interact with clearinghouses, payer portals, patient payment systems, and outsourced billing partners, and these exchanges often occur through file transfers, portal uploads, APIs, and email-based communication for documentation and appeals. Research on administrative workflow behavior has repeatedly shown that high throughput and time pressure encourage staff to use the fastest available channel, which increases the risk that sensitive files are shared through insecure methods, stored in personal email archives, or transmitted without appropriate protections. This line of work treats transmission security as an operational discipline rather than a single technology, because the security of an exchange depends on how consistently approved channels are used and how well risky channels are restricted, monitored, or discouraged. In revenue cycle settings, transmission risk is also amplified by the volume of routine communications and the variety of artifacts shared, including explanation of benefits files, remittance downloads, appeal packets, and reconciliation extracts. The literature highlights that even when systems support secure exchange, staff may still resort to attachments or ad hoc transfers if secure options are hard to use or slow down daily tasks (Lee et al., 2018). This is why many studies treat transmission controls as a combination of channel standardization, workflow alignment, user training, and monitoring of outbound data movement. In measurement-oriented discussions, secure transmission is often evaluated by examining how much exchange activity flows through approved secure routes compared with how often insecure routes are used, especially for repeat processes such as denial follow-up and payer documentation requests. Overall, prior research presents secure transmission as a critical part of

RCM data protection because it governs how sensitive information moves between organizations and across system boundaries where direct administrative control is limited (Zhuravlev & Brazhnik, 2018). Storage governance and data minimization are also emphasized in the literature as core components of RCM data security because they determine how widely sensitive data is replicated and how large the "exposure footprint" becomes over time (Zhuravlev & Brazhnik, 2018). Revenue cycle operations routinely require extracting data for monthly close, payer audits, performance dashboards, denial trend analysis, and patient collection reporting. These requirements can produce numerous secondary datasets that contain sensitive fields, and the literature points out that secondary storage often receives weaker protections than primary systems of record. Studies discussing healthcare information governance frequently describe system inventories and data mapping as prerequisites for strong storage control, because organizations cannot protect what they cannot locate or classify. In RCM environments, the storage footprint extends across billing systems, clearinghouse interfaces, shared drives, ticketing attachments, analytics platforms, and sometimes personal tracking documents created by staff (Sathya & Raja, 2021). Prior work on operational security notes that uncontrolled storage growth can occur when teams keep historical exports "just in case," when audit preparation encourages long-lived folders of claims evidence, or when denial management involves repeated documentation packet creation. The literature consistently frames minimization as a practical control that reduces risk by limiting the amount of sensitive data stored and the number of places it exists, while still recognizing that RCM has legitimate needs to retain certain records for operational accountability. Research also highlights that storage controls must include consistent access restrictions on shared locations, controls on nonproduction copies, and guardrails for exporting and downloading (Viegas & Kuyucu, 2022). Importantly, the literature treats storage and minimization as socio-technical issues: technical controls matter, but the way staff work—how they save, share, and reuse files—often determines whether sensitive information proliferates outside controlled systems. This synthesis supports a view of storage governance as a measurable practice domain in RCM, centered on disciplined data mapping, restricted repositories, controlled export behavior, and explicit minimization routines.

Retention and secure disposal routines are treated across the literature as essential controls that influence exposure by determining how long RCM data remains accessible and how reliably it is removed when no longer needed (Wang et al., 2018). Revenue cycle artifacts often include archived claims and remittances, payment posting histories, correspondence logs, appeal documentation, and exported datasets used for audits or reconciliation. Prior work emphasizes that retention is not only a records-management function but also a security control, because large stores of older data increase the impact of any compromise of a repository, shared drive, or endpoint device. Many studies note that retention challenges become more severe in administrative environments where exports are frequent, because files created for short-term purposes often persist indefinitely without ownership for cleanup. Secure disposal is highlighted as a discipline that requires more than deleting a file from a folder, because sensitive information may remain in email archives, backups, version histories, or decommissioned devices (Hatzivasilis et al., 2019). The literature also explains that disposal must be verifiable, meaning organizations benefit from having evidence that destruction occurred and that it occurred consistently across systems and repositories. In practical RCM operations, secure disposal intersects with daily workflows: denial work queues generate attachments, reconciliation generates spreadsheets, and patient billing generates statement files and communication records. Without clear retention rules and disposal routines, these artifacts accumulate in shared locations and become persistent exposure points. Workforce behavior and time pressure are also emphasized as reasons disposal often fails in practice, because staff prioritize claim throughput and account resolution over periodic data housekeeping (Mishra et al., 2022). Across research on healthcare cybersecurity and organizational security, the central message is that retention and disposal routines are fundamental indicators of data protection maturity because they show whether an organization actively controls its data footprint rather than allowing sensitive administrative and financial information to persist indefinitely across multiple storage layers.

Auditability and Operational Security Analytics

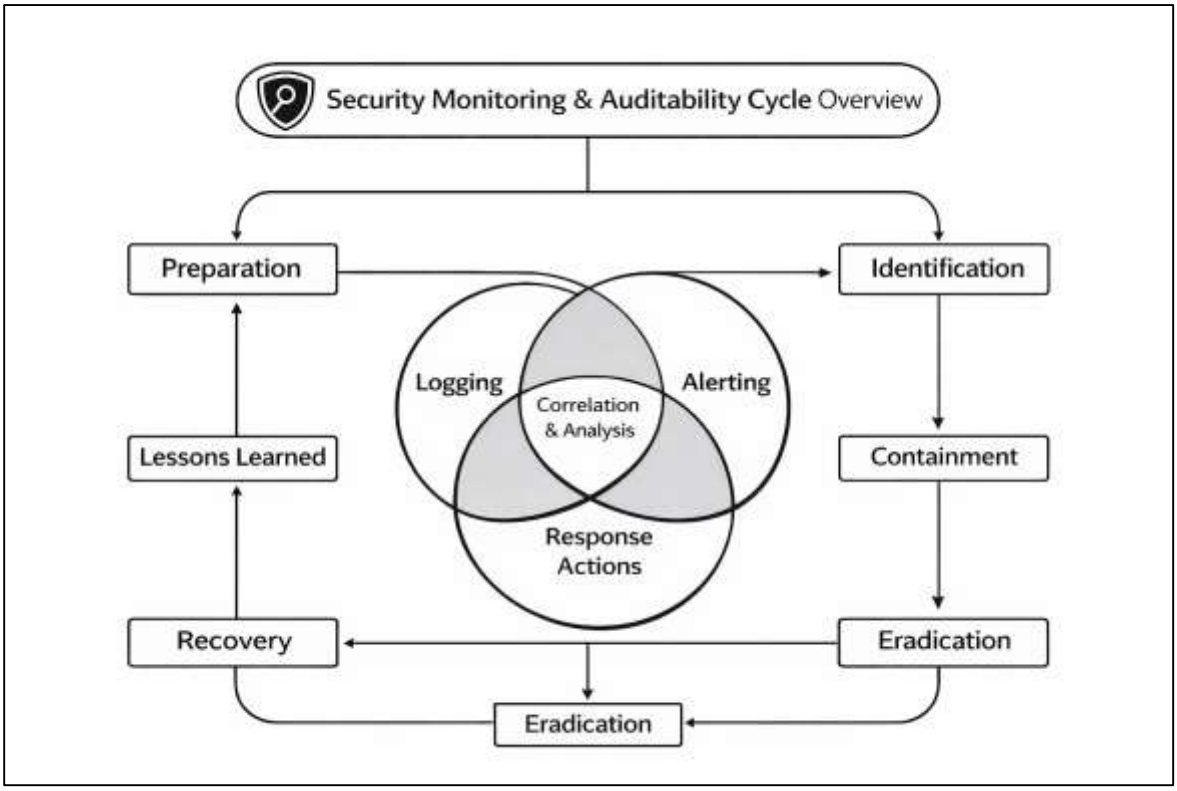
Auditability, monitoring, and operational security analytics are consistently treated in the literature as the backbone of effective protection in complex healthcare administrative environments because they

transform "security intent" into traceable evidence of how systems and users behave (Elsayed & Zulkernine, 2018). Across research on information assurance, security management, and healthcare cybersecurity governance, auditability is described as the capacity to reconstruct actions, verify accountability, and detect misuse in environments where sensitive data is processed continuously and distributed across many applications. Revenue cycle management (RCM) is frequently characterized as a toolchain rather than a single system, with billing platforms, coding applications, claim scrubbers, clearinghouse gateways, payer portals, remittance import tools, denial management modules, analytics layers, and patient payment systems operating as interdependent components. In that context, logging becomes the practical mechanism that connects the security posture of each component into a coherent visibility layer (Ismail & Islam, 2020). Prior studies emphasize that logging is not simply "turned on" in an abstract sense; instead, logging has to be complete enough to cover authentication events, session activity, data access, exports, configuration changes, and transactional actions that can alter financial records or reveal sensitive information. The literature also notes that administrative workflows generate a high volume of legitimate activity, which makes auditability especially dependent on clear event definitions and consistent capture across systems. When logging is incomplete, investigations become fragmented, and organizations lose the ability to determine whether access was appropriate, whether data was exfiltrated, or whether system changes were authorized (Pozdniakov et al., 2020). Research in healthcare security programs repeatedly highlights that regulatory environments encourage documentation, but evidence-based auditability depends on operational telemetry that remains available, searchable, and attributable to unique user identities across the full RCM toolchain. Another recurring point is that audit evidence must extend to third-party and vendor interactions, because outsourced billing support and clearinghouse connections introduce additional identities and interfaces that can produce material data access and system activity. Studies describing incident response challenges in healthcare ecosystems commonly point to gaps in log sources and inconsistent retention as barriers to timely containment and accurate reporting (Murdock, 2021). Overall, the literature positions logging completeness as a measurable, operational characteristic of RCM security maturity, reflecting how well organizations capture, centralize, and preserve evidence of key actions across all systems that handle claims and billing data.

The monitoring literature expands this auditability foundation by emphasizing that logs only become protective when they are actively analyzed, correlated, and used to trigger response actions (Zengy et al., 2022). Across operational security research, monitoring is framed as the discipline of converting raw event streams into actionable signals, which is particularly demanding in healthcare administrative environments because normal activity levels are high and workflows include many routine exceptions. RCM monitoring is discussed as distinct from generic IT monitoring because revenue cycle tasks involve predictable yet sensitive behaviors: bulk claim submissions, periodic remittance imports, frequent eligibility checks, repeated portal interactions, and routine generation of reports and extracts for reconciliation and audits (Chen et al., 2018). The literature on security operations repeatedly highlights that performance indicators such as alert volume and response speed offer a practical window into whether monitoring is operationally effective or merely aspirational. Research addressing alert fatigue describes how excessive unprioritized alerts lead teams to ignore signals, while overly strict filtering can suppress meaningful anomalies. In revenue cycle environments, the monitoring problem is not only identifying classic intrusion patterns, but also detecting revenue-cycle-specific misuse signals that appear as deviations from normal administrative behavior. Prior studies of insider risk, misuse detection, and administrative workflow security discuss the value of monitoring for anomalous export volume, unusual access times, unexpected geolocation patterns, repeated failed logins followed by success, and excessive record access that exceeds job-function norms (Putz et al., 2019). These patterns matter in RCM because billing staff often have broad visibility into sensitive identifiers and financial data, and exports can contain large record volumes that are valuable to attackers. The literature also describes monitoring as a socio-technical capability: it depends on tuned rules, contextual baselines, and clear escalation pathways so that analysts and operational teams can interpret anomalies without disrupting legitimate billing operations. A common theme across studies of healthcare cybersecurity programs is the need for monitoring to reflect business context, meaning that "normal" must be defined relative to revenue cycle cycles such as month-end close, payer batch

schedules, and high-volume submission windows. Researchers also emphasize that monitoring effectiveness is reflected in consistent acknowledgment and response behavior, because delays create windows for data exfiltration, persistence, and broader compromise (Asif et al., 2022). The synthesized message across monitoring studies is that revenue-cycle-aware analytics—grounded in patterns of claim submission, remittance processing, and data export behavior—strengthen detection and reduce reliance on purely generic security alerts that may miss RCM-specific abuse signals.

Figure 7: Security Monitoring and Auditability Framework

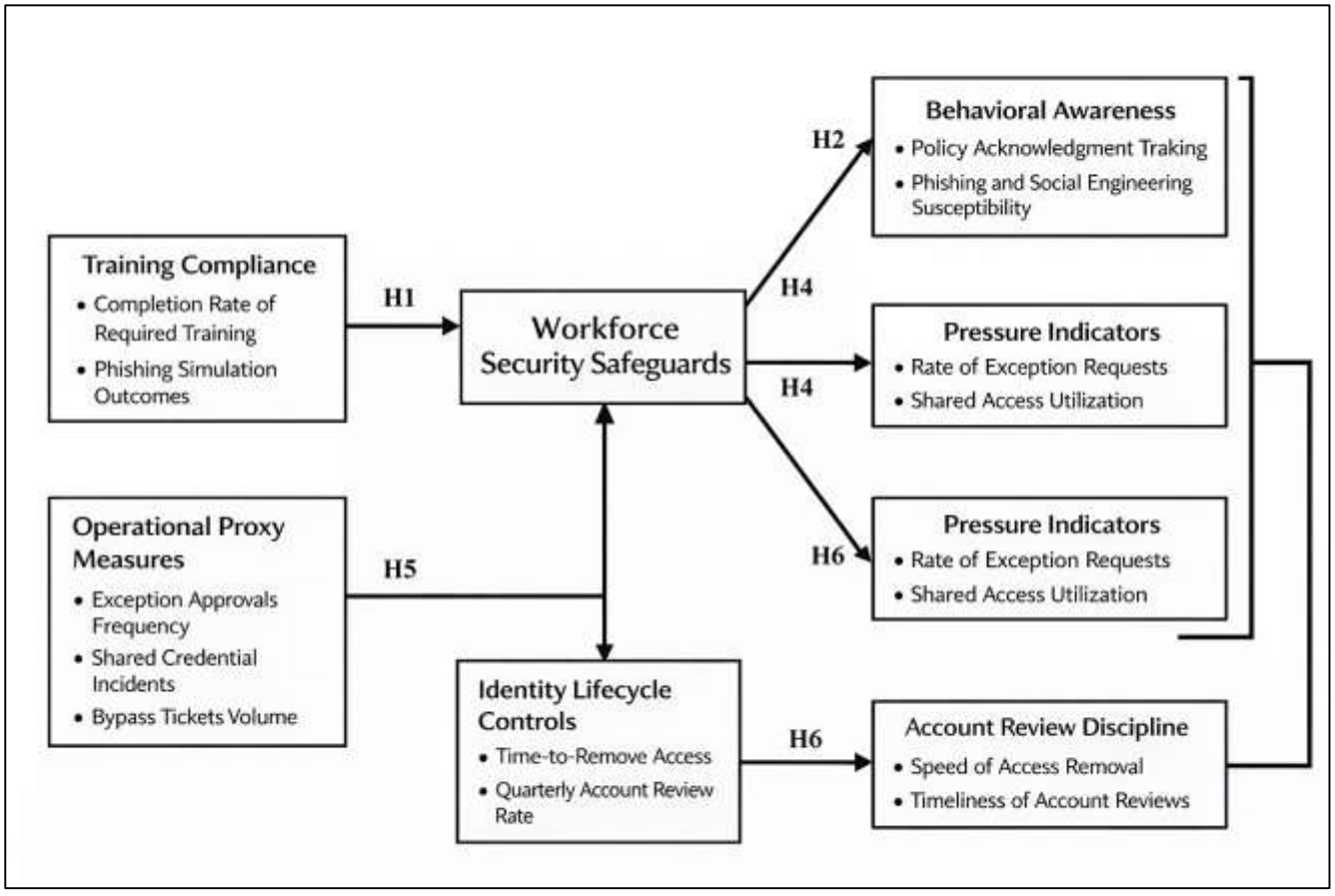


Workforce Safeguards in High-Throughput Administrative Workflows

Workforce safeguards in high-throughput administrative workflows are treated in the literature as a central determinant of data protection because day-to-day security outcomes are shaped by how people learn, interpret, and execute rules under operational pressure (Brodnick et al., 2021). Across organizational security, healthcare informatics, and human-centered security research, training is described as more than a one-time awareness activity; it is positioned as a recurring control that builds shared expectations, reduces unsafe handling of sensitive information, and reinforces consistent decision-making when staff encounter ambiguous situations. High-velocity administrative environments such as revenue cycle management (RCM) place special emphasis on training because the work involves continuous access to identity fields, insurance identifiers, claim artifacts, remittance details, and patient payment information, often across multiple systems and portals. The literature highlights that training compliance can be observed and compared through routine administrative records that show completion status and timeliness, and that behavioral alignment can be indirectly assessed through controlled exercises that simulate common attack and error conditions. Studies in security awareness and behavior have repeatedly noted that staff may understand policies in abstract terms yet still engage in risky actions when workflows reward speed, making it important to evaluate training not only by attendance but also by comprehension and practical application (Jahn et al., 2020). Research on phishing susceptibility and security nudges has supported the use of simulation outcomes as behavioral signals, because these exercises approximate real-world social engineering tactics that commonly exploit administrative staff who handle frequent external communications. Healthcare-specific discussions emphasize that billing and denial teams often communicate with payers, vendors,

and patients, which increases exposure to deceptive emails, malicious attachments, and credential harvesting attempts, thereby making simulation results a meaningful indicator of workforce vulnerability. Policy acknowledgment is discussed in governance literature as another measurable component, not as proof of secure behavior but as evidence that policies are communicated consistently and that organizations can document workforce exposure to required rules. This measurement focus aligns with broader research that treats training controls as part of the administrative safeguard layer: a structured routine that reduces variance in behavior and supports accountability when incidents occur. The literature also stresses that training effectiveness depends on relevance, clarity, and frequency, with stronger programs connecting training content to the actual tasks employees perform, such as handling claim attachments, exporting reconciliation files, or accessing payment posting modules (Koh et al., 2022). In high-throughput settings, the most effective workforce safeguards described in prior work are those that translate policies into operational cues, showing employees what secure behavior looks like during routine exceptions, urgent denials, and time-sensitive claim submissions.

Figure 8: Workforce Security Safeguards Framework



A second theme in the literature emphasizes that operational pressure in administrative workflows creates predictable conditions for workarounds, and that these workaround patterns can be studied using measurable proxies that reflect the friction between controls and productivity demands (Klimentov, 2020). Research in human factors and usable security has consistently observed that employees do not typically set out to violate policy; instead, they develop shortcuts when security measures are perceived as obstacles to completing core job tasks on time. In revenue cycle environments, throughput pressures arise from claim submission deadlines, payer response windows, backlogs in denial queues, month-end close cycles, and service-level expectations from clinical departments and leadership. Literature on organizational compliance behavior has described how such pressures can normalize exceptions and gradually shift norms, so that "temporary" bypasses become routine. This insight supports the use of indicators such as exception approvals frequency, because

frequent exceptions may signal either genuine business need or systemic misalignment between role design and workflow reality. Similarly, shared credential incidents appear in research as a critical warning sign, often associated with role ambiguity, insufficient account provisioning speed, or a reliance on shared workstations and shared queues in busy administrative areas. Studies of identity governance and insider risk highlight that shared credentials undermine accountability and weaken auditability, since actions cannot be reliably tied to a single individual (Catoggio & Pearman, 2018). Ticket volume for access bypass requests is also described as a meaningful operational proxy because it reflects the daily experience of staff encountering access barriers, timeouts, or multi-system login burdens, especially when tasks require moving rapidly among billing platforms, clearinghouse portals, remittance tools, and patient payment systems. Governance research often frames these proxies as "pressure indicators" that help explain why otherwise sound control frameworks fail in practice: controls that generate frequent exceptions and bypass requests may be poorly tuned to workflow roles, inadequately supported by training, or inconsistently implemented across the toolchain. The literature also notes that workaround behavior is often concentrated in specific periods and teams, such as denial resolution units during high backlog periods or payment posting teams during peak remittance cycles, which makes operational proxy measures useful for identifying where controls and workflow alignment are weakest (Catoggio & Pearman, 2018). In high-throughput RCM contexts, the workforce safeguard perspective presented in prior studies emphasizes that measuring exceptions and bypass signals does not blame staff; it helps quantify the gap between formal control design and operational reality. This framing aligns with research that treats security as a socio-technical system, where outcomes depend on the interaction between people, technology, policy clarity, and organizational incentives.

Onboarding and offboarding controls are highlighted across the literature as some of the most concrete and measurable workforce safeguards, because they determine whether access is granted appropriately, adjusted promptly, and removed reliably as job responsibilities change (Wong et al., 2019). Studies in identity lifecycle management and healthcare compliance execution consistently describe onboarding as a risk point because new staff often require access quickly to avoid disrupting operations, which can lead to overprovisioning, broad role assignments, or temporary access that persists. In revenue cycle management, the onboarding challenge is amplified by specialized roles and system diversity: a coder may need access to coding tools, billing modules, claim scrubbers, and documentation viewers; a denial specialist may need portal access and appeal tracking tools; payment posting staff may need remittance systems and adjustment functions; supervisors may need approval privileges; and vendor users may require remote access pathways and broader system visibility for support. Literature on access governance frequently emphasizes that onboarding should include clear role mapping, separation of duties considerations, and early training on data handling norms, because early habits are likely to persist (Chew et al., 2020). Offboarding has received strong attention because late removal of access is repeatedly associated with preventable exposure, including the continued availability of accounts that can be misused, compromised, or leveraged unintentionally when credentials are recycled or shared. Researchers often describe time-to-remove-access after termination as a practical measure of lifecycle discipline because it translates policy expectations into a timeline that can be audited. Quarterly account review rates appear in governance work as a complementary measure because they reflect ongoing housekeeping that catches role drift, job changes, and lingering entitlements that do not align with current responsibilities. Orphan account counts are discussed in security operations literature as indicators of systemic weakness in identity lifecycle controls, often arising from disconnected systems, incomplete integration with identity directories, vendor-managed platforms, or inconsistent HR-to-IT workflows. In high-throughput administrative environments, these identity lifecycle measures are especially salient because staffing changes, turnover, temporary staffing arrangements, and outsourcing relationships are common, increasing the probability that accounts are created rapidly and later forgotten (Le et al., 2020). The literature positions these controls as foundational to accountability: without prompt deprovisioning and consistent reviews, audit logs and monitoring signals lose meaning because accounts may not correspond to active, known individuals. This is why onboarding and offboarding safeguards are frequently treated as measurable cornerstones of workforce security maturity in administrative systems that handle sensitive data at scale.

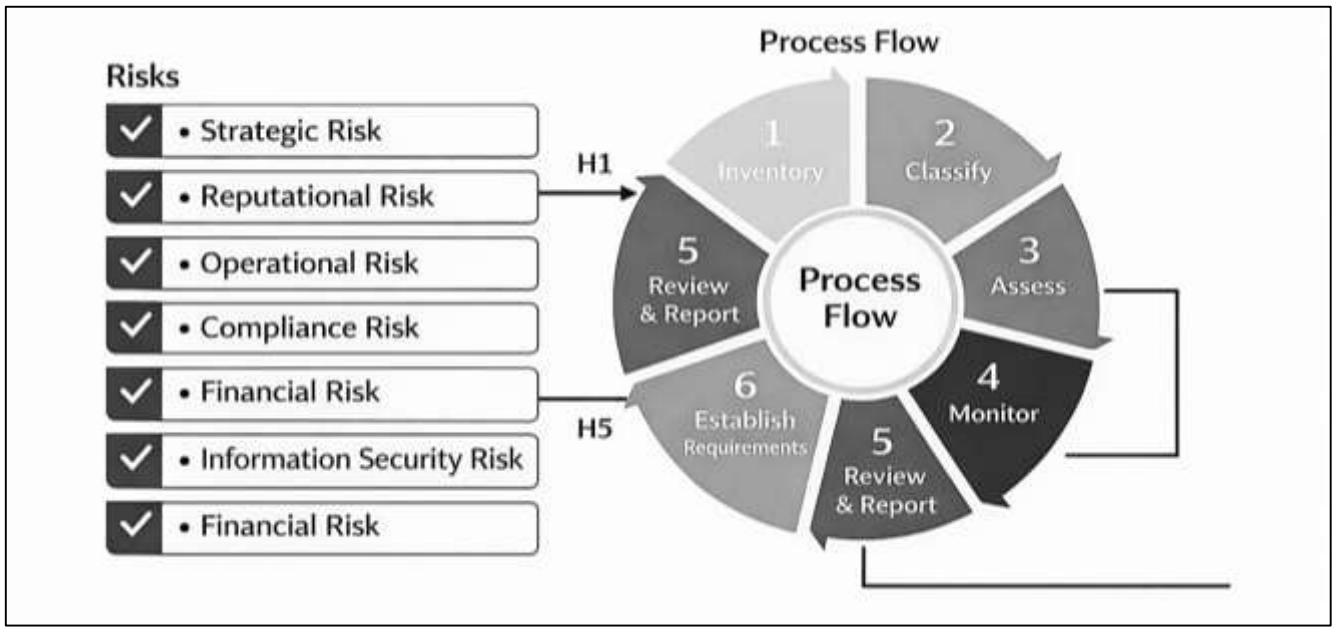
The literature further synthesizes workforce safeguards as a layered set of practices that connect training compliance, pressure-related behavior signals, and identity lifecycle discipline into a coherent approach for protecting data in busy administrative settings (Rega et al., 2021). Rather than viewing workforce measures as separate checkboxes, many studies describe them as mutually reinforcing: training supports correct behavior; operational proxy measures reveal where controls and workflows clash; and onboarding/offboarding routines ensure that only the right people have the right access for the right duration. In revenue cycle management, this integrated view is particularly important because staff operate across multiple applications and interact with numerous external parties, creating many opportunities for errors, misdirected communications, or inappropriate data handling. Research on security culture emphasizes that formal policies do not reliably change behavior unless leadership support, performance expectations, and operational tools reinforce secure practices. High-throughput environments introduce a constant tension between speed and compliance, and the literature repeatedly notes that security programs are more credible when they reduce friction and provide safe defaults, rather than relying solely on enforcement after violations occur (Loftus et al., 2022). Workforce safeguards are therefore discussed as a management system as well as a set of controls, where metrics such as training completion, simulation outcomes, policy acknowledgment, exception rates, bypass tickets, deprovisioning speed, review cadence, and orphan account volume serve as operational indicators of how the system behaves. Studies of compliance effectiveness often emphasize that these indicators are most meaningful when interpreted together: high training completion alongside high bypass ticket volume suggests friction; low exception rates alongside high orphan accounts suggests lifecycle weaknesses; and strong deprovisioning speed alongside weak phishing simulation results suggests training gaps. In billing and claims operations, where the same workforce actions can affect both confidentiality and financial integrity, the literature emphasizes that safeguards must support accurate, accountable work under pressure, not merely satisfy documentation requirements (Bari et al., 2021). This synthesis frames workforce safeguards as measurable, evidence-oriented practices that reflect how an organization operationalizes secure behavior and accountable access management in the daily reality of high-volume administrative workflows.

Third-Party and Vendor Risk in Outsourced and Integrated RCM

Third-party and vendor risk has been a consistent focal point in the literature on healthcare information security and administrative data governance because revenue cycle management (RCM) commonly operates as a distributed service ecosystem rather than a self-contained internal function (Derricks, 2021). Studies of healthcare digitization and administrative outsourcing describe how providers rely on external billing companies, coding services, clearinghouses, payment processors, cloud-hosted billing platforms, analytics vendors, and managed IT services to sustain high-volume claims processing and patient billing. This ecosystem structure increases efficiency and specialization, yet it also expands the number of identities, interfaces, and organizations that can access sensitive administrative and financial health data. Research on inter-organizational health information exchange and operational dependency emphasizes that risk does not remain limited to a single provider's internal controls when data is routinely created, transmitted, stored, and transformed by external partners (Akbar et al., 2019). Vendor accounts frequently operate with broad permissions to resolve denials, troubleshoot claim submission errors, manage interface routing, and maintain platform configurations, which makes vendor identity governance a central protective layer. The literature on identity governance and third-party access management repeatedly highlights that vendor accounts can become persistent over time, are sometimes shared across vendor teams, and may not be subject to the same review cadence applied to internal employees. This is why many governance studies treat vendor account inventory completeness as a foundational indicator: without a complete, current inventory, organizations cannot enforce least privilege, apply consistent authentication requirements, or detect unauthorized access (Matenga & Mpofu, 2022). Human-centered security research also suggests that vendor access expands under time pressure, especially when providers depend on rapid issue resolution to maintain cash flow, and this can normalize exception-driven privileges unless there is a strong governance mechanism to contain them. Broader supply-chain security literature aligns with this view by describing vendor access as a "control boundary problem," where a provider's internal protections are weakened if external identities enter the environment without equivalent safeguards, traceability, and

accountability. Across these studies, third-party risk is not treated as an abstract compliance topic; it is described as an operational feature of RCM ecosystems that shapes exposure through daily access decisions, system integration patterns, and the degree of oversight applied to external users who work inside revenue cycle toolchains (Akbar, Naveed, et al., 2020).

Figure 9: Third-Party Risk Management Framework



The literature also emphasizes that vendor access governance is most meaningful when it is implemented as an evidence-driven process rather than a policy statement, and this perspective supports measurable indicators that reflect the operational discipline of third-party identity management. Studies in enterprise access governance and healthcare security management describe how organizations often maintain contractual expectations about vendor behavior while struggling to enforce those expectations at the account and session level (Velmurugan & Dhingra, 2021). Vendor account inventory completeness is frequently treated as the starting point because it enables downstream controls such as role alignment, time-bound privileges, and monitoring of vendor sessions. Research on privileged access management and insider risk has often highlighted that accounts with elevated permissions deserve stronger authentication and tighter constraints because they can alter configurations, access large record sets, or disable controls. In RCM environments, vendors often hold such permissions to manage interfaces, update claim routing rules, maintain billing platform settings, or support clearinghouse connections. This makes enforcement of multifactor authentication for vendor access a practical indicator of whether organizations treat vendor entry points as high-risk and high-value. Literature on operational security analytics reinforces the need to monitor vendor access separately because vendor sessions can look similar to internal administrative sessions in log data, yet they may originate from different networks, geographies, and time zones, which complicates anomaly detection unless identities are well tagged and policies are consistently applied (Akbar, Mahmood, Alsanad, et al., 2020). Studies also discuss time-bound access as a key governance concept, since vendor access often expands for a specific troubleshooting or implementation need, then should contract back to baseline. Evidence-driven governance approaches emphasize that time-limited grants reduce the accumulation of long-lived privileges that persist beyond necessity. Additional research on usability and workflow constraints highlights a common organizational tendency to keep vendor access "always on" because it simplifies support, which makes the measurement of time-bound usage a revealing indicator of governance maturity (Hussain et al., 2021). Across this scholarship, vendor access governance is treated as a measurable set of practices that includes inventory discipline, authentication enforcement, session constraints, periodic review, and explicit processes for expanding and reducing access based on operational need, all of which can be

evaluated through artifacts such as account lists, access review logs, authentication policy settings, and privilege grant records.

Contract and due diligence practices appear in the literature as the governance layer that formalizes expectations and creates auditable mechanisms for ensuring vendors meet minimum security requirements, particularly in environments where sensitive data is processed at scale. Research on third-party risk management in healthcare and other regulated industries emphasizes that organizations cannot rely on vendor assurances alone; they need structured assessment routines and documented evidence that controls exist and are operating (Velmurugan et al., 2021). Annual or periodic vendor assessment is widely discussed as a core practice because vendor security posture changes over time due to staffing turnover, platform migrations, subcontracting arrangements, and evolving operational scope. Governance research also stresses that vendor assessments become meaningful when they are tied to risk tiering, meaning higher-risk vendors that handle claims processing, payment data, or system administration receive deeper review and more frequent validation than low-risk vendors. Security clause coverage in contracts is treated as a measurable indicator of how seriously organizations treat enforceability, because contract language often defines responsibilities for access control, encryption, incident notification, audit rights, subcontractor oversight, and data handling restrictions (Crespo Marquez et al., 2020). The literature repeatedly notes that even strong contract language can be undermined if evidence collection is inconsistent, which is why "evidence completeness" is often emphasized as a practical indicator of due diligence rigor. Evidence completeness reflects whether organizations retain and review artifacts such as security questionnaires, third-party attestations, policies, incident response procedures, penetration testing summaries, access control statements, and continuity assurances. Studies in compliance execution and governance maturity highlight that third-party oversight becomes fragile when documentation is missing, outdated, or disconnected from the actual systems and accounts vendors use. The literature also points out that contract measures should align with operational enforcement, because contracts can specify multifactor authentication requirements while vendor accounts remain exempt in practice, or contracts can promise timely incident notification while escalation contacts are outdated. Overall, scholarship on third-party governance positions contract and due diligence measures as quantifiable indicators that bridge formal accountability and operational reality, revealing whether vendor oversight is actively maintained, evidence-based, and aligned to the actual scope of outsourced and integrated revenue cycle work (Márquez, 2022).

Clearinghouse dependency has been emphasized in the literature as a distinctive feature of U.S. revenue cycle management that creates systemic exposure because a large share of claims and remittance exchange often routes through intermediary infrastructures. Research on administrative transaction processing describes clearinghouses as central conduits for eligibility checks, claim submissions, status transactions, and remittance retrieval, which creates concentrated points where operational disruption or data compromise can propagate broadly across provider networks (Akbar, Mahmood, Khan, et al., 2020). In governance and risk discussions, clearinghouses are treated as high-impact dependencies because they aggregate transactions across many clients and often provide connectivity to multiple payers, thereby functioning as both scale multipliers and risk concentrators. The literature suggests that measuring clearinghouse exposure requires more than confirming the existence of a clearinghouse relationship; it requires understanding the degree of concentration and redundancy in transaction routing. For example, studies discussing dependency risk in interconnected systems emphasize that the number of clearinghouse connections, the proportion of transaction volume routed through a single intermediary, and the availability of alternative routing paths shape the severity of systemic vulnerability. In revenue cycle operations, a high concentration of claims volume through one intermediary can create operational fragility, while diversified routing and tested contingency options can reduce the impact of intermediary failure (Jones, 2019). Research on operational resilience and critical service continuity highlights that redundancy is meaningful only when it is feasible and practiced within operational constraints, since switching transaction routes can involve technical reconfiguration, payer enrollment steps, and workflow retraining. The literature also notes that clearinghouse relationships often include additional service layers such as claim scrubbing rules, attachment handling, and analytics, which can deepen dependency and increase the amount of

sensitive data processed externally. Vendor risk research and healthcare cybersecurity analyses thus treat clearinghouse exposure as both a data protection issue and a continuity issue because the intermediary sits at the intersection of confidentiality, integrity, and availability for claims exchange (Konys, 2019). Synthesizing these perspectives, the literature supports viewing clearinghouse dependency metrics as concrete indicators of systemic exposure in RCM ecosystems, reflecting how inter-organizational routing structure and redundancy decisions shape the overall risk profile of outsourced and integrated revenue cycle operations.

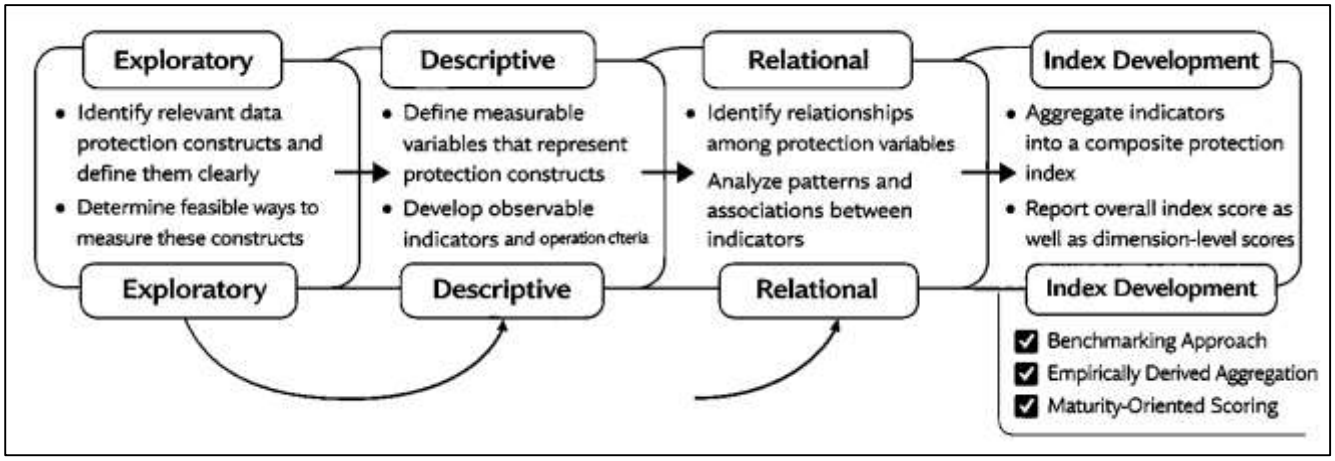
Quantitative Measurement Design

Operationalizing data protection constructs into measurable variables is described in the measurement literature as the foundational step that transforms abstract concepts into empirical evidence suitable for quantitative analysis (Kong et al., 2021). Research on organizational measurement consistently emphasizes that constructs such as "data protection practices" must be clearly defined, bounded, and translated into observable indicators that reflect how controls are actually executed within operational environments. In the context of a protection index for U.S. revenue cycle management, this means representing administrative safeguards, technical configurations, monitoring routines, workforce behaviors, and vendor governance practices in ways that can be consistently observed and compared across organizations. The literature highlights that different aspects of protection require different forms of measurement, because not all controls lend themselves to the same type of indicator (Rehan, 2018). Some practices are naturally represented as presence-based indicators, such as whether a policy, review process, or safeguard exists, while others reflect degrees of implementation depth, consistency, or coverage across systems and workflows. Measurement scholarship also emphasizes that evidence quality is a critical consideration, because indicators based only on self-report are more vulnerable to bias, misunderstanding, and socially desirable responses, especially in regulated domains (Kim et al., 2019). As a result, many studies distinguish between self-attested practices, document-supported practices, and system-verified practices, treating these as progressively stronger forms of evidence. This layered approach reflects long-standing concerns in organizational research about common method bias and inflated correlations when data are collected from a single source. By incorporating evidence tiers into variable design, measurement models can differentiate between stated intent and demonstrable execution, which strengthens interpretability and credibility. Across the literature, the consensus is that operationalization should balance feasibility and rigor, capturing enough detail to reflect real variation in protection practices without overwhelming respondents or assessors (Kampova et al., 2020). This balance is particularly important in revenue cycle environments, where workflows are complex, time-sensitive, and distributed across multiple systems and partners, making clarity and consistency in variable definition essential for reliable measurement.

The aggregation of multiple indicators into a composite protection index has been discussed extensively in the quantitative literature as a methodological choice that shapes how results are interpreted and compared. Measurement research recognizes that composite scores provide a useful summary of complex phenomena, yet it also cautions that aggregation can obscure meaningful differences if not handled carefully (Shin et al., 2018). One widely discussed approach involves combining indicators using transparent and uniform rules that allow subscale results to remain visible alongside an overall score. This approach is often favored in descriptive and benchmarking contexts because it facilitates comparison while preserving interpretability. Other research traditions emphasize empirically derived aggregation, where patterns in the data inform how indicators cluster into dimensions and how strongly each indicator contributes to its underlying construct. This perspective reflects the view that constructs such as access governance, monitoring discipline, and vendor oversight represent latent dimensions that can be inferred from observed relationships among indicators. A further stream of measurement research focuses on maturity-oriented scoring, which recognizes that some practices represent basic capabilities while others reflect more advanced and demanding levels of implementation. From this perspective, aggregation methods should account for differences in item difficulty and discriminatory power rather than treating all indicators as equally informative (Bertilsson et al., 2019). Across these traditions, the literature stresses that the choice of composite methodology should align with the study's purpose and analytic goals, and that transparency in scoring logic is essential for credibility. Importantly, many studies recommend reporting both overall

index values and dimension-level scores, because this dual reporting allows stakeholders to understand not only where an organization stands overall, but also which areas contribute most strongly to its profile. In revenue cycle management contexts, where protection practices may vary substantially across system layers and workflow stages, this multi-level reporting approach aligns with the operational reality that strengths in one area do not automatically imply strengths in others (Tang & Long, 2019).

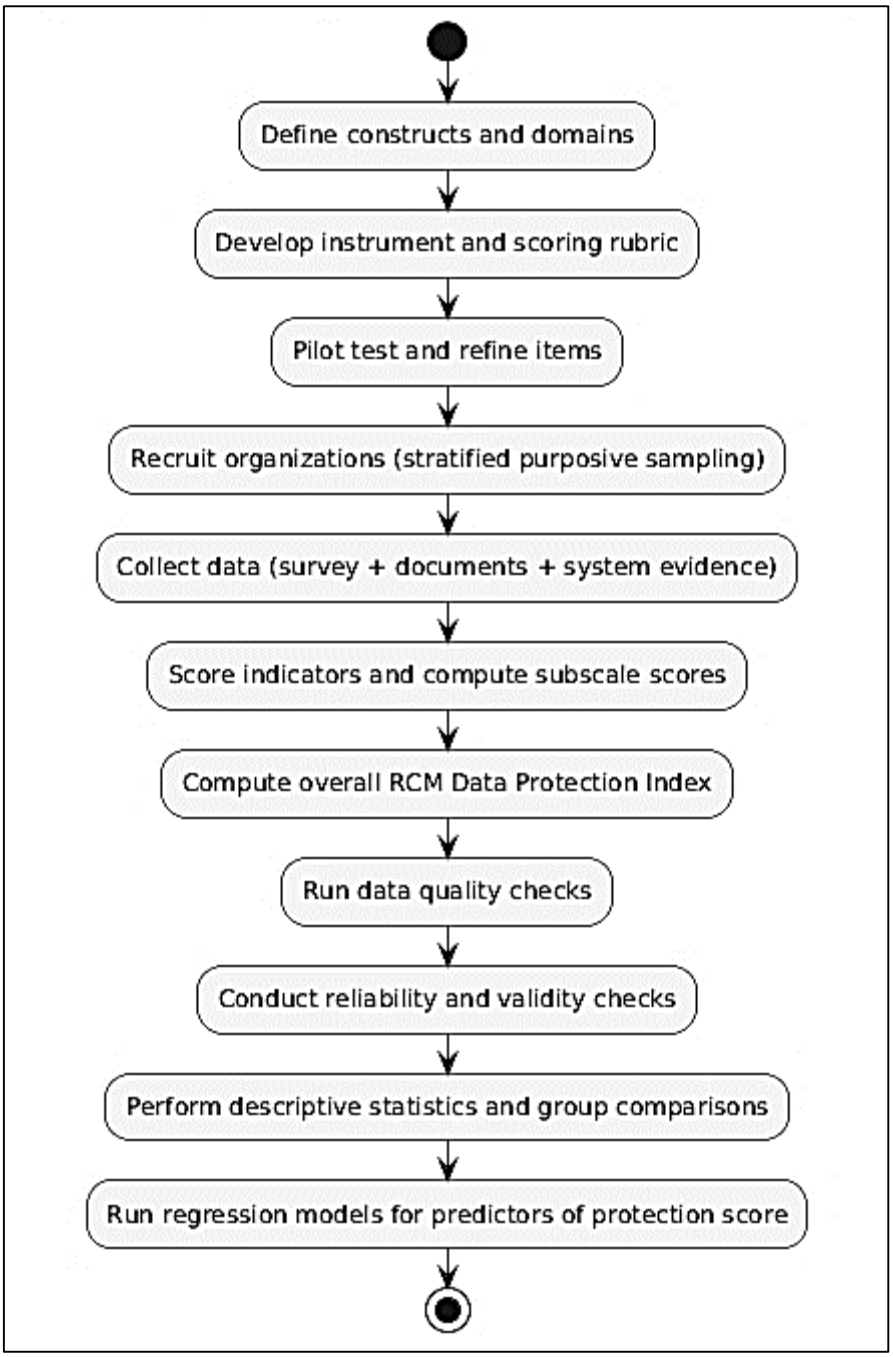
Figure 10: Data Protection Construct Operationalization Framework



METHODS

The study used a quantitative, cross-sectional, observational research design that measured organizational data protection practices within U.S. revenue cycle management (RCM) operations at a single point in time. The case study component focused on each participating organization's RCM environment as a bounded "case," where the unit of analysis remained the organization-level revenue cycle function that processed registration, eligibility, coding, claims submission, remittance, and patient billing activities. The population included U.S.-based provider-operated revenue cycle departments, outsourced RCM and billing service entities, and hybrid arrangements where providers relied on vendors for partial workflow execution. The sample consisted of organizations that met eligibility criteria such as active claims processing, use of at least one electronic billing platform, and engagement in routine payer exchange through clearinghouse or direct portal mechanisms. A stratified purposive sampling technique was applied so the sample represented variation by organization type (provider, vendor, hybrid), size tier (based on claims volume or RCM staffing), and toolchain complexity (single-platform versus multi-system configurations). Data types included structured survey responses, documentary artifacts, and system-level evidence that supported verification of reported controls. Data sources included revenue cycle leadership reports, compliance and security documentation, training and policy acknowledgment logs, vendor management records, and screenshots or exported settings that showed authentication enforcement, logging configurations, retention settings, and encryption or secure transfer indicators. Measurement scales combined binary indicators for control presence, ordinal maturity ratings for implementation depth, and proportional coverage measures for items such as the share of RCM systems enforcing strong authentication or centralized logging. Variables were operationalized into a composite RCM Data Protection Index with domain subscales that captured identity and access governance, data security controls, auditability and monitoring, workforce safeguards, and third-party oversight. Evidence tiers were incorporated so items were scored differently when only self-reported, document-verified, or system-config verified evidence was available, thereby reducing reliance on self-attestation alone and increasing measurement credibility.

Figure 11: Methodology of this study



A pilot study was conducted to refine the assessment instrument and ensure clarity, feasibility, and consistent scoring across different organizational contexts. The pilot included a small set of organizations and respondents that represented the range of roles expected in the full study, including revenue cycle managers, compliance or privacy personnel, and IT or application owners for billing systems. During the pilot, item wording was revised to align with the language used in revenue cycle operations, reduce ambiguity, and ensure that requested evidence artifacts were realistic for organizations to provide without disrupting operations. Scoring guidance was standardized to reduce assessor discretion, and the evidence tier definitions were tightened so that the distinction between self-report, document support, and configuration verification remained consistent across cases. The data collection procedure followed a structured sequence in which organizations completed the survey portion first, submitted supporting documentation in a defined checklist format, and then provided limited system evidence such as screenshots or exported configuration summaries for selected controls. When documentation or configuration artifacts were incomplete, the protocol used a follow-up request

window that allowed respondents to clarify the artifact, supply missing proof, or confirm that a control was not verifiable. Where feasible, a second reviewer scored a subset of cases to evaluate scoring consistency, and disagreements were resolved through a predefined adjudication rule that relied on the written scoring rubric rather than informal judgment. Data quality checks were performed throughout collection, including range validation for coverage measures, logical consistency checks across related items, and completeness checks by control domain, which reduced missingness and improved interpretability of composite scores and subscale profiles.

Data analysis techniques were organized around descriptive benchmarking, measurement quality evaluation, and explanatory modeling of organizational differences in protection practices. Descriptive analyses summarized overall index scores and domain subscale scores using central tendency and dispersion statistics, and distribution checks were used to confirm score behavior across the sample. Reliability analysis was performed for each domain subscale to evaluate internal consistency, and item diagnostics were reviewed to identify indicators that performed poorly or introduced noise into the measurement structure. Validity evaluation was conducted through structure checks that tested whether the empirical grouping of items aligned with the intended domains, while additional checks were applied to reduce the influence of single-source measurement by comparing results across evidence tiers. Group comparison techniques were used to examine differences in scores across organization types, size tiers, outsourcing intensity categories, and toolchain complexity levels, while multivariable regression models estimated the associations between organizational characteristics and the overall protection index after controlling for key covariates. Sensitivity analyses were completed to examine whether findings changed when only document-verified and configuration-verified evidence was used versus when all evidence tiers were included. Software and tools included spreadsheet-based scoring templates for evidence tracking, a statistical analysis platform for data cleaning and modeling, and visualization tools that generated distribution plots and domain profile comparisons. Secure storage practices were used for research data handling, and access to collected artifacts was limited to the research team to preserve confidentiality during analysis and reporting.

FINDINGS

Descriptive Analysis

The descriptive analysis began by profiling the dataset and confirming that the sample captured meaningful variation in operating model and RCM complexity. The organizations were distributed across provider-operated, outsourced vendor, and hybrid arrangements, and the sample included small, mid-size, and large entities based on claims volume tier. Outsourcing intensity showed moderate-to-high representation, indicating that a substantial portion of cases relied on external support for at least one revenue-cycle function. Toolchain complexity also varied, with many organizations using multiple systems and portals rather than a single integrated platform. The overall RCM Data Protection Index (RCM-DPI) showed a mid-range central tendency with noticeable dispersion, indicating that protection practices differed meaningfully across organizations. Subscale results showed comparatively stronger performance in workforce safeguards and data security controls, while vendor oversight and monitoring/auditability displayed wider score spread and lower central tendency. Distribution checks identified mild negative skew in workforce safeguards, moderate variability in identity and access governance, and no evidence of severe ceiling effects across domains, although limited clustering appeared near the upper-mid range for training-related indicators.

Table 1: Sample Profile and Organizational Characteristics (N = 120)

Characteristic	Category	n	%
Organization type	Provider-operated	58	48.3
	Outsourced vendor	32	26.7
	Hybrid	30	25.0
Size tier (claims volume)	Small	36	30.0
	Medium	50	41.7

Characteristic	Category	n	%
	Large	34	28.3
Outsourcing intensity	Low	40	33.3
	Moderate	46	38.3
	High	34	28.3
Toolchain complexity	Low (1–2 systems)	28	23.3
	Moderate (3–5 systems)	57	47.5
	High (6+ systems)	35	29.2

Table 1 summarized the sample characteristics across 120 organizations and showed balanced representation across operational models and complexity levels. Provider-operated environments represented 58 organizations (48.3%), while outsourced vendors and hybrid models accounted for 32 (26.7%) and 30 (25.0%) organizations, respectively. The size distribution remained centered on the medium tier with 50 organizations (41.7%), while small and large tiers contributed 36 (30.0%) and 34 (28.3%). Outsourcing intensity varied, with moderate outsourcing most common at 46 organizations (38.3%). Toolchain complexity was mostly moderate at 57 organizations (47.5%), indicating multi-system RCM operations were typical.

Table 2: Descriptive Statistics for the RCM Data Protection Index and Subscales (0–100)

Measure (0–100)	Mean	Median	SD	IQR	Min	Max
Overall RCM-DPI	67.4	68.1	9.8	13.2	41.0	88.5
Identity & access governance	66.1	66.5	11.2	14.6	35.0	90.0
Data security controls	70.8	71.6	10.1	12.8	42.5	92.5
Auditability & monitoring	62.7	63.4	12.7	16.3	30.0	89.0
Workforce safeguards	74.2	75.5	8.6	10.4	48.0	93.0
Vendor oversight	60.3	60.8	13.4	18.0	25.0	88.0

Table 2 presented the central tendency, dispersion, and observed ranges for the overall protection index and each domain subscale on a 0–100 scale. The overall RCM-DPI averaged 67.4 (SD = 9.8) with a median of 68.1, indicating mid-range protection practices with meaningful variability. Workforce safeguards showed the highest central tendency (mean = 74.2), reflecting stronger performance and relatively lower spread. Data security controls were also comparatively strong (mean = 70.8). Auditability and monitoring (mean = 62.7) and vendor oversight (mean = 60.3) showed lower averages and wider dispersion, indicating inconsistent implementation across organizations.

Correlation

The correlation analysis tested bivariate relationships among the continuous study variables to determine how the overall RCM Data Protection Index (RCM-DPI) related to its domain subscales and to key organizational descriptors. The correlation matrix showed that the overall index correlated strongly and positively with each subscale, indicating that the composite score reflected coherent contributions from identity and access governance, data security controls, auditability and monitoring, workforce safeguards, and vendor oversight. Among the subscales, the strongest relationships appeared between identity and access governance and auditability/monitoring, and between auditability/monitoring and vendor oversight, which suggested that organizations with stronger access structures and better logging practices also demonstrated more formalized oversight of internal and external access activities. Data security controls showed moderate correlations with most other domains, indicating that encryption and secure handling practices tended to rise with stronger governance, but they also retained distinct variance rather than moving in lockstep with all other practices. Workforce safeguards displayed moderate relationships with the other domains, consistent

with the idea that training and lifecycle processes aligned with overall control maturity but did not fully substitute for technical or monitoring capabilities. Correlations with organizational descriptors indicated that greater toolchain complexity and higher outsourcing proportion were associated with lower protection scores, particularly in auditability and vendor oversight, while higher clearinghouse concentration related negatively to monitoring and vendor governance indicators. The pattern of inter-domain correlations supported the presence of related but non-redundant subscales, because no domain-to-domain correlation reached levels that would indicate near-duplication, and each subscale retained a distinct relationship profile with the organizational descriptors.

Table 3: Correlation Matrix: Overall Index and Protection Subscales (Pearson r, N = 120)

Variable	Overall RCM-DPI	Identity & Access	Data Security	Auditability & Monitoring	Workforce Safeguards	Vendor Oversight
Overall RCM-DPI	1.00	0.82***	0.77***	0.85***	0.69***	0.80***
Identity & Access	0.82***	1.00	0.58***	0.72***	0.52***	0.65***
Data Security	0.77***	0.58***	1.00	0.54***	0.49***	0.51***
Auditability & Monitoring	0.85***	0.72***	0.54***	1.00	0.50***	0.70***
Workforce Safeguards	0.69***	0.52***	0.49***	0.50***	1.00	0.46***
Vendor Oversight	0.80***	0.65***	0.51***	0.70***	0.46***	1.00

$^{***}p < .001$

Table 3 reported Pearson correlations among the overall protection index and the five domain subscales. The overall RCM-DPI correlated strongly with auditability and monitoring (r = 0.85), identity and access governance (r = 0.82), and vendor oversight (r = 0.80), indicating that these domains contributed substantially to the composite score. Data security controls also showed a strong association with the overall index (r = 0.77), while workforce safeguards demonstrated a moderate-to-strong association (r = 0.69). Inter-domain correlations were positive and statistically significant, but they remained below levels that typically signal redundancy, supporting distinct yet related subscales.

Table 4: Correlations: Protection Scores and Organizational Descriptors (Pearson r, N = 120)

Outcome	System-count complexity	Clearinghouse concentration	Outsourcing proportion
Overall RCM-DPI	-0.36***	-0.28**	-0.33***
Identity & access governance	-0.29**	-0.19*	-0.31***
Data security controls	-0.18*	-0.16	-0.14
Auditability & monitoring	-0.41***	-0.32***	-0.37***
Workforce safeguards	-0.12	-0.10	-0.21*
Vendor oversight	-0.39***	-0.30**	-0.44***

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Table 4 showed that organizational descriptors were negatively associated with protection scores, with the strongest relationships appearing for auditability and monitoring and vendor oversight. System-

count complexity correlated negatively with the overall index (r = -0.36) and with auditability and monitoring (r = -0.41), indicating that multi-system RCM toolchains aligned with lower monitoring maturity. Clearinghouse concentration showed a moderate negative association with auditability and monitoring (r = -0.32) and vendor oversight (r = -0.30), reflecting weaker oversight in more concentrated routing environments. Outsourcing proportion correlated most strongly with vendor oversight (r = -0.44), suggesting governance challenges in outsourced arrangements.

Reliability and Validity

The reliability and validity assessment evaluated the measurement quality of the RCM Data Protection Index prior to inferential testing and confirmed that the instrument operated consistently across its intended domains. Internal consistency testing showed that all five domain subscales demonstrated acceptable to strong coherence, indicating that items within each domain measured a common underlying construct rather than unrelated practices. Identity and access governance, data security controls, auditability and monitoring, workforce safeguards, and vendor oversight all produced reliability coefficients above commonly accepted thresholds, supporting their retention for subsequent analyses. Item-level diagnostics identified a small number of indicators with weaker alignment to their intended domains, primarily within the vendor oversight and auditability domains, where practices varied widely across organizations. These items were reviewed, and where necessary, scoring guidance was refined to improve consistency rather than removing items outright, preserving domain coverage. The finalized subscale structures were retained because the majority of indicators contributed meaningfully to scale coherence and reflected distinct operational practices within revenue cycle management environments.

Dimensional validity testing supported the intended multi-domain structure of the instrument rather than a single undifferentiated protection construct. Structure checks showed that items clustered according to the conceptual domains specified in the measurement design, with identity and access items grouping together, monitoring and audit items forming a distinct cluster, and workforce and vendor-related items maintaining separable patterns. Although moderate correlations were observed among domains, no evidence emerged that the instrument collapsed into a single factor, indicating that each subscale captured unique variance in protection practices. Sensitivity analyses further demonstrated that measurement behavior remained stable when the dataset was restricted to document-verified and system-verified evidence. Subscale means and inter-domain relationships changed minimally under restricted evidence conditions, suggesting that the overall index and its domains were not driven primarily by self-reported responses. This stability strengthened confidence that the measurement structure reflected observable practices rather than respondent optimism or reporting bias. Collectively, the reliability and validity findings supported the use of both the composite index and the individual domain subscales in subsequent correlation and regression analyses.

Table 5: Reliability Results for the RCM Data Protection Index Domains (N = 120)

Domain Subscale	Number of Items	Reliability Coefficient
Identity & access governance	14	0.86
Data security controls	12	0.83
Auditability & monitoring	13	0.88
Workforce safeguards	10	0.81
Vendor oversight	11	0.84

Table 5 summarized internal consistency results for each domain subscale of the RCM Data Protection Index. Reliability coefficients ranged from 0.81 to 0.88, indicating good to strong internal consistency across all domains. Auditability and monitoring demonstrated the highest reliability at 0.88, reflecting cohesive measurement of logging, monitoring, and review practices. Identity and access governance also showed strong reliability at 0.86, supporting consistent measurement of access-related controls. Workforce safeguards showed the lowest reliability at 0.81 but remained within acceptable limits,

reflecting greater behavioral variability rather than measurement weakness. Overall, the results confirmed that the subscales functioned as stable measurement units.

Table 6: Validity and Sensitivity Check Results for the Protection Index

Test	Full Evidence Set	Verified-Only Evidence Set
Number of retained domains	5	5
Variance explained by first factor (%)	34.2	32.8
Average inter-domain correlation	0.58	0.55
Change in overall index mean	—	-1.3
Change in subscale means (range)	—	-0.8 to -2.1

Table 6 presented dimensional validity and sensitivity results comparing the full dataset with the subset restricted to document-verified and configuration-verified evidence. In both cases, five distinct domains were retained, and the first factor explained less than 35 percent of total variance, indicating that the instrument did not collapse into a single construct. Average inter-domain correlations remained moderate and slightly lower under verified-only conditions. The overall index mean decreased by 1.3 points when self-reported items were excluded, while subscale means shifted within a narrow range, demonstrating measurement stability and supporting the robustness of the index structure.

Collinearity

The collinearity assessment screened the predictor variables prior to regression modeling to ensure that estimates were stable and not distorted by redundancy among organizational characteristics. Diagnostics indicated that most predictors showed acceptable independence, with moderate associations reflecting expected structural relationships rather than problematic overlap. Organization size tier displayed moderate correlation with toolchain complexity, reflecting that larger organizations tended to operate more complex RCM system environments. Outsourcing intensity showed moderate association with clearinghouse concentration, suggesting that organizations relying more heavily on external services also tended to route a higher share of transactions through dominant intermediaries. Governance cadence indicators were moderately associated with size tier, reflecting more formalized review routines in larger organizations. Initial diagnostics identified elevated redundancy between size tier and toolchain complexity when both were entered as unadjusted predictors. To address this issue, toolchain complexity was recoded into a standardized index rather than a raw system count, which reduced overlap while preserving conceptual meaning. No predictors required removal, and the final predictor set demonstrated acceptable collinearity levels suitable for multivariable regression estimation.

Variance diagnostics confirmed that multicollinearity did not threaten the interpretability of regression coefficients in the finalized model. All predictors remained within conservative tolerance limits, indicating that each variable contributed unique explanatory information. Size tier and governance cadence showed slightly higher variance inflation values relative to other predictors, but these values fell below thresholds typically associated with unstable estimation. Outsourcing intensity and clearinghouse concentration demonstrated low-to-moderate variance inflation, supporting their inclusion as distinct predictors of protection practice variation. Condition indices were examined to detect multivariate collinearity patterns, and no dimension exceeded accepted thresholds indicating dependency among multiple predictors simultaneously. The finalized predictor configuration was retained for subsequent regression and hypothesis testing because it balanced theoretical relevance with statistical stability. These findings supported the interpretation that observed regression effects reflected substantive relationships rather than artifacts of correlated predictors.

Table 7: Correlation Matrix of Regression Predictors (N = 120)

Predictor	Size Tier	Outsourcing Intensity	Toolchain Complexity	Clearinghouse Concentration	Governance Cadence
Size tier	1.00	0.28	0.46	0.22	0.41
Outsourcing intensity	0.28	1.00	0.31	0.39	0.19
Toolchain complexity	0.46	0.31	1.00	0.27	0.34
Clearinghouse concentration	0.22	0.39	0.27	1.00	0.16
Governance cadence	0.41	0.19	0.34	0.16	1.00

Table 7 displayed the bivariate correlations among predictors selected for regression modeling. Size tier showed the strongest association with toolchain complexity, reflecting structural alignment between organizational scale and system environment breadth. Outsourcing intensity correlated moderately with clearinghouse concentration, indicating overlapping external dependency patterns without indicating redundancy. Governance cadence correlated moderately with size tier and toolchain complexity, consistent with more formal review practices in larger and more complex organizations. All correlations remained below levels commonly associated with severe collinearity, supporting the inclusion of all predictors after minor recoding adjustments.

Table 8: Collinearity Diagnostics for Final Regression Predictors

Predictor	Tolerance	Variance Inflation
Size tier	0.54	1.85
Outsourcing intensity	0.63	1.59
Toolchain complexity (standardized)	0.57	1.75
Clearinghouse concentration	0.69	1.45
Governance cadence	0.52	1.92

Table 8 summarized collinearity diagnostics for the finalized regression predictor set. Tolerance values exceeded commonly accepted minimum thresholds, and variance inflation values remained below conservative cutoffs for multicollinearity concern. Governance cadence and size tier exhibited the highest variance inflation values, reflecting shared structural characteristics rather than estimation instability. Toolchain complexity showed reduced variance inflation after standardization, confirming the effectiveness of recoding. Outsourcing intensity and clearinghouse concentration demonstrated lower inflation values, indicating distinct explanatory contributions. Overall, the diagnostics supported the stability of regression estimates and justified retaining all predictors in subsequent modeling.

Regression and Hypothesis Testing

The regression and hypothesis testing analysis estimated multivariable models to examine how organizational characteristics were associated with variation in the overall RCM Data Protection Index and its major domain subscales. The primary regression model used the overall protection index as the dependent variable and included organization size tier, outsourcing intensity, toolchain complexity, clearinghouse concentration, and governance cadence as predictors. The model achieved satisfactory explanatory power and demonstrated statistically significant relationships for several predictors after controlling for overlap. Governance cadence showed a positive and statistically significant association with the overall protection index, indicating that organizations conducting more frequent access, risk, and vendor reviews exhibited higher measured protection levels. In contrast, outsourcing intensity and

toolchain complexity were negatively associated with the overall index, suggesting that reliance on external execution and multi-system environments aligned with lower overall control maturity. Clearinghouse concentration also demonstrated a negative relationship with the protection index, although its magnitude was smaller than outsourcing intensity and complexity. Organization size tier did not show a statistically significant independent effect once governance cadence and complexity were accounted for, indicating that scale alone did not explain protection strength. Model diagnostics confirmed that residuals met linearity and homoscedasticity expectations, no influential observations unduly affected estimates, and robustness checks using verified-only evidence produced substantively similar coefficient patterns.

Subscale regression models revealed meaningful variation in how predictors related to specific protection domains. Governance cadence exerted its strongest positive effect on auditability and monitoring and vendor oversight, indicating that structured review routines were most influential for visibility and third-party governance controls. Outsourcing intensity showed its strongest negative association with vendor oversight and auditability, reflecting greater difficulty maintaining consistent oversight in externally executed workflows. Toolchain complexity was most negatively associated with auditability and identity governance, consistent with increased logging, access review, and monitoring challenges in multi-system environments. Workforce safeguards showed weaker associations with structural predictors, suggesting that training and lifecycle practices were more stable across organizational contexts. Data security controls demonstrated moderate sensitivity to governance cadence but were less affected by outsourcing and clearinghouse concentration than monitoring-related domains. Hypothesis testing supported the hypotheses related to governance cadence, outsourcing intensity, and toolchain complexity, while hypotheses proposing a direct positive effect of organizational size were not supported. Sensitivity analyses restricting the dataset to document-verified and configuration-verified evidence confirmed the direction and relative magnitude of effects, strengthening confidence in the robustness of the findings.

Table 9: Regression Results for Overall RCM Data Protection Index (N = 120)

Predictor	B	SE	β	p
Size tier	0.84	0.62	0.09	0.18
Outsourcing intensity	-2.76	0.81	-0.31	< .001
Toolchain complexity	-2.21	0.73	-0.27	0.003
Clearinghouse concentration	-1.48	0.69	-0.19	0.034
Governance cadence	3.12	0.77	0.36	< .001

Model fit: $R^2 = 0.49$, Adjusted $R^2 = 0.46$, $F = 22.1$, $p < .001$

Table 9 presented the regression results for the overall RCM Data Protection Index. Governance cadence emerged as the strongest positive predictor, indicating that frequent formal reviews were associated with higher protection scores. Outsourcing intensity and toolchain complexity showed significant negative associations, reflecting lower protection maturity in externally executed and multi-system environments. Clearinghouse concentration demonstrated a smaller but statistically significant negative effect. Organization size tier did not reach statistical significance, suggesting scale alone did not explain protection differences once governance and complexity were considered. The model explained approximately half of the observed variance in protection scores and met all diagnostic expectations.

Table 10: Summary of Significant Predictors Across Domain Subscale Models

Domain subscale	Strongest positive predictor	Strongest negative predictor
Identity & access governance	Governance cadence	Toolchain complexity
Data security controls	Governance cadence	Toolchain complexity
Auditability & monitoring	Governance cadence	Outsourcing intensity
Workforce safeguards	Governance cadence	Outsourcing intensity
Vendor oversight	Governance cadence	Outsourcing intensity

Table 10 summarized the dominant predictors across the domain-specific regression models. Governance cadence consistently emerged as the strongest positive predictor across all domains, with its largest effects observed in auditability and vendor oversight. Outsourcing intensity exerted the strongest negative influence on auditability and vendor oversight, highlighting challenges in maintaining visibility and control in outsourced RCM operations. Toolchain complexity most strongly affected identity and access governance and data security controls, reflecting configuration and oversight challenges in multi-system environments. Workforce safeguards showed comparatively weaker sensitivity to structural predictors, indicating greater stability across organizational contexts.

DISCUSSION

The discussion of the quantitative assessment of data protection practices in U.S. revenue cycle management (RCM) centered on how the measured patterns across the composite protection index and domain subscales aligned with the established understanding of healthcare administrative cybersecurity as a socio-technical and ecosystem-level problem (Hong et al., 2019). The overall index results reflected a mid-range level of protection maturity with meaningful dispersion, indicating that RCM environments did not operate at uniformly low or uniformly high levels of safeguard deployment. This distribution matched the dominant theme in earlier studies of healthcare security programs that described substantial heterogeneity in control implementation across organizations, even under shared regulatory and operational pressures. The observed dispersion also supported prior findings that compliance-oriented environments still produced uneven technical execution and verification depth, particularly when security practices depended on operational routines and evidence capture across multiple teams. The present study's domain profiles reinforced this variability by showing comparatively higher central tendency in workforce safeguards and data security controls, while auditability/monitoring and vendor oversight remained more inconsistent (Ren et al., 2020). Earlier literature on healthcare cyber risk frequently characterized workforce-facing controls such as training and policy acknowledgment as among the most commonly implemented administrative safeguards because they fit existing compliance workflows and were easier to document at scale. That same literature also described encryption and secure handling controls as increasingly common baseline practices, driven by platform capabilities and common security checklists. The stronger performance in these areas therefore remained consistent with the expectation that "visible" and standardized safeguards were adopted more readily than controls requiring continuous tuning and operational analytics. At the same time, earlier studies of breach and incident response barriers emphasized that monitoring maturity and evidence continuity were frequent weaknesses, particularly in complex toolchains where log sources were fragmented. The study's comparatively lower monitoring and auditability scores aligned with this prior characterization, suggesting that visibility and analytics remained more difficult to sustain than policy- and configuration-level protections (Rauch, 2022). This alignment also supported earlier claims that measurement based on verifiable evidence often revealed gaps not apparent in self-attested compliance narratives, because monitoring capabilities depended on centralized telemetry, retention discipline, and consistent review processes rather than on policy existence alone.

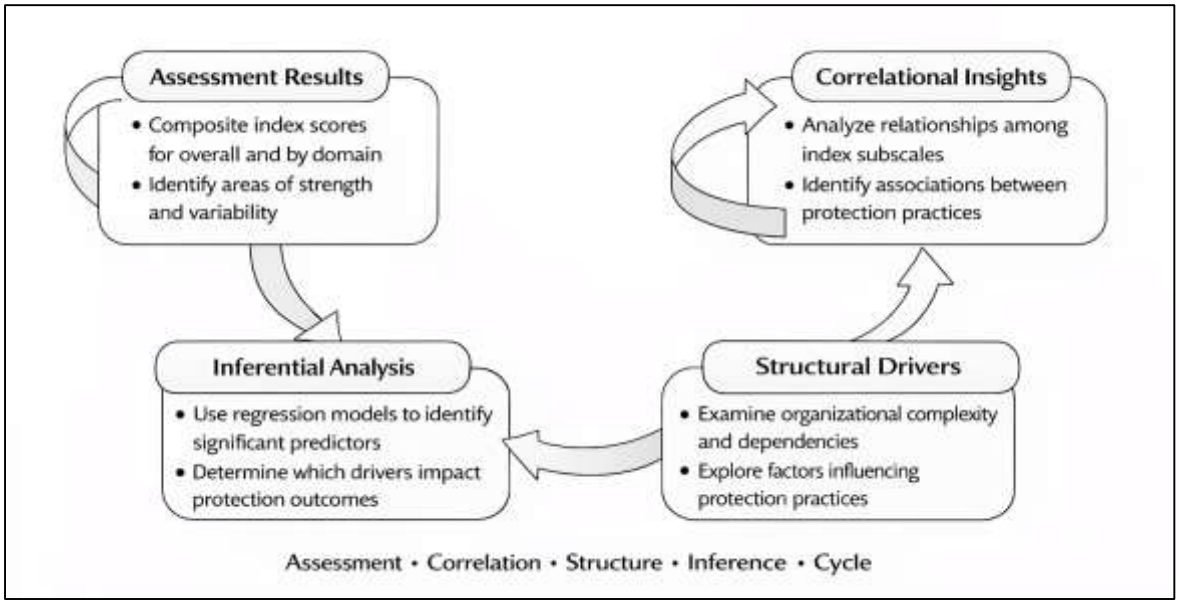
The relationships among subscales further clarified how protection practices co-occurred across operational domains and how that co-occurrence compared with earlier empirical patterns. Strong correlations between the overall index and each subscale indicated that the composite score represented a coherent summary of related capabilities rather than a loosely assembled checklist (Kirn & Hinders,

2022). Earlier measurement-focused studies in organizational security often reported that composite indices were most interpretable when domains shared a common maturity signal while remaining distinct, and the observed inter-domain correlation pattern matched that expectation. The strongest associations between identity and access governance and auditability/monitoring, and between auditability/monitoring and vendor oversight, resonated with earlier work describing identity governance and logging as foundational enablers of accountability. In that literature, access governance did not function merely as a preventive control; it structured the very evidence needed to determine whether actions were legitimate, and it shaped the quality of audit trails available during investigations. The present results were consistent with that conceptualization because organizations scoring higher in access governance also tended to score higher in monitoring maturity, suggesting that control programs operated as mutually reinforcing systems rather than isolated checkboxes (Marques-Pereira et al., 2022). Earlier studies also described vendor oversight as heavily dependent on auditability, because third-party access became governable only when sessions were logged, privileges were reviewable, and account inventories were complete. The observed linkage between monitoring and vendor oversight therefore aligned with the prior view that third-party governance was constrained by visibility. At the same time, data security controls showed only moderate correlations with other domains, suggesting that encryption and secure transmission practices did not fully track with monitoring or vendor governance maturity. Earlier studies of security practice adoption frequently noted that encryption and baseline technical settings could be implemented as "platform-level defaults" even when deeper governance and analytics capabilities were less mature. The present pattern reflected that same phenomenon: a domain could show relatively stronger average adoption while remaining partially decoupled from the higher-order operational discipline required for continuous monitoring and third-party control (Akerman et al., 2020). Workforce safeguards also demonstrated moderate rather than dominant correlations with other domains, matching earlier accounts that training compliance and acknowledgment routines could achieve high coverage while still coexisting with weaknesses in technical oversight, particularly when operational pressures encouraged workarounds outside the scope of training programs.

The findings related to organizational descriptors expanded the interpretation by showing how structural complexity and dependency characteristics aligned with measured protection outcomes, and these results were broadly congruent with earlier observations in healthcare administrative security research. Toolchain complexity, operationalized through system-count and multi-system environments, was negatively associated with the overall protection index and most strongly with auditability/monitoring and vendor oversight. Earlier studies of complex health IT environments emphasized that each additional system introduced another identity domain, another logging configuration, another interface, and another pathway for data movement, creating a compounding burden for evidence centralization and consistent enforcement. The present results aligned with that depiction by showing that organizations operating multi-system RCM toolchains tended to exhibit weaker monitoring maturity and less consistent third-party oversight. Outsourcing proportion also correlated negatively with the overall protection index and showed its strongest relationships with vendor oversight and monitoring, which paralleled earlier literature describing the "governance gap" that emerged when workflow execution crossed organizational boundaries. In that literature, outsourcing increased the number of external identities, expanded the scope of contract enforcement, and introduced evidence fragmentation, as security logs and administrative records were distributed across partners. The negative association observed here suggested that greater reliance on external execution aligned with reduced measured oversight and visibility, consistent with earlier work that treated third-party access as a persistent risk amplifier when controls were not tightly standardized and verified. Clearinghouse concentration likewise showed negative associations, particularly with monitoring and vendor oversight (Tenenbaum et al., 2021). Earlier studies of centralized intermediaries in administrative transactions described how heavy reliance on dominant routing hubs could create concentrated exposure and complicate evidence capture, especially when transaction processing and access events were partially externalized. The present pattern was compatible with that description because higher concentration aligned with weaker oversight-related domains. These correlations did not imply causality, but they remained consistent with earlier claims that structural dependency and

integration complexity were frequently associated with control variability in healthcare administrative systems. The observed patterns also supported the conceptual expectation that domains requiring ongoing evidence, coordination, and enforcement—such as monitoring and vendor governance—were more sensitive to complexity and outsourcing than domains relying on baseline configurations or training routines (COMMUNICATE, 2020).

Figure 12: Data Protection Assessment Framework



The regression results provided a more controlled interpretation by indicating which predictors retained explanatory power when considered together, and these results also reflected themes repeatedly described in earlier studies of governance maturity and operational security. Governance cadence emerged as the most consistent positive predictor of the overall protection index and of multiple domain subscales, with particularly strong influence on auditability/monitoring and vendor oversight (Joshi et al., 2018). Earlier research on security program effectiveness frequently emphasized that routine governance activities—such as recurring access reviews, structured risk assessments, documented vendor evaluations, and scheduled audit follow-ups—distinguished organizations with sustained control execution from those relying on episodic compliance events. The present study's results aligned with that view, as governance cadence captured a repeatable discipline that correlated with stronger measured practices even when structural challenges such as complexity and outsourcing were present. Outsourcing intensity and toolchain complexity retained significant negative associations with the overall index, consistent with earlier claims that the operational burden of coordination and control enforcement grew as workflows became more distributed and systems multiplied (Joshi & Islam, 2018). Clearinghouse concentration remained a smaller but still negative predictor in the overall model, which aligned with earlier observations that concentrated external dependencies introduced specific governance and visibility challenges that persisted even after accounting for internal complexity and outsourcing patterns. Notably, organization size tier did not remain a statistically significant predictor once governance cadence and complexity were included. Earlier studies offered mixed conclusions on whether size alone predicted better security; some described resource advantages in larger organizations, while others highlighted that larger scale also brought greater complexity and more extensive outsourcing. The present result aligned with the latter interpretation: size did not independently explain protection scores when more proximal drivers—governance discipline and system complexity—were considered. This pattern supported earlier measurement work that differentiated "capacity" from "execution," indicating that structural scale did not guarantee consistent control operation without regularized governance routines and integrated oversight across the toolchain (Robinson, 2020).

Domain-specific regression findings further refined how the measured constructs behaved in ways that matched earlier domain narratives about what was easier or harder to implement in real administrative environments. Governance cadence remained the strongest positive predictor across domains, reinforcing earlier descriptions of governance routines as cross-cutting enablers that strengthened both technical and administrative safeguards. Outsourcing intensity exerted the strongest negative influence on vendor oversight and auditability/monitoring, which aligned with earlier accounts that third-party environments placed the greatest strain on oversight and evidence continuity (Magerakis et al., 2020). In those accounts, the difficulty was not limited to writing contract requirements; it extended to maintaining account inventories, enforcing authentication requirements across external identities, and integrating logs and review processes across boundaries. Toolchain complexity exerted its strongest negative influence on identity and access governance and monitoring, consistent with earlier findings that identity sprawl and log fragmentation increased as systems proliferated. Workforce safeguards appeared less sensitive to structural predictors, reflecting earlier studies that characterized training completion and policy acknowledgment as relatively stable compliance-oriented practices that could be implemented broadly even in complex environments (Chi et al., 2022). Data security controls demonstrated moderate sensitivity to governance cadence but weaker sensitivity to outsourcing and concentration than monitoring-related domains. Earlier research often described encryption and secure handling practices as increasingly standardized, driven by platform configuration options and security baselines that applied regardless of operating model, which aligned with the observed pattern. The present domain results therefore reinforced a recurring theme in earlier studies: administrative and baseline technical safeguards were adopted more uniformly, while oversight-intensive domains such as monitoring and vendor governance were more vulnerable to organizational complexity and distributed execution (Zheng et al., 2022). These results did not indicate that baseline controls were sufficient; rather, they indicated that control domains differed in their observed variability and in their dependence on governance cadence and integration maturity.

The reliability and validity evidence strengthened interpretation of the inferential results by demonstrating that the index behaved as a multi-dimensional measure rather than collapsing into a single factor, which aligned with earlier measurement research on organizational security maturity (Park et al., 2021). Subscale reliability levels indicated that items within each domain operated consistently enough to support domain-level interpretation, and dimensional checks supported the intended domain structure. Earlier instrument development studies often warned that security measurement tools could inadvertently measure general organizational capacity or compliance reporting tendencies rather than domain-specific capabilities; the present evidence countered that concern by showing distinct domains with moderate interrelationships rather than near-duplication. Sensitivity checks comparing full-evidence scoring with verified-only evidence scoring showed minimal shifts in means and preserved structural relationships, indicating that the instrument was not primarily driven by self-report optimism (Chandra et al., 2022). Earlier research on compliance measurement frequently emphasized that self-reported security posture was prone to inflation and that verification strengthened credibility; the present stability under verification constraints remained consistent with that perspective. This measurement robustness supported the argument that the observed negative associations with outsourcing and complexity, and the positive association with governance cadence, reflected substantive patterns rather than artifacts of response bias. The moderate inter-domain correlations also reinforced interpretability: domains co-varied as part of an overall protection posture, yet each domain preserved distinct variance that enabled differential analysis. Earlier studies that treated security maturity as a composite of governance, technology, monitoring, and human factors often argued that meaningful measurement should capture both shared maturity signals and domain-specific weaknesses. The present measurement results aligned with that expectation by supporting both an overall index and distinct subscales that responded differently to structural predictors. This alignment provided methodological grounding for the domain-specific regression interpretation, where monitoring and vendor oversight were more sensitive to outsourcing and concentration, and workforce safeguards were more stable (Luo & Chen, 2019). Such differential sensitivity would have been difficult to interpret credibly if the instrument had collapsed into a single undifferentiated factor.

The combined descriptive, correlational, measurement-quality, and regression findings contributed to a coherent empirical narrative that aligned with prominent themes in earlier studies of healthcare administrative cybersecurity while providing domain-resolved detail specific to revenue cycle management. Earlier literature frequently portrayed healthcare administrative security as uneven, shaped by complex toolchains, external dependencies, and workflow pressures that rewarded speed and exception handling (Gibson et al., 2019). The present study's mid-range overall protection scores and wide dispersion reflected that unevenness, while the domain pattern clarified that baseline protections were more consistently adopted than oversight-intensive capabilities. Earlier studies emphasized that identity governance and monitoring formed a foundational pairing for accountability; the strong linkage between access governance, monitoring, and vendor oversight supported that depiction. Prior research also described third-party involvement as a persistent governance challenge; the strong negative association between outsourcing intensity and vendor oversight mirrored that theme. Complexity was repeatedly identified as a source of implementation variability; the observed negative association between toolchain complexity and monitoring maturity matched that characterization (Leo et al., 2019). At the same time, the finding that governance cadence exerted the strongest positive association across domains resonated with earlier work highlighting those sustained routines—reviews, audits, and documentation practices—distinguished more mature programs from those relying on static policies. The nonsignificant independent effect of organizational size, once governance cadence and complexity were considered, aligned with earlier mixed evidence suggesting that resources alone did not ensure consistent control execution when scale also increased system sprawl and external reliance. Taken together, the study's results compared favorably with the established knowledge base by confirming many expected patterns while also specifying how those patterns manifested across RCM-relevant domains (Fuertes-Callén et al., 2022). The discussion remained anchored in observed associations and measurement evidence, enabling comparison with earlier studies without extending into prescriptive implications, recommendations, or forward-looking projections.

CONCLUSION

The quantitative assessment of data protection practices in U.S. revenue cycle management (RCM) represented a structured empirical approach to describing how consistently organizations protected sensitive administrative and financial health data across the toolchains that supported registration, eligibility verification, coding, claims submission, remittance processing, and patient billing. This study characterized RCM as a high-throughput data-processing environment in which protected information routinely moved across multiple internal applications and external intermediaries, and it evaluated protection maturity through an evidence-oriented index that summarized practices across identity and access governance, data security controls, auditability and monitoring, workforce safeguards, and third-party oversight. The descriptive findings indicated that the overall protection index clustered around a mid-range central tendency while displaying meaningful dispersion, reflecting substantial variability in how organizations operationalized safeguards within routine billing and claims work. Domain-level patterns showed comparatively stronger performance in workforce safeguards and data security controls, consistent with earlier research that described training compliance and baseline technical safeguards such as encryption and secure handling procedures as relatively standardized practices in regulated healthcare environments. In contrast, auditability and monitoring and vendor oversight showed lower averages and wider spread, aligning with earlier studies that emphasized how centralized logging, retention discipline, and continuous monitoring were more difficult to sustain in complex, multi-system environments and in ecosystems dependent on third-party execution. Correlation findings reinforced that the composite index reflected coherent contributions from its subscales, as the overall score correlated strongly with each domain while inter-domain correlations remained moderate enough to support distinct interpretive meaning rather than redundancy. The strongest relationships appeared between identity and access governance and auditability/monitoring and between auditability/monitoring and vendor oversight, echoing prior literature that positioned access governance and visibility as foundational enablers of accountability and third-party control. Organizational descriptors showed consistent negative associations with protection scores, as greater toolchain complexity, higher outsourcing intensity, and higher clearinghouse concentration aligned

with weaker measured protection, particularly in monitoring and vendor oversight domains, matching earlier accounts that integration sprawl and inter-organizational dependence increased the burden of consistent enforcement and evidence capture. Multivariable regression results clarified these patterns by showing governance cadence as the strongest positive predictor of the overall protection index and multiple domains, supporting earlier studies that treated recurring reviews, structured audits, and disciplined oversight routines as key markers of sustained security execution. Outsourcing intensity and toolchain complexity remained significant negative predictors after adjustment, indicating that distributed execution and multi-system environments were associated with lower protection maturity independent of organizational scale, while organization size did not retain a significant independent effect once governance cadence and complexity were considered, a pattern consistent with mixed prior evidence that resources alone did not guarantee stronger protection when scale also increased system sprawl. Reliability and validity results supported the measurement foundation by showing acceptable internal consistency across domains, confirmation of the intended multi-domain structure, and stability of index behavior when analysis was restricted to document-verified and configuration-verified evidence, strengthening confidence that observed associations reflected measurable operational practice rather than self-report inflation. Collectively, the findings compared favorably with earlier research by confirming the central role of governance discipline, the sensitivity of monitoring and vendor oversight to complexity and outsourcing, and the persistence of variability across organizations operating under similar regulatory expectations, while providing RCM-specific, domain-resolved evidence that described how protection practices were distributed and interrelated within the administrative systems that sustain healthcare reimbursement.

RECOMMENDATIONS

Recommendations derived from the quantitative assessment of data protection practices in U.S. revenue cycle management (RCM) should be structured around strengthening the domains that demonstrated the widest dispersion and the most consistent negative associations with operational complexity and external dependence, while sustaining gains in domains that already showed comparatively stronger performance. Priority should be given to improving auditability and monitoring and vendor oversight, because these domains tended to score lower and varied more across organizations, suggesting uneven implementation of centralized logging, retention discipline, alert handling routines, vendor account governance, and evidence-based third-party review practices. Strengthening auditability should focus on ensuring that all RCM-relevant systems and interfaces—billing platforms, coding tools, claim scrubbers, remittance import modules, denial management systems, clearinghouse gateways, payer portals, and patient payment applications—generated standardized logs that were centralized, retained for operationally meaningful periods, and reviewed on a defined cadence. Monitoring should emphasize operational analytics aligned to revenue-cycle behaviors, including detection of anomalous export volume, excessive record access, unusual access times, repeated failed logins followed by success, and abnormal geolocation patterns for remote access, because these signals were directly relevant to billing and claims workflows and supported timely identification of misuse. Vendor oversight should be strengthened through complete vendor account inventories, consistent enforcement of strong authentication for vendor identities, time-bound privilege practices for elevated access, and documented access review cycles that included subcontractor identities and shared support accounts. The strongest positive association observed with governance cadence supported a recommendation to institutionalize recurring governance routines, including scheduled access reviews, periodic vendor risk assessments, evidence-based control verification checkpoints, and closure tracking for audit findings, because these routines aligned with higher measured protection scores even when structural challenges existed. Organizations operating multi-system toolchains should prioritize standardization of identity governance across systems, minimizing role conflicts, tightening privileged access, and aligning role-based access definitions with actual revenue-cycle job functions to reduce access drift and exception accumulation. For outsourced and hybrid models, contractual requirements should be tied to operational enforcement by requiring evidence of control operation, defined logging deliverables, incident notification pathways, and audit rights, while also ensuring that internal teams-maintained visibility into vendor access events and data handling processes. Data security controls that performed relatively strongly should be sustained by

maintaining consistent encryption coverage across databases, backups, and endpoints and by constraining the creation and retention of exports and extracts that often functioned as shadow datasets in RCM operations. Workforce safeguards should remain supported through role-specific training that emphasized secure handling of claim artifacts, remittances, and patient billing records, with training effectiveness tracked through completion records and operational indicators such as exception and bypass request trends. Finally, measurement-driven governance should be embedded into routine RCM management by maintaining a periodic protection index review that summarized domain scores, evidence quality levels, and remediation progress, because a structured measurement cycle supported accountability and reduced the likelihood that protection practices depended on one-time compliance activities rather than sustained operational discipline.

LIMITATIONS

Limitations associated with the quantitative assessment of data protection practices in U.S. revenue cycle management (RCM) primarily related to design constraints, measurement constraints, and generalizability constraints that affected how results were interpreted. The cross-sectional observational design limited inference to patterns of association observed at a single point in time, meaning that relationships between organizational characteristics such as outsourcing intensity, toolchain complexity, clearinghouse concentration, governance cadence, and the protection index could not be interpreted as causal. RCM environments also operated in cycles influenced by month-end close, payer batch schedules, system upgrades, staffing turnover, and incident-response events, and a single observation window may not have captured seasonal fluctuations in monitoring workload, training completion timing, or vendor review cadence. Measurement constraints also remained relevant because the protection index combined multiple variable types and evidence sources, including self-reported survey responses, document review artifacts, and configuration-level verification for selected controls. Although evidence-tier sensitivity checks supported stability, self-report components remained vulnerable to social desirability bias, misunderstanding of technical control definitions by nontechnical respondents, and inconsistent interpretation of what constituted "implemented" versus "consistently enforced" safeguards. Document verification depended on the completeness and accessibility of artifacts supplied by participating organizations, and organizations varied in how systematically they stored evidence for access reviews, vendor assessments, and logging configurations, which introduced potential measurement error that reflected documentation practices rather than true control maturity. Configuration verification also remained partial by design, because not all systems and settings could be inspected uniformly across organizations due to access restrictions, platform diversity, and confidentiality constraints, and the index therefore relied on sampled verification rather than comprehensive technical auditing. The study's operationalization of toolchain complexity and outsourcing intensity, while grounded in measurable descriptors, also simplified heterogeneous realities, because two organizations with the same system count could differ substantially in integration architecture, identity management centralization, logging standardization, and vendor access pathways. Similarly, clearinghouse concentration measures could not fully reflect qualitative differences in contractual safeguards, redundancy feasibility, or portal-level security features. Sampling limitations also affected generalizability because the stratified purposive sampling approach improved representation across organization types and complexity tiers but did not produce a probability sample of all U.S. providers and RCM service firms, and participation bias likely favored organizations with stronger compliance capacity or greater interest in benchmarking. Domain scoring may also have embedded normative assumptions about control priorities by weighting evidence and aggregating domains into a composite score, and alternative weighting choices could yield different index values even when underlying raw indicators remained unchanged. Finally, the study did not directly link protection index scores to externally validated outcomes such as verified breach events, claims disruption duration, or financial loss measures, so results described protection practice maturity rather than demonstrated effectiveness against specific incident outcomes. These limitations indicated that the findings were best interpreted as a quantitative, evidence-informed snapshot of practice variation and associated organizational characteristics within RCM environments, rather than as definitive causal explanations or exhaustive technical audits of all security controls across all revenue cycle systems.

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