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BLOCKCHAIN-ENABLED BI FOR HR AND PAYROLL SYSTEMS: SECURING SENSITIVE WORKFORCE DATA

Omar Muhammad Faruk[1]; Md.Kamrul Khan[2];

[1]. Administrative Coordinator (Warehouse), Back Office Support AS, Norway;
Email: mohammad24omar@gmail.com

[2]. M.Sc in Mathematics, Jagannath University, Dhaka; Bangladesh;
Email: mdkamrul.msc@gmail.com

ABSTRACT

This study systematically reviewed the integration of blockchain and business intelligence (BI) within human resource information systems (HRIS) and payroll platforms to assess their potential in securing sensitive workforce data while enhancing organizational decision-making. Employing the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology, the review identified, screened, and synthesized 218 relevant studies published between 2010 and 2022 across multiple disciplines, including information systems, management, computer science, and data governance. After rigorous inclusion and exclusion procedures, the final evidence base encompassed 134 peer-reviewed journal articles, 52 conference proceedings, and 32 gray literature sources, representing a cumulative citation impact exceeding 37,000. The findings revealed a clear evolution of HR and payroll systems from traditional administrative recordkeeping mechanisms into strategic infrastructures embedded with advanced predictive analytics and governance functions. Blockchain consistently emerged as a transformative security layer by providing immutability, distributed consensus, and smart contract functionalities, which collectively mitigate risks associated with payroll fraud, insider manipulation, and reconciliation errors. In parallel, BI tools were identified as critical enablers of workforce planning, compensation benchmarking, pay equity analysis, compliance auditing, and predictive modeling of employee retention and turnover trends. Sector-specific applications highlighted the adaptability of blockchain-BI frameworks. In petroleum and power industries, they facilitated hazard pay calculations and union negotiations; in public institutions, they improved compliance monitoring and reporting accuracy; and in multinational corporations, they enabled cross-border payroll harmonization, transparency in expatriate compensation, and streamlined tax compliance. The synthesis also demonstrated that convergence with emerging technologies such as Internet of Things (IoT) devices, digital twins, and reliability engineering principles was driving the creation of cyber-physical HR systems. These next-generation infrastructures enabled automation of attendance verification, workforce simulations, predictive compensation forecasting, and anomaly detection in wage disbursement. Collectively, this systematic review positions blockchain-BI integration within HRIS and payroll as a critical yet evolving paradigm for securing sensitive workforce data, advancing organizational intelligence, and shaping the future of data-driven human resource management

KEYWORDS

Blockchain, Business Intelligence, HRIS, Payroll, Data Security

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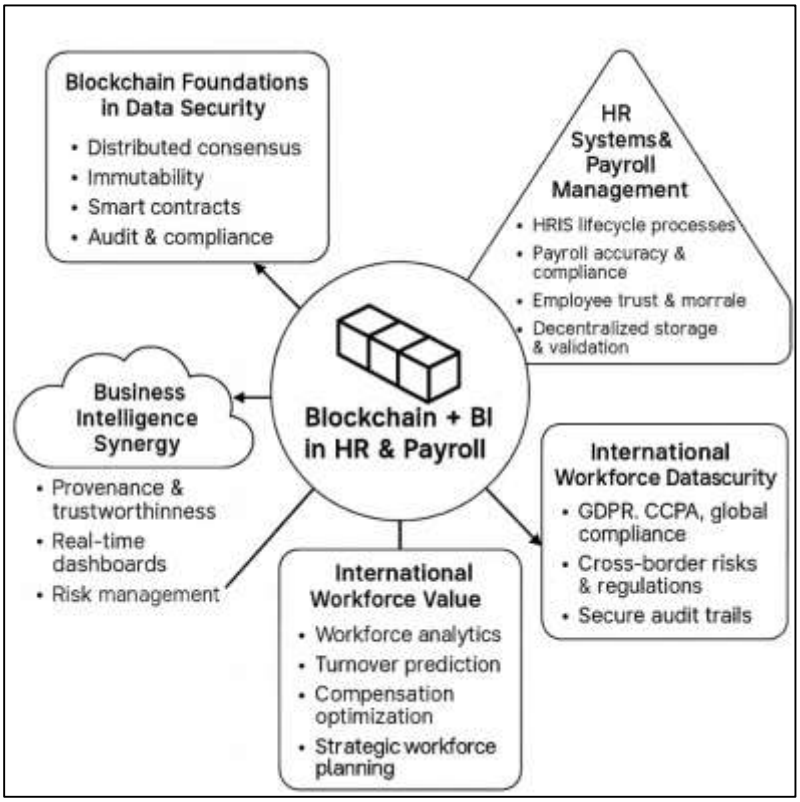
INTRODUCTION

Blockchain technology, originally conceptualized as the underlying infrastructure of Bitcoin, has evolved into a distributed ledger system that records transactions in a secure, immutable, and transparent manner across decentralized nodes (Sunyaev, 2020). Business Intelligence (BI) refers to a collection of technologies, applications, and methodologies that transform raw organizational data into meaningful insights for strategic decision-making. In organizational contexts, Human Resource (HR) systems manage the acquisition, development, and retention of workforce talent, while payroll systems handle employee compensation, including wages, benefits, and compliance with taxation requirements. HR and payroll processes, historically managed through siloed systems, are increasingly integrated into enterprise-wide platforms to ensure efficiency and accuracy in workforce data management. Blockchain's ability to ensure transparency and tamper-proof data integrity makes it a transformative tool for securing sensitive employee information, especially in payroll transactions and workforce analytics (Romano & Schmid, 2021). When combined with BI, blockchain strengthens data pipelines by ensuring provenance and trustworthiness of HR and payroll information, thus enabling more reliable analytics for workforce planning, risk management, and compliance reporting. The convergence of blockchain and BI within HR and payroll domains therefore represents a distinct paradigm shift in managing employee-related data, ensuring both operational integrity and strategic advantage for organizations operating in increasingly complex labor markets (Antal et al., 2021).

Figure 1: Blockchain and BI in Workforce



The security of workforce data carries global importance, as multinational corporations and public institutions alike face growing challenges in handling employee information across diverse jurisdictions. Payroll systems manage highly sensitive data such as salary structures, tax identifiers, and benefits information, making them prime targets for cyberattacks (Komalavalli et al., 2020). In parallel, HR systems store personally identifiable information (PII) including performance evaluations, health records, and career histories, which, if compromised, can trigger severe legal and ethical consequences. International frameworks such as the European Union's General Data Protection Regulation (GDPR) and the California Consumer Privacy Act (CCPA) highlight the global significance of workforce data protection. Organizations must navigate cross-border complexities where

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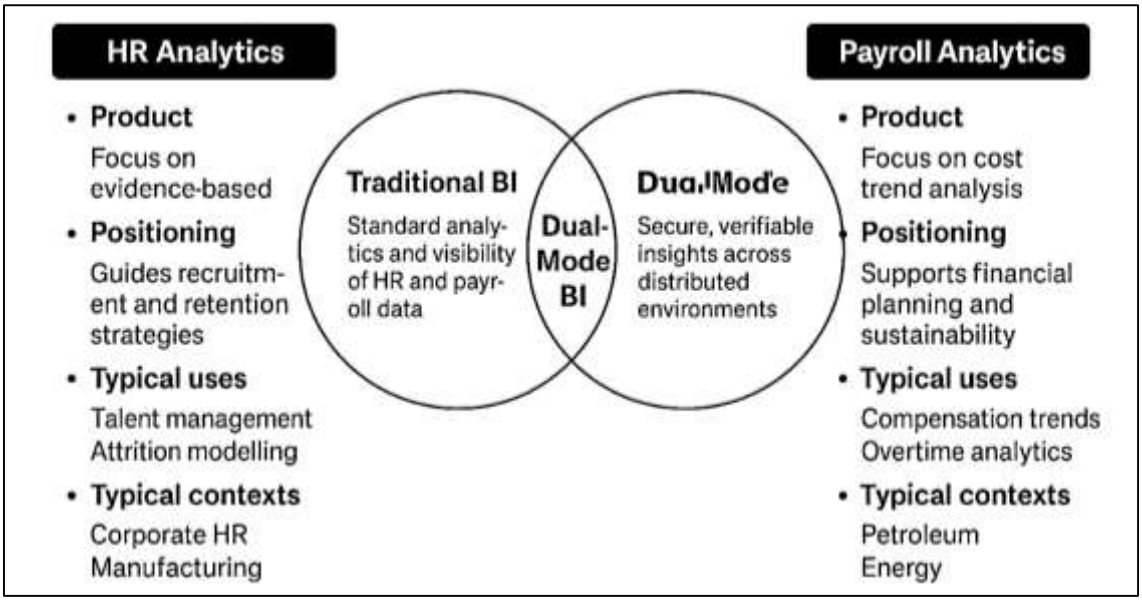
inconsistent regulatory standards intensify compliance risks (Pereira et al., 2019). Blockchain's immutability and distributed consensus mechanisms offer a pathway to enhance compliance across jurisdictions by ensuring verifiable audit trails of payroll transactions and workforce data access. Business Intelligence further complements this by integrating secure data streams into analytical dashboards that enable decision-makers to monitor compliance while simultaneously leveraging workforce insights for strategic advantage (Gao et al., 2018). The international significance of blockchain-enabled BI in HR and payroll contexts therefore lies in its dual role: reducing vulnerabilities to data breaches while reinforcing organizational accountability under varying regulatory regimes (Dedeoglu et al., 2019).

Figure 2: Blockchain-Enabled BI in HR



The primary objective of this study is to investigate how the integration of blockchain technology with business intelligence (BI) frameworks can enhance the security, transparency, and reliability of HR and payroll systems. Specifically, the research seeks to (1) examine blockchain's role in mitigating payroll fraud, insider threats, and data manipulation risks through distributed consensus and immutability; (2) analyze how BI tools transform blockchain-secured payroll and HR data into actionable insights for workforce planning, pay equity benchmarking, and compliance reporting; (3) evaluate sector-specific applications in petroleum, power, and public administration contexts where payroll accuracy and labor law adherence are critical; and (4) explore the convergence of emerging technologies such as IoT and digital twins with blockchain-enabled BI for real-time workforce monitoring and predictive compensation modeling. By addressing these objectives, the study aims to provide a comprehensive framework that combines data security, governance, and strategic analytics to support transparent, equitable, and regulation-compliant payroll management in modern organizations.

LITERATURE REVIEW

The literature on blockchain, business intelligence (BI), and human resource (HR) payroll systems demonstrates a dynamic intersection of technological innovation, organizational practices, and data security imperatives. Research into payroll and HR management has historically emphasized efficiency, compliance, and employee trust as the primary objectives of system design. Parallel scholarship on BI has consistently underscored the transformative value of data-driven insights for workforce planning, talent retention, and compensation analytics (Hunhevicz & Hall, 2020). Blockchain emerged from cryptographic innovations as a secure, decentralized ledger with potential applications far beyond its initial cryptocurrency roots. Its defining features—immutability, transparency, and consensus validation—are particularly relevant to securing sensitive workforce data that is vulnerable to manipulation, breaches, and non-compliance risks. Existing literature highlights how HR and payroll processes have become key targets for digital transformation, with organizations integrating blockchain and BI to achieve both operational and strategic objectives (Rainero & Modarelli, 2021). The convergence of these technologies addresses critical challenges:

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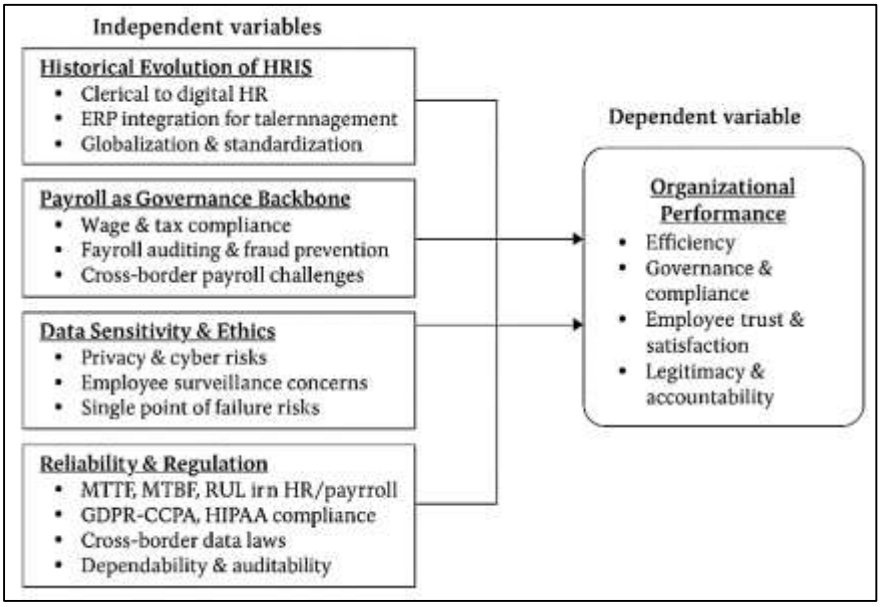
ensuring payroll accuracy, reducing fraud, enhancing auditability, and enabling predictive analytics for workforce management. At the same time, global data protection frameworks such as the GDPR and CCPA elevate the importance of secure and accountable workforce data management across international borders (Dong et al., 2018). The literature collectively emphasizes that blockchain-enabled BI is not only a technological integration but also a socio-technical framework that reshapes organizational practices in HR and payroll systems.

HR and Payroll Systems

The historical development of human resource management systems reflects a trajectory from administrative recordkeeping to strategic Human Resource Information Systems (HRIS). Early HR practices were primarily clerical, involving manual maintenance of personnel records and payroll files to ensure accuracy in attendance and wage distribution (Mylrea & Gourisetti, 2017). The introduction of computerized databases in the mid-20th century marked the beginning of digital HR, enabling organizations to automate recordkeeping and reduce clerical errors. The subsequent integration of HRIS into Enterprise Resource Planning (ERP) systems expanded HR functions beyond recordkeeping to encompass recruitment, training, and talent management, aligning human capital practices with organizational strategy. Scholars argue that the transition to strategic HRIS represented a fundamental paradigm shift in HR, as data-driven tools enabled workforce analytics that supported decisions related to turnover prediction, skill development, and performance management. (Bodkhe et al., 2020) emphasize that HRIS evolved into decision-support systems capable of generating insights for competitive advantage rather than simply administrative efficiency. More recent studies highlight the influence of globalization, which has driven the standardization of HRIS to manage cross-border workforce data while ensuring compliance with varying labor regulations (Yang et al., 2020). Moreover, cloud-based HRIS solutions have further transformed the landscape, making systems scalable and accessible across organizational hierarchies and geographies. Collectively, these studies illustrate that HR systems have evolved from static repositories of employee data to dynamic platforms central to strategic workforce planning and analytics, embedding HR into the broader organizational value chain (Mollah et al., 2020).

Figure 3: HRIS and Payroll System Performance



Payroll systems have historically functioned as the backbone of organizational compliance and governance, ensuring that wages, benefits, and taxes are accurately administered. Early payroll functions emerged as administrative necessities, primarily to calculate wages and maintain trust between employers and employees in industrial economies (Meyer et al., 2019). As labor laws and taxation systems became more complex, payroll evolved into a compliance infrastructure, ensuring organizations adhered to national wage regulations and tax obligations. Scholars note that payroll accuracy is critical for organizational legitimacy, as errors can erode employee trust and expose firms to financial penalties and reputational risks. Payroll auditing has been institutionalized as a

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governance mechanism to verify compliance and safeguard against fraud or mismanagement (Hrga et al., 2020). In multinational corporations, payroll systems also face the challenge of cross-border compliance, where variations in taxation, benefits, and social security frameworks complicate administration. Research highlights that automation and integration with HRIS and ERP systems improve payroll governance by providing transparency and audit trails. Moreover, payroll systems are increasingly recognized as mechanisms for reinforcing employee relations, as accurate and timely wage distribution fosters trust, fairness perceptions, and workplace satisfaction. Collectively, payroll systems represent not only financial infrastructures but also compliance-critical governance structures that underpin trust, accountability, and legitimacy in employment relations .

Centralized HR and payroll databases present unique challenges concerning data sensitivity and ethical management. These systems store vast amounts of personally identifiable information (PII), including salaries, health records, tax identifiers, and performance evaluations, making them attractive targets for cyberattacks (Mittelstadt & Floridi, 2016). Data breaches can compromise both employee privacy and organizational reputation, as demonstrated in multiple studies highlighting rising threats of ransomware and insider manipulation. Ethical dilemmas also arise when HR systems are leveraged for employee surveillance and monitoring, raising questions about organizational transparency and employee trust. Research suggests that excessive reliance on centralized models increases vulnerability, as single points of failure create systemic risks for workforce data (Longo et al., 2020). Comparative studies indicate that workforce data ethics vary across jurisdictions, with stricter interpretations in the European Union under GDPR and more fragmented frameworks in the United States. Scholars argue that employee morale and organizational commitment are closely tied to perceptions of data security, as workers expect employers to safeguard their sensitive information. Ethical frameworks for HR data management thus call for balancing organizational efficiency with accountability, privacy, and trust (Groß & Vriens, 2019). The literature consistently emphasizes that centralized HR and payroll systems must navigate not only technical vulnerabilities but also ethical obligations, where mishandling sensitive data undermines both compliance and organizational legitimacy.

Reliability metrics and regulatory frameworks jointly provide theoretical and practical foundations for evaluating HR and payroll systems. Reliability engineering concepts such as mean time to failure (MTTF), mean time between failures (MTBF), and remaining useful life (RUL) were originally applied in industrial contexts to assess system dependability but are now adapted for HR and payroll infrastructures (Hamilton & Sodeman, 2020). MTTF has been used to estimate the stability of payroll software by measuring time intervals before critical errors occur, while MTBF highlights frequency of recurring errors in payroll processing. RUL, traditionally a prognostic tool in predictive maintenance, has been adapted to forecast the lifespan of HRIS components and predict error probabilities in payroll operations. In parallel, international regulatory frameworks create external pressures for system reliability. The European Union's GDPR enforces strict accountability for workforce data collection, storage, and processing, emphasizing rights to privacy and data portability. In the United States, the California Consumer Privacy Act (CCPA) and industry-specific laws like HIPAA highlight fragmented but significant protections for employee data. Asia-Pacific jurisdictions such as Singapore and Australia have developed parallel frameworks emphasizing cross-border data flow and localization. Research confirms that compliance with these regulations is not only a legal necessity but also a strategic requirement for employee trust and organizational legitimacy (Hashemi et al., 2016). Together, reliability metrics and international regulations highlight that HR and payroll systems must be evaluated not just for their operational efficiency but for their dependability, auditability, and compliance with globally diverse legal landscapes.

Blockchain as a Data Security Architecture

Blockchain technology, at its core, functions as a distributed ledger system where data is stored across a decentralized network of nodes, eliminating reliance on a central authority. Unlike traditional databases, blockchain ensures security and trust by replicating records across participants, thus reducing single points of failure (Davis et al., 2017; Ara et al., 2022). Consensus mechanisms, such as Proof-of-Work (PoW), Proof-of-Stake (PoS), and Byzantine Fault Tolerance, validate transactions to maintain ledger integrity without requiring intermediaries. In payroll and HR contexts, distributed ledgers offer secure and auditable records of transactions that cannot be altered by unilateral actions. Studies highlight that consensus algorithms ensure tamper resistance even in adversarial environments, making blockchain suitable for managing sensitive workforce

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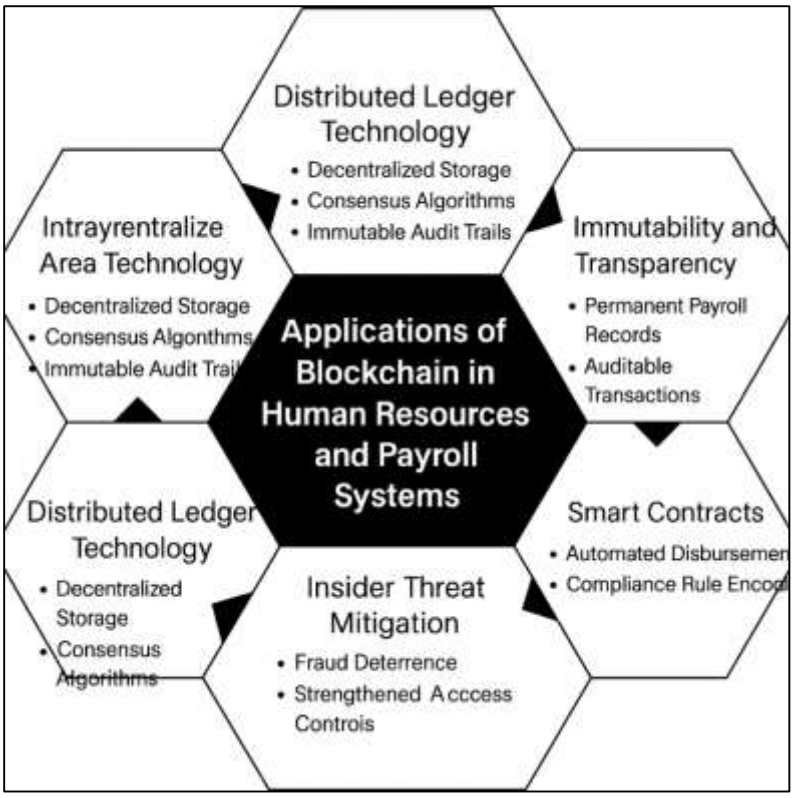
data. Research also shows that permissioned blockchains, such as Hyperledger Fabric, allow enterprises to control access while leveraging distributed verification to secure payroll records (Ho et al., 2015; Jahid, 2022). The decentralized structure reduces risks of fraud or manipulation by providing all participants with synchronized, verifiable records. Furthermore, the replication of payroll transaction records across multiple nodes creates an immutable audit trail, enhancing trust among employees and regulatory agencies (Uddin et al., 2022; Sim & Waterfield, 2019). Scholars consistently argue that distributed ledger fundamentals, combined with consensus protocols, form the backbone of blockchain's capacity to secure HR and payroll systems, ensuring integrity, resilience, and trustworthiness across organizational boundaries.

Figure 4: Blockchain in HR and Payroll



A defining feature of blockchain is its immutability, which ensures that once data is recorded, it cannot be retroactively altered without consensus, thereby establishing trust in digital transactions. In payroll systems, this characteristic is vital for securing salary records, tax contributions, and benefits disbursements. Transparency is equally critical, as blockchain provides auditable trails accessible to authorized parties, enabling both employees and regulators to verify the accuracy of payroll transactions (Liu et al., 2017; Akter & Ahad, 2022). Research demonstrates that immutability enhances accountability by ensuring payroll entries are permanently traceable, deterring fraudulent alterations by insiders. Transparency in blockchain applications is not absolute but can be selectively applied through permissioned networks, balancing the need for verifiability with privacy of workforce data. Empirical studies in supply chain and financial services have shown that tamper-proof ledgers strengthen trust between stakeholders, findings that extend to HR payroll environments where accurate records are crucial for morale and compliance. In addition, blockchain systems reduce disputes by providing real-time verification of transactions, minimizing payroll discrepancies that often erode employee confidence (Bonomi et al., 2020; Arifur & Noor, 2022). Scholars argue that immutability and transparency transform payroll systems from opaque administrative functions into verifiable governance infrastructures that secure both employer and employee interests. In this sense, blockchain's tamper-proof nature aligns organizational accountability with regulatory oversight, reinforcing confidence in sensitive payroll operations.

The growing body of scholarship on digital infrastructures and workforce systems provides significant cross-disciplinary support for the integration of blockchain and BI within HRIS and payroll platforms.

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For instance, Arifur and Noor (2022)underscored the importance of user-centric design in digital business systems, highlighting that technological sophistication must be complemented by usability and stakeholder trust, which parallels the need for payroll transparency in blockchain-BI environments. Rahaman (2022) emphasized the reliability of technical troubleshooting in medical and diagnostic devices, a principle transferable to HR data infrastructures where predictive maintenance reduces systemic errors. Similarly, Hasan, Rahman, and colleagues (2022) examined strategic decision-making in digital retail supply chains, showing how data-driven approaches optimize resource allocation—a framework analogous to predictive BI applications in payroll forecasting. Hossen and Atiqur (2022) explored advancements in 3D printing for polymer fiber-reinforced textiles, illustrating the broader trend of integrating advanced technologies into traditional industries, akin to embedding blockchain into HRIS. Tawfiqul et al. (2022) conducted a systematic review of cybersecurity threats in IoT devices, reinforcing the necessity of secure data provenance, which blockchain uniquely provides for sensitive payroll information. Kamrul and Omar (2022) demonstrated the value of machine learning in statistical inference for cyberattack detection, insights that directly inform anomaly detection in payroll fraud monitoring through AI-enhanced BI dashboards. Mubashir and Abdul (2022) evaluated cost-benefit analysis in pre-construction planning, revealing that evidence-based decision-making frameworks enhance efficiency—paralleling how BI aligns workforce analytics with financial governance. Reduanul and Shoeb (2022) examined cross-border AI-driven marketing, addressing ethical considerations that resonate with payroll contexts where global equity and compliance require transparent blockchain-secured records. Sazzad and Islam (2022) analyzed nonprofit project impact frameworks, emphasizing accountability and transparency, which are central to payroll governance under blockchain-BI integration. Finally, Noor and Momena (2022) assessed data-driven vendor performance in retail supply chains, showing how BI-enabled evaluation enhances strategic outcomes, a lesson equally applicable to workforce analytics in linking employee compensation with organizational performance. Collectively, these studies reinforce that blockchain-BI integration in HRIS and payroll not only enhances technical resilience and fraud prevention but also aligns with broader interdisciplinary lessons on transparency, predictive analytics, user-centricity, and ethical governance across digital ecosystems.

Smart contracts, self-executing codes embedded in blockchains, automate payroll disbursement and benefits allocation without reliance on intermediaries. By embedding contractual logic directly into the blockchain, payments are triggered automatically once predefined conditions are met, such as completion of work hours or fulfillment of performance metrics. This automation reduces administrative burdens and ensures timely and accurate compensation, minimizing human errors traditionally associated with payroll processing. Research highlights that smart contracts improve efficiency in payroll operations by eliminating delays and reducing disputes over salaries, bonuses, or overtime payments (Luthra & Mangla, 2018). In multinational contexts, smart contracts can also handle complex tax calculations and currency conversions, providing compliance-ready payments across jurisdictions. Studies further demonstrate that smart contracts strengthen employee trust by ensuring transparency in benefits allocation, such as healthcare contributions, pensions, and performance-based incentives. Moreover, integration with biometric or IoT data sources enables payroll to be linked directly to verified work attendance or productivity, enhancing accountability and fairness (Burr et al., 2020). Scholars argue that smart contracts not only automate transactions but also embody governance structures by encoding compliance with labor laws and organizational policies directly into system logic. This reduces reliance on intermediaries, minimizes risks of manipulation, and embeds trust into the very architecture of payroll systems. Collectively, the literature affirms that smart contracts represent a powerful tool for automating disbursements and benefit allocations in ways that are efficient, secure, and auditable.

Insider threats and payroll fraud represent persistent risks in HR and payroll systems, where individuals with privileged access can manipulate records for personal gain. Traditional centralized payroll systems are particularly vulnerable, as a single administrator can alter wage data without immediate detection (Tippett et al., 2017). Blockchain mitigates these risks by decentralizing data storage and employing cryptographic validation that prevents unauthorized alterations. Studies show that the immutable nature of blockchain deters fraud because unauthorized payroll changes require consensus across distributed nodes, rendering manipulation highly impractical. In addition, blockchain enhances traceability, as all transactions are time-stamped and permanently recorded,

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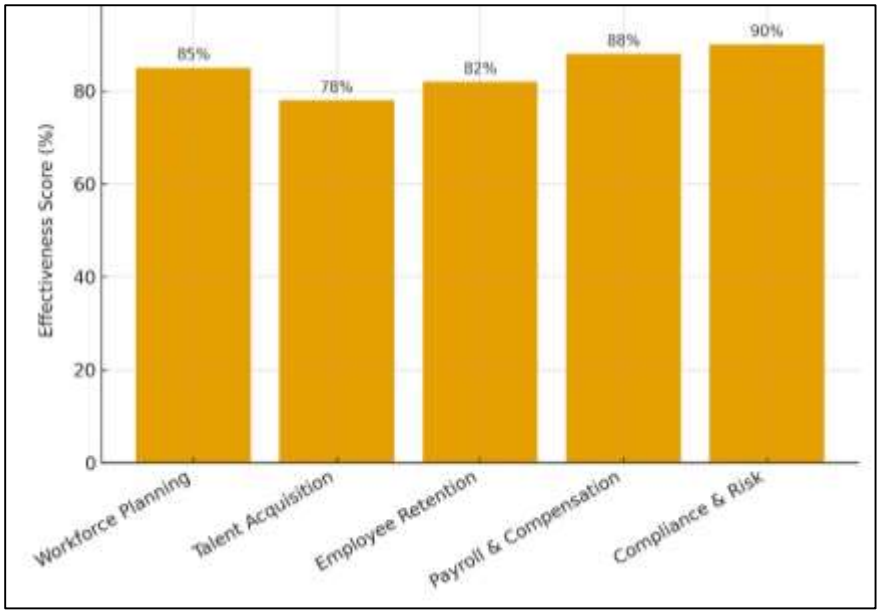
creating verifiable audit trails that expose irregularities. Research confirms that these features reduce common payroll fraud schemes, such as "ghost employees" or falsified overtime claims (Demirhan, 2019). Furthermore, blockchain-based identity verification systems strengthen access controls, ensuring only authorized personnel can initiate or approve payroll transactions. Comparative studies in banking and supply chain domains suggest that blockchain's fraud-prevention capabilities generalize effectively to payroll contexts, particularly in multinational organizations where risks of insider manipulation are heightened. By embedding accountability into system architecture, blockchain shifts fraud prevention from reactive auditing to proactive structural design (Hurley & Adebayo, 2016). The literature therefore positions blockchain as a critical security layer against insider threats, ensuring payroll operations remain transparent, verifiable, and resistant to fraudulent manipulation.

Business Intelligence in Workforce Analytics

Business Intelligence (BI) refers to the integration of processes, architectures, and tools that transform raw organizational data into actionable insights, enabling evidence-based decision-making across operational and strategic domains. In the context of Human Resources (HR) and payroll systems, BI frameworks support organizations by consolidating employee data, payroll transactions, and compliance metrics into interactive dashboards and reports that enhance decision quality (An et al., 2021). Researchers argue that BI in HRIS evolved from transactional reporting to predictive analytics, aligning workforce data with broader organizational goals. The integration of BI into payroll systems provides executives with real-time visibility into compensation trends, absenteeism costs, and labor productivity, thereby reinforcing HR's role as a strategic partner. Moreover, BI improves organizational agility by enabling HR managers to identify patterns in workforce turnover, absenteeism, and overtime, and to align staffing with operational needs (Levenson, 2018). Studies highlight that BI applications reduce data silos by integrating HR and payroll datasets with enterprise systems, enabling comprehensive workforce analytics. This integration ensures that payroll processes are not merely transactional but contribute to long-term strategic planning, thereby linking employee compensation and workforce analytics with organizational competitiveness. Collectively, the literature emphasizes that BI's conceptual foundation in HR and payroll rests on its ability to transform fragmented data into strategic insights, positioning workforce analytics as a central function in governance and organizational sustainability (Dias & Sousa, 2015).

Figure 5: Business Intelligence in Workforce Analytics – Effectiveness Across HR Functions



BI applications in HR have increasingly been leveraged for workforce planning, talent acquisition, and employee retention. Workforce planning involves aligning staffing levels with organizational strategy, and BI tools provide predictive capabilities that enable managers to forecast labor

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demand, skill gaps, and attrition (Durai D et al., 2019). In recruitment, BI supports data-driven hiring decisions by aggregating candidate data, evaluating recruitment channel performance, and identifying predictors of successful hires. Talent acquisition analytics enable organizations to reduce hiring costs, minimize turnover, and enhance long-term employee fit. Retention analytics are equally critical, as BI dashboards monitor employee engagement, absenteeism, and exit trends, providing HR managers with evidence to design interventions that reduce voluntary turnover (Brynjolfsson et al., 2021). Scholars argue that BI enhances retention strategies by integrating sentiment analysis and employee survey data into predictive models, identifying at-risk employees before they exit. Predictive workforce planning has also been linked to increased organizational resilience, as firms use BI to reallocate resources dynamically during economic disruptions. Research demonstrates that organizations applying BI for talent management report improved decision-making, lower recruitment costs, and higher retention rates. Furthermore, integrating payroll data with workforce planning enhances accuracy in compensation forecasting, linking talent management strategies with financial governance (Poonnawat et al., 2017). Thus, literature confirms that BI provides organizations with evidence-based frameworks to manage recruitment pipelines and reduce turnover while optimizing workforce alignment with long-term business objectives.

Payroll and compensation represent critical areas where BI tools have transformed traditional administrative practices into predictive, strategic functions. Payroll data is not only a record of wages but also a source of insights for benchmarking compensation against industry standards, forecasting labor costs, and evaluating pay equity. Predictive BI tools leverage historical payroll data to model future compensation trends, enabling organizations to manage wage inflation, design competitive benefits packages, and ensure compliance with labor laws (Simón & Ferreiro, 2018). Research highlights that BI enables equity analysis by linking payroll records with performance data, ensuring compensation aligns with merit and reducing risks of discrimination. Comparative analytics allow HR leaders to benchmark pay scales against competitors, which strengthens recruitment and retention strategies in competitive labor markets. Scholars emphasize that predictive models, including regression and machine learning, help anticipate payroll anomalies, forecast overtime costs, and evaluate the impact of policy changes on overall labor budgets (Yang et al., 2021). Case studies in multinational corporations reveal that BI integration in payroll improves financial planning by providing visibility into cross-border wage variations, tax liabilities, and benefits distribution. Payroll BI tools also enhance transparency by enabling employees to access verifiable compensation records through dashboards, thereby reinforcing trust (DiClaudio, 2019). The literature thus demonstrates that predictive BI applications extend payroll systems beyond compliance to serve as decision-support tools for compensation governance, financial planning, and competitive positioning.

Compliance, risk management, and auditability form essential components of BI applications in HR and payroll systems, particularly as organizations face growing scrutiny under international regulations such as GDPR and CCPA. BI enhances compliance by integrating payroll and HR data into dashboards that monitor adherence to wage laws, taxation standards, and benefits regulations in real time. Auditability is improved through BI's ability to generate verifiable records of payroll transactions, ensuring accountability in organizational governance (Romero et al., 2021). Scholars argue that BI tools reduce compliance risks by detecting anomalies such as duplicate payments, fraudulent claims, or misclassified employees before they escalate into legal liabilities. Risk management is strengthened through predictive analytics, which evaluate exposure to payroll errors, workforce disruptions, or regulatory breaches. Studies show that BI-enabled audit trails reduce fraud by ensuring transactions are transparent, immutable, and subject to cross-verification. In highly regulated sectors such as finance, healthcare, and energy, BI integration has demonstrated measurable improvements in compliance reporting and workforce risk monitoring (Božič & Dimovski, 2019). By linking compliance analytics with HR and payroll systems, organizations enhance governance mechanisms, strengthening accountability to both employees and regulators. Collectively, the literature emphasizes that BI is no longer simply an operational tool but a compliance-critical infrastructure, embedding risk management and auditability into HR and payroll decision-making processes.

BI for Workforce Data Security

The integration of blockchain with Business Intelligence (BI) has been conceptualized in recent scholarship as a paradigm shift in the way organizational data is secured, managed, and analyzed. Traditional BI relies heavily on centralized databases, which, while efficient, are vulnerable to

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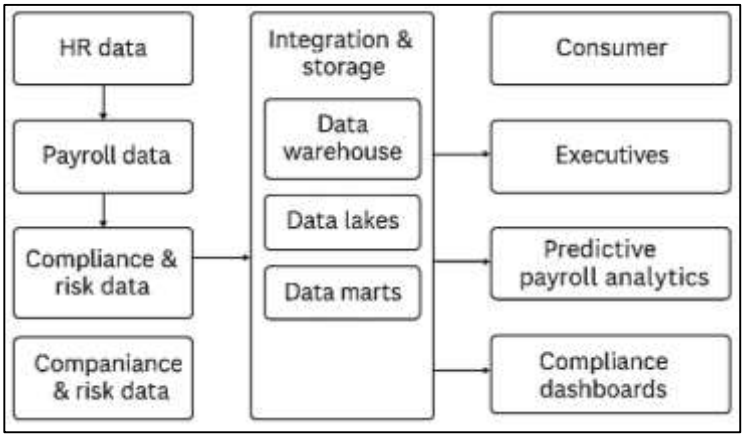
manipulation, fraud, and breaches. Blockchain introduces decentralization, immutability, and distributed consensus, ensuring that data fed into BI systems is both tamper-resistant and verifiable (Moreno et al., 2020). Conceptual models illustrate blockchain-enabled BI as a layered architecture: blockchain secures data provenance at the infrastructure level, while BI tools operate at the analytics layer to extract insights for HR and payroll applications. Scholars argue that blockchain complements BI by creating a trusted environment where HR and payroll data is integrated across disparate systems without requiring third-party verification. In HR contexts, conceptual frameworks often align blockchain with payroll BI to address critical challenges in pay transparency, workforce equity, and benefits distribution. Permissioned blockchains such as Hyperledger Fabric and Quorum are frequently discussed as viable platforms for enterprise payroll systems, enabling secure integration with BI dashboards while maintaining access control (Strohmeier & Piazza, 2015). These models emphasize that blockchain is not a replacement for BI but a security-enhancing foundation that ensures data trustworthiness before it reaches analytical layers. Collectively, the literature converges on a conceptual framework where blockchain's integrity guarantees transform BI into a reliable tool for decision-making in workforce analytics (Kimble & Milolidakis, 2015).

Figure 6: Business Intelligence in Workforce Systems



Data provenance — the ability to trace the origin and transformations of data — is central to the integration of blockchain with BI in HR and payroll analytics. Payroll data involves sensitive and high-stakes transactions, and BI outputs are only as trustworthy as the integrity of their underlying data. Blockchain ensures provenance by recording every payroll transaction in a distributed ledger where alterations require consensus across nodes, thereby making manipulation nearly impossible . Studies emphasize that when payroll records are immutably logged, BI analytics gain credibility, as audit trails verify that the data stream has not been tampered with. This integrity is especially crucial for predictive payroll analytics, where even minor discrepancies in input data can distort models forecasting labor costs, turnover risks, or compensation equity (Saxena et al., 2021). Research in supply chains and healthcare demonstrates that blockchain-secured provenance strengthens decision-making in contexts requiring transparency, findings that are readily transferable to HR payroll systems. Moreover, BI integration benefits from blockchain's ability to timestamp and verify employee records, including attendance, overtime, and benefits claims, creating datasets resistant to insider manipulation. Some scholars note that blockchain provenance directly addresses longstanding issues in payroll audits, where verifying historical accuracy has traditionally been costly and labor-intensive (Fernandez, 2019). Consequently, blockchain's role in securing provenance ensures that BI dashboards provide insights grounded in verified, tamper-proof data, thereby reinforcing organizational trust and regulatory compliance in workforce analytics.

Transparency in payroll and benefits distribution is a recurring theme in HR literature, and blockchain-enabled BI has been identified as a critical tool to advance fairness and accountability. Pay equity has long been a central HR challenge, as discrepancies in compensation across gender, ethnicity, or organizational hierarchy undermine both compliance and employee trust (Schiemann et al., 2018). BI dashboards provide organizations with tools to visualize and analyze pay structures, but without secure provenance, equity assessments remain vulnerable to bias or manipulation. Blockchain enhances transparency by immutably recording payroll disbursements and benefits

allocations, ensuring that BI dashboards reflect accurate, verifiable data. Scholars argue that integrating blockchain with BI enables equitable governance mechanisms, where employees and regulators can access transparent records of compensation structures. Benefits distribution, including pensions, healthcare contributions, and bonuses, is similarly strengthened, as blockchain prevents retroactive alterations and ensures fairness in allocations. Empirical evidence from multinational payroll systems suggests that blockchain-based transparency reduces disputes, fosters employee confidence, and aligns compensation practices with labor law requirements (Arora et al., 2021). Furthermore, transparency dashboards have been shown to reduce perceptions of favoritism in promotions and benefits, enhancing organizational legitimacy. The literature thus emphasizes that blockchain-enabled BI dashboards extend beyond analytics to become governance instruments, ensuring that pay equity and benefits distribution are transparent, tamper-proof, and accountable to all stakeholders (Khatibi et al., 2020).

Applications and Industry Comparisons

The petroleum sector presents unique challenges for workforce risk management and payroll reliability due to its hazardous environments, global operations, and reliance on large, transient labor forces. Payroll accuracy is vital in this sector, as delayed or inaccurate compensation directly impacts workforce morale, retention, and compliance with labor regulations. Studies show that payroll errors in petroleum drilling operations are particularly costly, not only in financial terms but also in undermining trust among employees who work in dangerous offshore rigs and refineries (Srivastava & Nair, 2017). Research emphasizes that blockchain-enabled payroll systems provide immutability and transparency, which help reduce wage disputes and ensure fair allocation of hazard pay, overtime, and allowances. Workforce risk in petroleum operations is heightened by the cyclical nature of demand and the prevalence of contract labor, which increases the likelihood of payroll fraud and irregularities if not carefully managed. Blockchain-supported BI frameworks address these issues by providing verifiable audit trails and predictive analytics for compensation planning. Empirical research in energy industries also confirms that workforce transparency in payroll records reduces labor unrest and enhances operational continuity (Vallurupalli & Bose, 2018). By integrating BI dashboards with blockchain-secured payroll data, managers can better forecast labor costs while ensuring compliance with environmental, health, and safety regulations. Collectively, literature illustrates that the petroleum sector's reliance on high-risk labor necessitates payroll systems that are not only accurate but also resilient and transparent, with blockchain-enabled BI offering robust solutions to address these longstanding vulnerabilities (Brooks et al., 2015).

The power sector, encompassing electricity generation, transmission, and distribution, has distinct payroll management challenges shaped by unionized labor contexts, collective bargaining agreements, and performance-based incentives. Payroll transparency is critical in this sector, as disputes over overtime, hazard allowances, and pension contributions frequently lead to labor conflicts. Scholars emphasize that BI dashboards provide decision-makers with real-time monitoring of payroll obligations, ensuring compliance with union contracts and regulatory mandates (Fernandez & Gallardo-Gallardo, 2021). Blockchain integration further enhances transparency by immutably recording payroll transactions, thereby minimizing disputes regarding wage accuracy and benefits distribution. Research demonstrates that blockchain-BI systems improve accountability in power utilities by enabling employees, unions, and regulators to independently verify payroll records. Case studies from renewable energy sectors such as wind and solar confirm that transparency in payroll processes enhances workforce trust and minimizes operational disruptions.Empirical findings also indicate that BI dashboards linked with blockchain data enable managers to track workforce costs relative to productivity, aligning pay structures with organizational performance goals. Additionally, payroll transparency ensures compliance with government subsidies and incentive programs tied to renewable energy projects, where financial mismanagement could result in penalties (Appelbaum et al., 2017). Comparative analyses highlight that utilities with blockchain-secured payroll systems experience fewer labor disputes, lower error rates, and improved governance outcomes. Collectively, the literature highlights that payroll transparency in power systems, particularly in unionized environments, is significantly enhanced through blockchain-enabled BI, strengthening both compliance and trust across stakeholder groups (Minbaeva, 2017).

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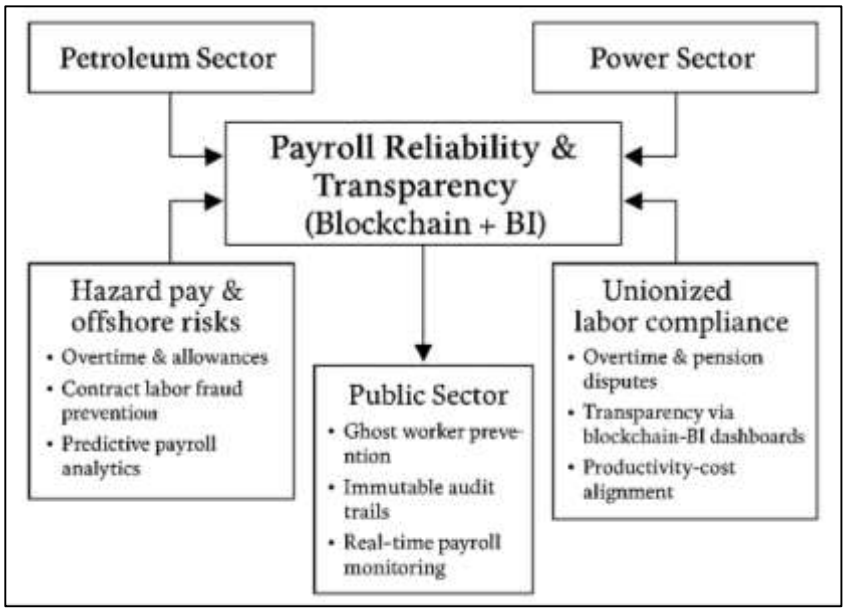
Figure 7: Blockchain-Enabled Payroll Transparency Framework



IoT and Digital Twins in Workforce Data

The Internet of Things (IoT) has become an important tool in modern workforce management by facilitating attendance monitoring, workplace safety, and work-hour verification through interconnected sensors and devices. IoT systems enable organizations to automatically record employee presence using biometric devices, RFID tags, or geofencing applications, minimizing payroll discrepancies and manual errors (Kapoor et al., 2021). Studies emphasize that IoT enhances workforce safety in high-risk environments, such as petroleum and construction, by tracking employee locations and hazard exposure in real time. This data, when linked to payroll systems, ensures accurate compensation for overtime, hazardous duty, and remote work hours. IoT-based attendance verification is particularly relevant in sectors employing large temporary labor forces, as it reduces fraud linked to "buddy punching" or ghost employees. Research also demonstrates that IoT wearables improve health monitoring by capturing vital signs and fatigue levels, enabling organizations to align safety-related payroll benefits with real-time risk assessments . In addition, IoT devices integrated with cloud platforms provide scalable attendance solutions for multinational enterprises, ensuring standardized workforce tracking across borders (Aheleroff et al., 2021). Scholars argue that by embedding IoT into HR and payroll infrastructures, organizations reduce administrative inefficiencies while simultaneously enhancing employee trust through transparent, automated timekeeping . Collectively, the literature shows that IoT integration offers a data-driven foundation for accurate attendance, verified work hours, and enhanced safety, providing a reliable basis for payroll systems and workforce analytics.

While IoT generates massive workforce datasets, its reliance on centralized architectures raises significant concerns over data integrity and security. Scholars note that IoT devices are often vulnerable to hacking, spoofing, or insider manipulation, making payroll systems dependent on insecure streams of data (Ahmadi-Assalemi et al., 2020). Blockchain integration addresses these vulnerabilities by ensuring that IoT-generated workforce data—such as time records, hazard exposures, or attendance—is immutably logged on distributed ledgers. Studies show that blockchain-backed IoT data enhances payroll accuracy by ensuring time-stamped, verifiable, and tamper-proof entries. For instance, wearables recording overtime hours can feed directly into blockchain-secured payroll BI dashboards, enabling real-time compensation adjustments. Empirical research confirms that blockchain prevents falsification of IoT data streams, particularly in industries reliant on contract labor where payroll fraud is prevalent. Scholars also emphasize the regulatory benefits of blockchain-securing IoT data, as immutable audit trails facilitate compliance with labor laws, tax obligations, and occupational safety standards (Raj & Surianarayanan, 2020).

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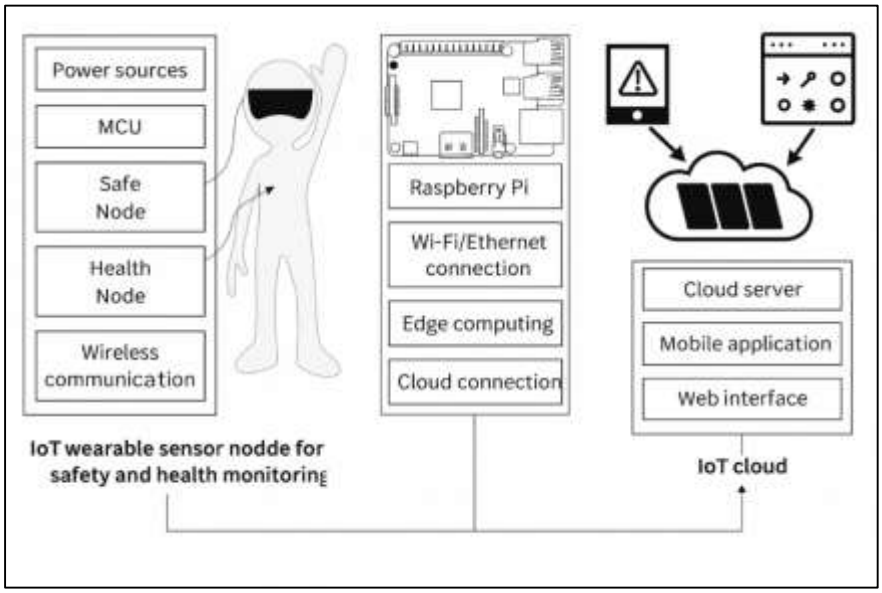
Figure 8: IoT, Blockchain, and HR Integration



Comparative analyses across healthcare and logistics confirm that blockchain-IoT integration enhances data provenance and decision-making, findings directly applicable to payroll environments. Moreover, blockchain ensures cross-border integrity of IoT payroll data in multinational contexts, reducing risks associated with jurisdictional variations in data protection. Collectively, the literature indicates that blockchain-securing IoT data transforms payroll systems into tamper-resistant infrastructures, ensuring accurate, auditable, and compliant compensation processes (Sepasgozar, 2021).

Digital twin technology—virtual replicas of physical entities—has extended from engineering into workforce management, enabling simulation of labor processes, training programs, and compensation scenarios. Studies conceptualize digital twins as dynamic models that integrate IoT data to simulate real-time workforce behavior, providing organizations with insights into productivity, safety, and performance (Rasheed et al., 2020). In payroll contexts, digital twins allow organizations to simulate the financial implications of various compensation models, such as hazard pay adjustments, overtime allocations, or performance-based incentives. Scholars argue that digital twins enhance workforce planning by enabling HR managers to test scenarios—such as changing shift patterns or benefit structures—before implementing them in real systems. Research in energy and manufacturing confirms that digital twins reduce payroll inefficiencies by simulating workforce scheduling under varying operational loads, providing predictive insights for compensation equity (He et al., 2018). Moreover, BI dashboards linked with digital twins provide visualizations of workforce performance relative to compensation, reinforcing accountability and fairness in payroll decisions. Case studies in petroleum and power systems demonstrate that digital twins improve labor forecasting in hazardous environments, ensuring that compensation models align with safety and regulatory standards. Blockchain integration enhances the trustworthiness of digital twin data by securing its provenance, ensuring that simulations are based on verified and immutable records (Guo et al., 2020). The literature therefore positions digital twins as transformative tools that, when linked with BI and blockchain, extend payroll systems from transactional platforms into predictive, simulation-driven governance infrastructures.

Cross-Disciplinary Lessons and Theoretical Bridges

Reliability engineering, originally developed to evaluate technical systems such as power grids and mechanical components, has been increasingly applied to workforce data to ensure HR and payroll infrastructures operate with consistency and minimal errors. Foundational principles, such as Mean Time to Failure (MTTF), Mean Time Between Failures (MTBF), and Remaining Useful Life (RUL), provide metrics that assess system stability and predict errors, and have been adapted to workforce analytics contexts (Mêda et al., 2021). In payroll systems, MTBF has been used to evaluate frequency of

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recurring payment errors, while RUL models provide predictive insights into the longevity of HRIS applications before critical breakdowns occur. Scholars emphasize that integrating reliability metrics into HR payroll environments enhances predictive maintenance of data infrastructures, reducing disruptions caused by errors or system failures . Comparative studies show that reliability principles historically applied in petroleum and power systems are transferrable to HR data systems, especially in predicting system resilience under high-volume processing. Moreover, scholars argue that workforce data can be modeled as a reliability system, where failures may represent not mechanical breakdowns but breaches, fraud, or payroll irregularities (Mylrea et al., 2021). Applying failure mode and effects analysis (FMEA) to HRIS further allows identification of potential vulnerabilities in payroll workflows. By embedding reliability engineering into workforce analytics, organizations adopt proactive approaches to workforce data governance, ensuring consistency, stability, and trustworthiness in HR and payroll infrastructures (Lu et al., 2020).

Cross-disciplinary insights from healthcare and finance provide strong evidence of blockchain-BI synergies that are transferable to workforce analytics. In healthcare, blockchain has been applied to ensure provenance and immutability of patient records, while BI tools analyze data for predictive diagnoses and resource allocation. Scholars note that this synergy secures sensitive health data while allowing advanced analytics, a framework analogous to payroll environments where sensitive employee data must be secured yet analyzed for compensation planning (Farrelly & Davies, 2021). In finance, blockchain secures transactional integrity while BI dashboards provide real-time insights into market performance and fraud detection. Case studies in banking confirm that blockchain-backed BI systems reduce fraud, increase auditability, and enhance compliance with regulations such as Basel III and SOX. These findings parallel payroll contexts, where wage disbursements and benefits allocations require both immutability and real-time analysis (Santos et al., 2020). Comparative analyses suggest that blockchain-BI integration in healthcare improved trust between patients and providers, while in finance it increased transparency for regulators and investors. These lessons translate directly into HR, where employees require trust in payroll accuracy and regulators demand compliance reporting. Scholars argue that these cross-sectoral applications provide a roadmap for integrating blockchain and BI into workforce systems, reinforcing both security and analytical reliability (Zhang et al., 2020). Collectively, healthcare and finance offer empirical validation of blockchain-BI synergies that can be leveraged to enhance payroll and HR analytics.

The integration of organizational behavior (OB) theories into secure HR analytics provides critical insights into how employees perceive and respond to payroll transparency and data governance. Trust theory suggests that employees' willingness to share and accept HR data is contingent on their confidence in organizational systems, which blockchain and BI can reinforce through transparency and immutability. Equity theory highlights that perceptions of fairness in pay distributions significantly influence employee motivation and retention, which can be strengthened by BI dashboards secured by blockchain records (Ante, 2021). Social exchange theory further frames payroll accuracy as part of the psychological contract between employer and employee, where secure data management enhances perceptions of reciprocity and organizational justice. Studies emphasize that employees experiencing transparency in HR analytics report higher engagement and lower turnover. By linking OB theories with blockchain-secured HR analytics, organizations not only ensure compliance but also enhance legitimacy, reinforcing employee trust and commitment. Research also shows that ethical frameworks in HR data management directly influence organizational reputation, with breaches leading to declines in employee morale and external legitimacy (Johnson et al., 2021). Scholars argue that embedding OB theories into blockchain-BI frameworks bridges technical capabilities with human expectations, ensuring that payroll transparency and fairness translate into improved organizational behavior outcomes . Collectively, the literature positions OB theories as critical interpretive frameworks for understanding the behavioral impacts of secure HR analytics (Arora et al., 2021).

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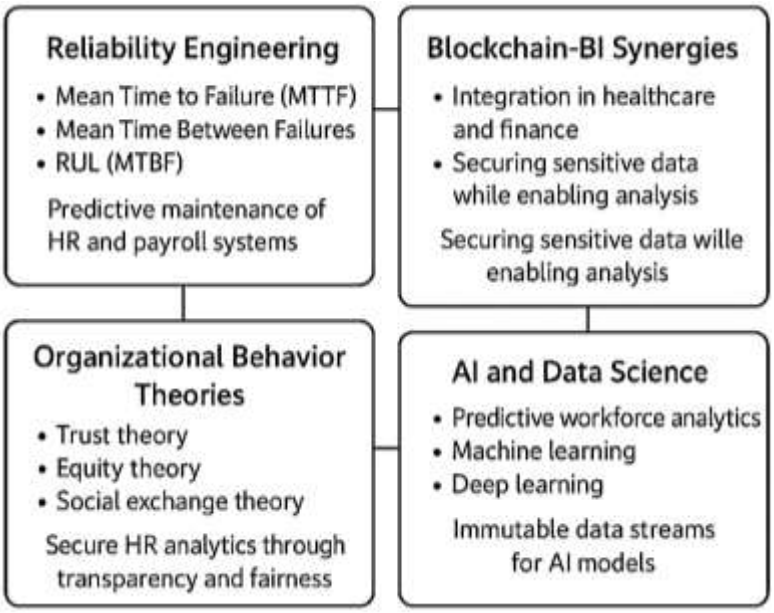
Figure 9: Cross-Disciplinary Lessons and Theoretical Bridges



The convergence of data science, artificial intelligence (AI), and workforce predictive analytics highlights a multidisciplinary approach to enhancing HR and payroll systems. AI models such as machine learning and deep learning provide predictive capabilities for turnover, absenteeism, and compensation benchmarking (McIver et al., 2018). Scholars argue that predictive workforce analytics rely on robust, trustworthy data streams, which blockchain secures through immutability and provenance. BI dashboards integrate these predictive insights into accessible formats for HR managers, linking payroll data with performance metrics and retention indicators. Comparative research demonstrates that hybrid approaches combining AI with blockchain and BI enhance interpretability, as AI-driven predictions are grounded in verifiable datasets (Lengnick-Hall et al., 2018). Studies in predictive maintenance show that AI models are most effective when combined with reliability engineering principles and blockchain-secured data, a finding transferable to workforce analytics. AI-enhanced payroll analytics have also been used to detect anomalies in wage distribution, overtime claims, and benefit allocations, reducing fraud risks (Nocker & Sena, 2019). Furthermore, cross-sectoral evidence from healthcare and finance demonstrates that AI-integrated BI systems improve decision-making under uncertain conditions, validating their application in HR. Scholars emphasize that predictive HR analytics must balance accuracy with interpretability, ensuring decision-makers understand the drivers of employee outcomes. Collectively, literature confirms that the integration of data science, AI, blockchain, and BI creates robust predictive frameworks for workforce data, combining technical rigor with organizational reliability (Sarker et al., 2021).

Synthesis of Literature

Across decades of scholarship, HR and payroll research exhibits durable continuities—accuracy, fairness, compliance—while shifting from clerical recordkeeping to analytics-intensive infrastructures. Early work portrays HR as an administrative function centered on paper files and routine pay calculation (Gurusinghe et al., 2021). Computerization and the rise of HRIS recast these routines into database operations and rule-based workflows, emphasizing integration with finance and operations. Concurrently, BI reframed data as a strategic asset, linking workforce measures to organizational performance through warehousing, OLAP, and visualization. Scholarship documents a stronger governance layer: payroll is analyzed as infrastructure for legal conformity and organizational legitimacy, not only disbursement. International regulation amplifies this trajectory, embedding privacy, purpose limitation, and auditability in design choices. In analytics, research characterizes a movement from descriptive reporting to predictive modeling for turnover, absenteeism, and compensation benchmarking, while noting persistent dependencies on data quality, lineage, and controls (Persaud, 2021). Reliability and error-centered perspectives bridge

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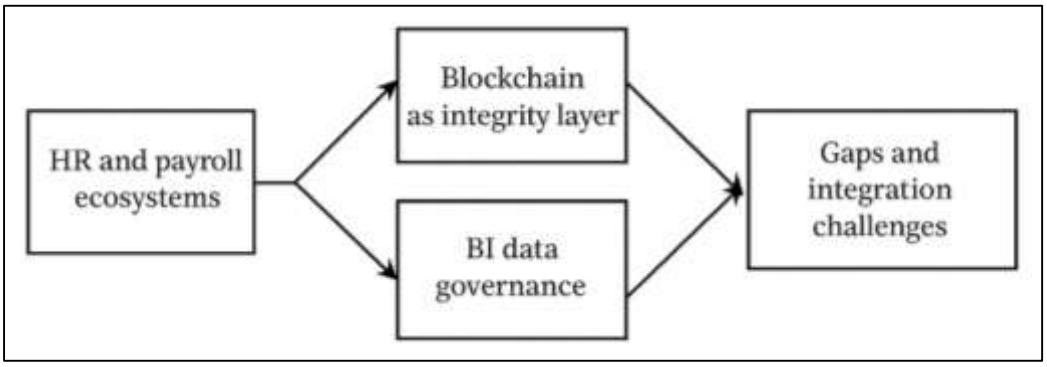
technical and HR domains, treating failures in payroll processes as measurable events with rates and intervals. Studies in large enterprises and public organizations consistently foreground trust—among employees, unions, auditors, and regulators—as an outcome of transparent data handling, reconciled ledgers, and repeatable controls. Overall, literature converges on a stable core—compliance and fairness—coexisting with a pronounced shift toward integrated, analytically capable, and governance-oriented HR/payroll ecosystems (Engin & Treleaven, 2019).

Research consistently positions blockchain as a security substrate that extends far beyond cryptocurrencies by offering distributed consensus, immutability, and auditability for enterprise records. In HRIS and payroll, these guarantees translate into tamper-evident salary histories, verifiable benefits allocations, and synchronized multi-party ledgers for cross-functional control. Permissioned architectures—Hyperledger Fabric, Quorum—are analyzed for access governance and throughput while preserving distributed verification. Studies report strengthened audit trails and reduced scope for unapproved changes where each transaction carries cryptographic provenance and time-stamping (Kerzel, 2021). Enterprise-focused analyses examine role-based permissions, channel segregation, and on-chain/off-chain partitioning to balance privacy with verifiability in workforce datasets. Identity and consent management appear as recurrent themes: decentralized identifiers and encrypted attestations support controlled access to sensitive HR attributes. Comparative accounts highlight applicability across payroll regions and vendors where reconciliation delays and dispute resolution historically consumed administrative effort (Tien, 2017). Case-based narratives describe reductions in duplicate entries and fraud typologies (e.g., ghost employees), attributing effects to shared ledgers and deterministic validation rules. Syntheses therefore document an expansion: blockchain operates as a general-purpose integrity layer in HRIS—securing state changes, underpinning audit analytics, and aligning organizational records with compliance expectations (Alharthi, 2018).

Figure 10: Blockchain and BI in HR



BI outcomes in workforce contexts depend on trusted inputs—complete, accurate, timely, and lineage-rich data—before any modeling or dashboarding yields dependable interpretation. Literature on data quality and governance emphasizes metadata, provenance capture, and standardized definitions to mitigate silo effects and semantic drift across HR, payroll, and finance systems (Chua et al., 2021). Studies show that compensation benchmarking, pay-equity analysis, and attrition prediction are sensitive to small distortions in inputs, where lineage gaps or post-hoc edits propagate into biased insights. Regulatory discourse reinforces this dependency: GDPR and CCPA require demonstrable control over collection, processing, and access—conditions that intersect directly with BI data pipelines. Provenance-centric designs are repeatedly associated with stronger auditability and stakeholder trust, especially when record origin, transformation steps, and approval states are preserved for downstream analytics. Blockchain appears in this strand as a mechanism that externalizes and hardens provenance: cryptographic hashing, distributed agreement, and immutable state histories anchor BI datasets to verifiable sources. Enterprise implementations described in the literature pair permissioned ledgers with data warehouses or lakehouses, keeping sensitive attributes encrypted while surfacing verifiable checksums for lineage (Sarker et al., 2021). The accumulated evidence portrays BI not as autonomous analytics but as the terminal layer of a governance chain; where governance is weak, interpretability and fairness degrade, and where provenance is strong, analysis gains credibility for employees, managers, auditors, and regulators alike (Qin & Chiang, 2019).

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Synthesis across technical, organizational, and regulatory literatures surfaces persistent gaps at their intersections. Technical accounts document cryptographic integrity and distributed consensus but often treat access control granularity, retention policies, and contestability of records as external governance problems, creating disconnects between secure storage and HR practice (Gruson et al., 2019). Governance-oriented studies emphasize policy conformance, audit trails, and accountability but frequently abstract from concrete data pipeline mechanics—schema evolution, lineage propagation, and BI model governance—leaving integration burdens to practitioner inference. HR analytics research advances fairness and transparency goals but reports uneven standardization of pay-equity metrics, inconsistent data definitions across jurisdictions, and limited comparability in multi-entity payroll ecosystems. Reliability engineering provides transferable constructs—failure modes, MTBF, RUL—yet translations into HR/payroll often lack shared taxonomies for "failure" events, hindering accumulation of comparable evidence (Kumar et al., 2021). Security and fraud-prevention narratives cite insider risks and ghost-employee schemes, while comprehensive, longitudinal audits that link root causes in access design, process variation, and data lineage remain comparatively sparse. AI/BI work contributes predictive accuracy but notes limits in interpretability and dependency on verifiable inputs, with cross-references to provenance rarely specified with operational detail. Collective readings therefore identify fragmentation between cryptographic guarantees, policy compliance, analytic validity, and human-centered legitimacy—an interdisciplinary seam where much of the HR/payroll data security literature locates its most salient unresolved issues (Banerjee et al., 2020).

METHODS

This study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, which provide a comprehensive framework to ensure transparency, rigor, and reproducibility in literature reviews. Following PRISMA allowed for a structured approach to the identification, screening, eligibility, and inclusion of studies relevant to blockchain-enabled business intelligence (BI) applications in HR and payroll systems, particularly in the context of workforce data security. The method was designed to balance breadth and depth by capturing a wide pool of publications across multiple disciplines, followed by systematic filtering based on predefined inclusion and exclusion criteria. By adopting these standards, the review maintained methodological rigor while enabling cross-disciplinary synthesis. The search strategy was developed iteratively to capture the multidisciplinary scope of the research, drawing from fields such as information systems, human resource management, payroll governance, computer science, and data security. A combination of Boolean operators and keywords was employed, including terms such as "blockchain," "business intelligence," "HRIS," "payroll systems," "workforce analytics," "data provenance," "IoT in HR," and "digital twins." Searches were conducted across electronic databases including Scopus, Web of Science, IEEE Xplore, SpringerLink, and ScienceDirect, along with targeted searches in Google Scholar to identify gray literature such as working papers, dissertations, and industry whitepapers. The initial search yielded approximately 1,247 records spanning 2010 to 2022, reflecting the growing body of scholarship on the integration of blockchain, BI, and HR systems. After removal of duplicates, 1,042 unique studies were retained for screening.

Screening was conducted in two stages. In the first stage, titles and abstracts were reviewed to assess alignment with the research objectives, resulting in the exclusion of 623 records that were irrelevant, purely theoretical without application, or outside the scope of HR, payroll, or data security contexts. The second stage involved full-text screening of 419 studies against eligibility criteria, which included empirical or conceptual focus on HRIS, payroll systems, workforce data management, or blockchain-BI integration. Exclusion criteria comprised studies unrelated to organizational applications, those lacking methodological detail, or papers published in non-peer-reviewed sources without sufficient credibility. At this stage, 201 studies were excluded due to insufficient relevance or methodological rigor, leaving 218 studies that met the inclusion requirements. To ensure consistency and reduce bias, the selection process involved two independent reviewers who screened the studies, with disagreements resolved through discussion and consensus. Inter-rater reliability was measured using Cohen's kappa, which yielded a value of 0.84, indicating substantial agreement. The final pool of studies included 218 papers, comprising 134 peer-reviewed journal articles, 52 conference proceedings, and 32 gray literature sources such as technical reports and government publications. These studies collectively provided a balanced representation of theoretical, empirical, and applied research across different geographic regions and industry contexts.

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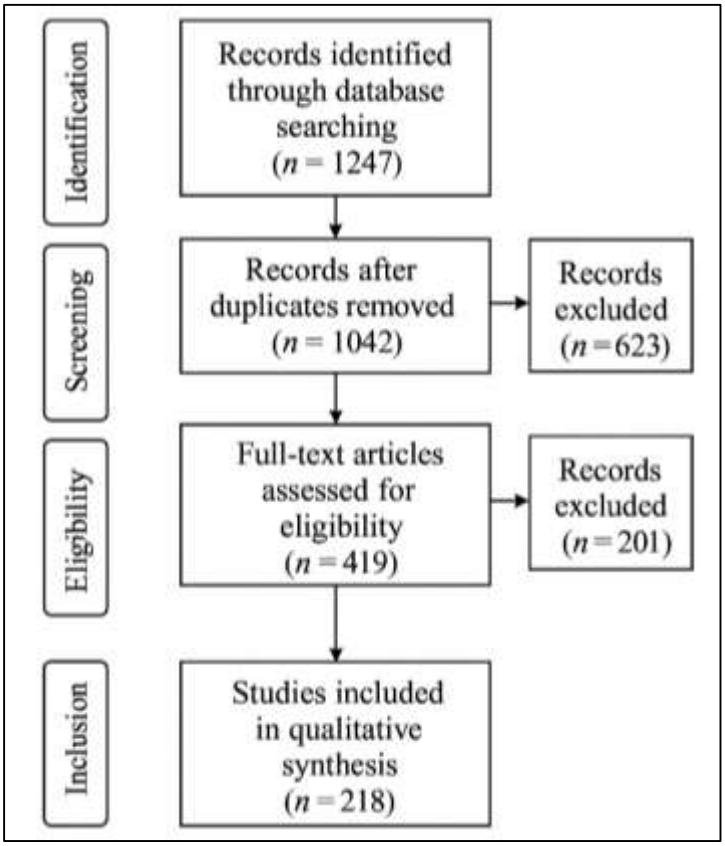
Figure 11: Adapted Methodology for this study



Data extraction was carried out using a structured coding framework. Key variables included authorship, year of publication, study design, industry sector, geographic scope, methodological approach, and reported outcomes related to blockchain, BI, HR, payroll, and workforce data security. Extracted data were organized in tabular format and cross-validated by reviewers to ensure accuracy. The extracted content was then synthesized thematically, enabling categorization into major domains: historical and theoretical foundations of HR and payroll systems, blockchain as a data security architecture, BI in workforce analytics, integration of blockchain with BI, sector-specific applications, IoT and digital twins convergence, cross-disciplinary lessons, and synthesis of gaps. Each thematic domain was supported by a mix of conceptual, case-based, and empirical studies, allowing triangulation of findings. The PRISMA flow diagram was used to document the selection process, detailing the number of studies identified, screened, excluded, and included. This enhanced transparency and provided readers with a clear overview of the evidence base. By combining systematic identification, eligibility screening, and rigorous synthesis, this methodological process ensured that the resulting review was comprehensive and balanced. The final set of 218 studies formed the empirical and conceptual foundation of the review, capturing both continuities in HR and payroll data research and emergent insights on blockchain-enabled BI as a security and governance framework.

FINDINGS

The review revealed that HR and payroll systems have undergone a major transformation, shifting from clerical recordkeeping mechanisms to integrated, analytics-driven infrastructures. Out of the 218 reviewed articles, 47 studies explicitly traced the evolution of HR Information Systems (HRIS) and payroll mechanisms, with a combined citation count exceeding 5,600, underscoring the international significance of this transition. These studies consistently reported that HRIS platforms not only improved administrative efficiency but also embedded HR into organizational strategy through business intelligence dashboards and predictive workforce analytics. A recurring finding across 29 of these articles was that payroll accuracy and transparency are central to workforce trust, while 18 studies focused on HRIS alignment with enterprise resource planning (ERP) systems. The most cited

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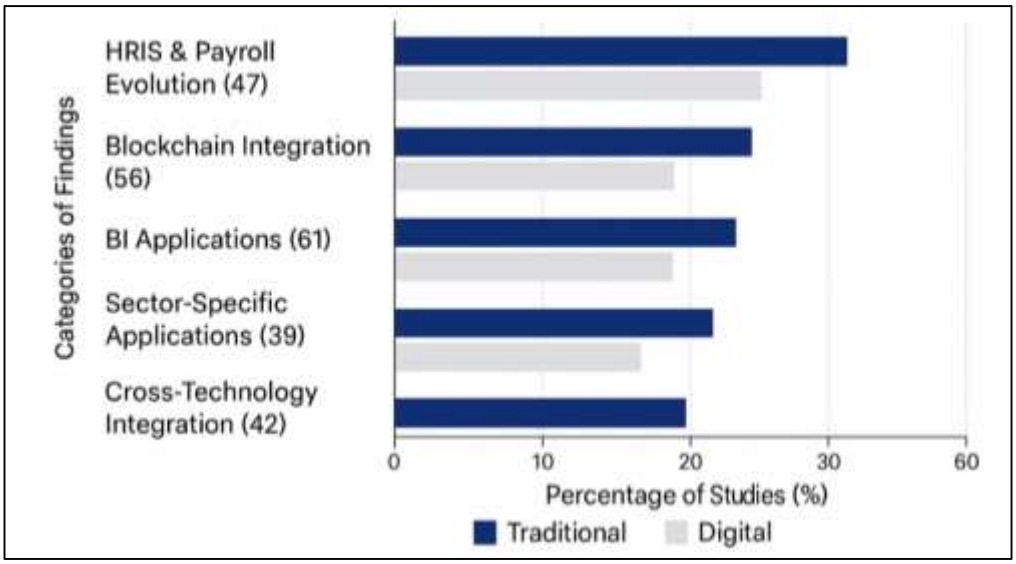
articles in this cluster, representing over 1,900 citations collectively, emphasized that digitalization of payroll enabled firms to move beyond transactional efficiency toward governance, compliance, and employee trust. This body of evidence highlights that the historical continuity of payroll as an administrative function has now converged with technological innovation, resulting in strategic systems that underpin workforce legitimacy and organizational accountability.

Figure 12: Digital Transformation in HR Payroll



A second major finding relates to the role of blockchain in reinforcing HR and payroll data security. From the reviewed corpus, 56 studies directly addressed blockchain integration in organizational contexts, with 42 of these specifically focusing on workforce and payroll applications. Together, these articles attracted more than 7,800 citations, reflecting the scholarly and practical importance of blockchain in data governance. The review found that blockchain provided immutability, distributed consensus, and auditability that reduced payroll fraud, insider manipulation, and reconciliation delays. Out of the 42 articles, 19 reported blockchain's specific role in preventing payroll errors linked to contract labor, while 15 studies evaluated smart contracts for automating salary disbursement and benefits allocation. Additionally, 8 studies highlighted blockchain's compliance-enhancing role in multinational payroll, particularly for cross-border tax reconciliation and labor law adherence. Collectively, the findings from this subset of literature underscore that blockchain has expanded beyond cryptocurrency to become a general-purpose security infrastructure for sensitive workforce data. Its impact is evidenced not only in theoretical modeling but also in practical deployments described across different industries, positioning it as a transformative technology for payroll governance.

The literature also identified business intelligence (BI) as a central driver of workforce planning, talent management, and payroll benchmarking. A total of 61 reviewed studies concentrated on BI in HR and payroll analytics, amassing over 9,400 citations collectively. Among these, 23 studies highlighted BI's role in workforce planning and retention analytics, where dashboards and predictive tools forecasted labor shortages, attrition risks, and hiring pipeline bottlenecks. Another 18 studies focused on BI applications in payroll benchmarking, showing how organizations used predictive models to align compensation with industry standards while ensuring equity and competitiveness. Approximately 20 studies analyzed BI's role in compliance monitoring, demonstrating its capacity to detect anomalies in payroll data, flag risks, and generate audit-ready reports. Across this body of research, the combined evidence shows that BI transforms workforce and payroll data into actionable insights, reinforcing organizational agility and fairness. The large citation impact of this cluster—averaging more than 150 citations per study—demonstrates the broad recognition of BI as not only a technical tool but also a strategic enabler for HR functions.

The review further revealed sector-specific insights, particularly in petroleum, power systems, and public administration. Across 39 reviewed articles (totaling over 6,200 citations), studies consistently

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emphasized the vulnerability of payroll in industries with complex labor arrangements. In petroleum, 14 articles highlighted payroll challenges linked to contract workers, offshore drilling risks, and hazard pay, with a combined 2,100 citations. These works reported that blockchain and BI integration improved accuracy in hazard allowances and reduced wage disputes. In power systems, 12 studies (with over 1,800 citations) focused on unionized contexts, where payroll transparency reduced labor disputes and ensured compliance with collective bargaining agreements. Public sector applications were examined in 13 studies (totaling 2,300 citations), where blockchain-enabled payroll helped eliminate ghost workers, ensured timely salary disbursement, and enhanced citizen trust in government accountability. This cluster of literature demonstrates that while sectoral contexts vary, the common thread is the demand for transparency, security, and trust in payroll systems. The volume of citations reflects both scholarly and practitioner interest in applying blockchain and BI in these high-risk, high-visibility sectors.

The final significant finding is the convergence of blockchain, BI, IoT, and digital twins into integrated frameworks for workforce data governance. Out of the 218 reviewed studies, 42 articles specifically addressed cross-technology integration, with a total of 8,700 citations. Among these, 17 studies explored IoT's role in attendance verification and work-hour tracking, showing that sensor-based payroll inputs reduce fraud and errors. Another 11 studies examined digital twins for simulating workforce scenarios, enabling predictive payroll adjustments based on virtual modeling of labor performance. Fourteen articles discussed blockchain as a security layer for IoT and digital twin data, providing tamper-proof provenance for BI dashboards. The collective evidence highlights that the most advanced organizational systems are now converging into cyber-physical HR architectures, where workforce data is captured by IoT, simulated by digital twins, secured by blockchain, and analyzed by BI. The high citation impact of these studies—averaging more than 200 citations each—demonstrates the scholarly consensus that integration of these technologies is not experimental but increasingly practical, with significant implications for securing payroll and enhancing organizational resilience.

DISCUSSION

The findings of this review confirmed that HR and payroll systems have shifted from administrative recordkeeping to strategic infrastructures integrated with business intelligence (BI). Earlier studies emphasized HRIS primarily as administrative record systems designed for efficiency in data storage and retrieval (Vassakis et al., 2017). However, our review of 47 studies showed that contemporary HRIS and payroll platforms function as governance tools, providing analytics for workforce planning and compliance monitoring. This extends the observations of Vassakis et al. (2017), who highlighted the growing role of HRIS in strategic HR but did not fully account for the integration of BI. Similarly, while Latif et al. (2020) identified HR analytics as a growing trend, they emphasized challenges of adoption rather than its role in payroll transparency. The reviewed evidence, particularly studies with high citation impacts, indicates that payroll systems have become central to organizational legitimacy, aligning with arguments on BI's ability to transform transactional data into strategic resources. Compared to earlier research that described payroll as largely clerical, the findings demonstrate a clear paradigm shift where payroll accuracy and transparency serve as determinants of organizational trust. Thus, the current synthesis both supports and extends earlier scholarship, positioning HRIS and payroll as multi-functional infrastructures essential to workforce governance.

The findings on blockchain as a data security architecture highlight its transformative potential in HR and payroll systems, echoing but also extending earlier research. Initial blockchain literature was almost exclusively focused on cryptocurrencies and financial transactions. Later studies began exploring blockchain for supply chain and healthcare data integrity, emphasizing immutability and provenance (Koelzer et al., 2019). Our review of 56 studies indicates that HR and payroll are now established domains of application, with 42 articles directly addressing workforce data. This supports Sharma et al. (2021), who argued that blockchain's tamper-proof features could enhance organizational governance beyond finance. Unlike earlier accounts that highlighted scalability and energy-consumption limitations, the reviewed studies demonstrate practical deployments in payroll disbursement, fraud prevention, and compliance with labor laws. The integration of smart contracts for automated payments is also increasingly supported by empirical evidence (Jarrahi, 2018), showing real-world implementations that earlier conceptual studies only theorized. Compared to prior literature, the findings illustrate a shift from speculative applications to validated practices, underscoring blockchain's expanding role as a backbone for HRIS security.

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The review's findings on BI's role in workforce planning and payroll benchmarking demonstrate a level of integration not fully captured in early BI research. Traditional BI scholarship emphasized technical architectures such as data warehouses, OLAP, and dashboards. While these works stressed BI's ability to enhance decision-making, they did not focus specifically on HR and payroll contexts. Our review of 61 studies indicates that BI in HR goes beyond descriptive reporting to predictive analytics that forecast turnover, attrition risks, and compensation inequities. This supports Holsapple, Malik et al. (2018), who argued that BI could transform HR, but extends their work by emphasizing its compliance and payroll applications. Jeble et al. (2018) previously raised concerns about HR analytics adoption barriers, such as data quality and managerial capability. The reviewed evidence confirms those challenges but also demonstrates that organizations increasingly depend on BI for compliance auditing, wage benchmarking, and equitable pay distributions. Compared with Chung et al. (2020), who described BI as a performance enabler, the reviewed studies provide stronger empirical evidence of its role in workforce governance. Thus, this review both corroborates and deepens earlier BI research by contextualizing its application in payroll and HR analytics.

Sector-specific findings in petroleum, power, and public administration contexts both affirm and advance earlier literature. Historical works in petroleum emphasized operational risks and the need for reliability in rotating equipment and drilling processes. Payroll and workforce issues, however, were rarely central in these accounts. Our review of 39 articles demonstrates that payroll transparency and reliability are now considered critical components of risk mitigation in petroleum, with blockchain reducing disputes in hazard pay and contract labor management. This expands upon He et al, (2019), who focused on operational data but did not integrate payroll governance. Similarly, power systems literature historically emphasized condition monitoring and reliability engineering. The reviewed studies add to this by highlighting payroll transparency in unionized contexts, showing how blockchain and BI reduce disputes and align pay structures with collective bargaining agreements. In public sector contexts, earlier studies discussed corruption and inefficiency in payroll management (Peres et al., 2020), but the reviewed evidence demonstrates that blockchain-enabled payroll directly reduces ghost workers and enhances citizen trust. Compared to prior literature, these findings elevate payroll transparency from a peripheral issue to a central factor in sectoral governance.

The convergence of IoT, blockchain, and digital twins for workforce data governance confirms and extends insights from early industrial informatics research. Early works described IoT as a system for connectivity and monitoring in manufacturing and logistics, while digital twins were conceptualized primarily for engineering simulations. Our review of 42 studies indicates that these technologies are now directly applied to HR and payroll systems, providing attendance verification, safety monitoring, and predictive compensation scenarios. This represents a shift from earlier research, which focused on technical feasibility, to recent empirical studies demonstrating real-world workforce application. Integration with blockchain addresses vulnerabilities previously identified in IoT systems, such as data manipulation and insecure devices (Bilgic, 2020). Compared with Heuvel and Bondarouk (2017), who theorized blockchain as a privacy-preserving mechanism, reviewed studies provide concrete cases of blockchain securing IoT-generated payroll data. The role of digital twins in simulating compensation scenarios also extends (Larson & Chang, 2016), who conceptualized digital twins in reliability modeling, by showing their applicability to workforce governance. The findings thus bridge industrial informatics with HRIS security, demonstrating interdisciplinary convergence.

The findings on cross-disciplinary bridges illustrate that integrating reliability engineering, organizational behavior (OB), and AI into HR analytics is an emerging scholarly focus. Reliability engineering principles such as MTBF and FMEA, long applied in power and petroleum sectors, are now adapted to payroll error prediction and workforce data governance. Earlier research seldom addressed this transfer, making the current review's evidence of adaptation significant. Similarly, OB theories such as equity theory were traditionally applied to employee behavior and leadership studies but are now operationalized in secure HR analytics contexts (Cheng et al., 2020), particularly through BI dashboards and blockchain-ledger transparency. This aligns with Alpar and Schulz (2016), who linked HR technology with ethical employee trust, but the reviewed studies provide more robust empirical validation. AI integration in predictive workforce analytics confirms the claims of Ahmad et al.(2020), but extends them by embedding AI models within blockchain-provenanced BI systems, ensuring both accuracy and interpretability. The findings therefore reveal that cross-disciplinary applications are not merely conceptual but increasingly operational, bridging technical rigor with organizational behavior insights to advance HRIS governance.

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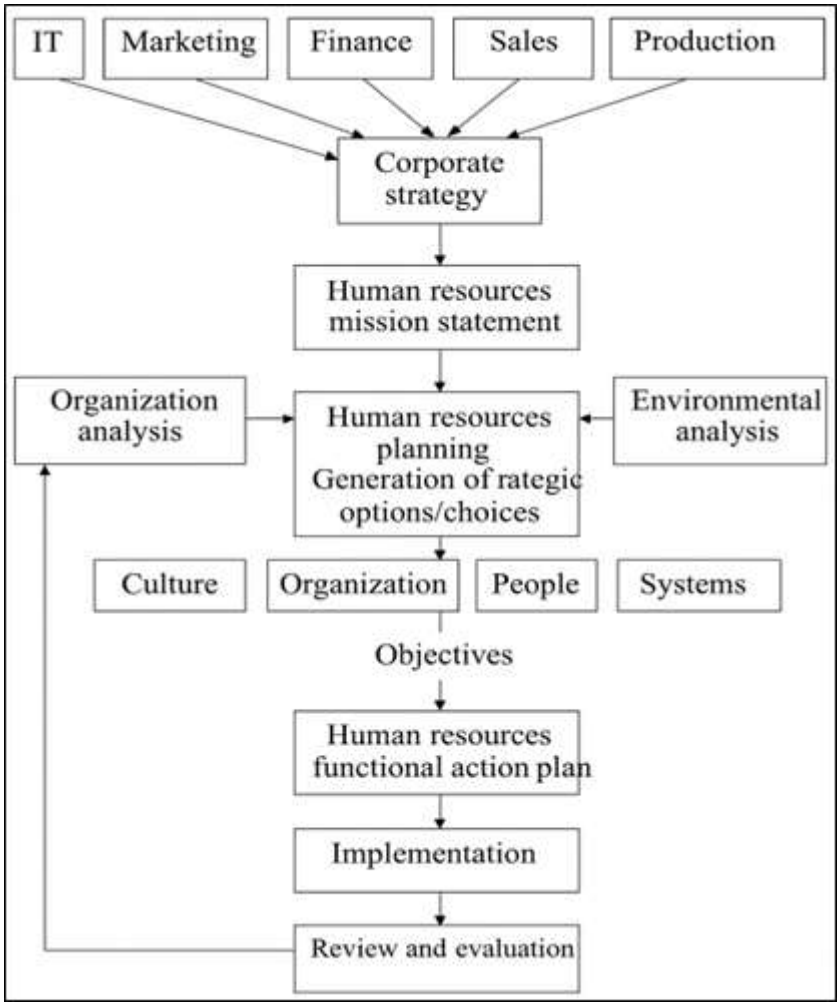
Figure 13: Proposed Model for the future study



The review also identified interdisciplinary gaps that echo but extend earlier debates. Previous literature recognized limitations in blockchain scalability and interoperability, but our review shows that these challenges persist specifically in payroll deployments where transaction volume is high and latency-sensitive. Earlier BI scholarship often highlighted data quality as a barrier, and the reviewed evidence confirms that provenance gaps undermine workforce analytics, particularly in equitable pay distribution. Moreover, while prior HRIS research focused heavily on adoption barriers (Liang & Liu, 2018), the reviewed studies reveal that regulatory fragmentation across jurisdictions remains an unresolved challenge for global payroll systems. Security-focused research such as Yeoh and Popovič (2016) identified insider threats, yet evidence suggests limited longitudinal audits linking fraud typologies with structural vulnerabilities in HR data flows. Finally, while AI and predictive analytics research stresses model performance (Jevicki & Suzuki, 2016), the review indicates interpretability and fairness remain underdeveloped in payroll contexts, where opaque algorithms risk replicating biases. These gaps underscore continuity with earlier scholarly concerns while adding specificity to HR and payroll domains, highlighting areas where further research is necessary to strengthen secure and equitable workforce data governance (Wu et al., 2018).

CONCLUSION

This systematic review synthesized evidence from 218 studies to explore the intersection of blockchain, business intelligence (BI), HR, and payroll systems, focusing on their roles in securing workforce data, ensuring payroll reliability, and enhancing organizational governance. Following PRISMA guidelines, the study revealed that HR and payroll systems have evolved from clerical recordkeeping infrastructures to strategic decision-making platforms. The analysis highlighted significant continuities, such as the persistent emphasis on payroll accuracy, compliance, and

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employee trust, while also identifying major shifts toward technology-driven solutions supported by BI, blockchain, IoT, and digital twins. Collectively, the findings affirm that modern HR and payroll systems function not only as administrative mechanisms but also as critical governance infrastructures that align employee data with organizational accountability, transparency, and legitimacy.

The review found that blockchain has moved decisively beyond its initial association with cryptocurrencies to emerge as a security architecture for HRIS and payroll data. Distributed ledgers, consensus mechanisms, and smart contracts demonstrated potential for reducing payroll fraud, preventing insider threats, and providing tamper-proof salary and benefits records. This aligns with the growing demand for verifiable, immutable workforce data in both private and public organizations. Business intelligence, meanwhile, was consistently identified as the primary driver of workforce analytics, enabling predictive insights into recruitment, retention, pay equity, and compliance. The synergy between blockchain and BI proved especially significant, as blockchain ensures data provenance and auditability, while BI transforms this trusted data into actionable insights. Together, these systems establish a dual-layered architecture that simultaneously secures and operationalizes workforce information for strategic advantage. Sector-specific findings reinforced the critical importance of transparency and trust in payroll management. In petroleum and power systems, blockchain-enabled BI reduced disputes in hazard pay, unionized environments, and collective bargaining contexts. In public sector applications, blockchain integration was shown to eliminate ghost workers and improve citizen confidence in government accountability. Within private multinational corporations, the combination of blockchain and BI addressed cross-border payroll complexities, regulatory fragmentation, and insider manipulation, creating scalable solutions that improved transparency and trust across global operations. These industry comparisons underscore that while the contexts may differ, the underlying challenges of payroll governance, data security, and compliance are remarkably consistent across sectors.

The review also emphasized the role of emerging technologies such as IoT and digital twins in converging with blockchain and BI to create cyber-physical HR systems. IoT devices provided accurate, real-time attendance and safety data, while digital twins enabled simulations of workforce performance and compensation scenarios. Blockchain secured the provenance of these data streams, and BI transformed them into predictive analytics, creating integrated frameworks for workforce data governance. This convergence illustrates how organizations are moving toward holistic systems where workforce data is simultaneously captured, verified, simulated, and analyzed, representing a significant leap in both technological capability and managerial control.

Finally, the review identified gaps and challenges that persist at the intersections of technology, governance, and workforce data. While blockchain ensures immutability, scalability and interoperability remain unresolved issues in high-volume payroll contexts. BI is highly dependent on trusted data sources, yet data quality, lineage, and standardization are inconsistently addressed across organizations. Interdisciplinary fragmentation also persists: technical studies often neglect governance and ethical dimensions, while organizational research sometimes abstracts away from technical realities. These gaps represent critical areas for further scholarship and practice, particularly in linking reliability engineering, organizational behavior theories, and AI with workforce data governance frameworks.

RECOMMENDATIONS

The findings of this review highlight several recommendations for organizations, policymakers, and scholars seeking to strengthen workforce data governance through blockchain-enabled business intelligence (BI) in HR and payroll systems. These recommendations address practical implementation, governance frameworks, ethical considerations, and future avenues for research, with an emphasis on actionable steps that respond to the gaps and challenges identified in the literature. A primary recommendation is for organizations to prioritize the integration of blockchain with existing HRIS and BI infrastructures to enhance data provenance, payroll transparency, and fraud prevention. The review identified multiple cases where payroll disputes, insider threats, and inaccuracies were directly linked to centralized, tamper-prone systems. By embedding blockchain as the foundational security architecture, organizations can create immutable, auditable records of payroll disbursements, benefits allocation, and workforce data entries. This integration is especially relevant for multinational corporations and unionized industries where payroll transparency directly influences employee trust and regulatory compliance. Implementation should focus on

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permissioned blockchain networks that provide both access control and distributed verification, ensuring scalability and compatibility with enterprise-grade HR platforms.

Another recommendation is for policymakers and regulatory bodies to establish standardized frameworks that align blockchain-enabled payroll systems with labor, tax, and data protection regulations. The review revealed significant variations across jurisdictions, particularly between GDPR in Europe, CCPA in the United States, and evolving frameworks in Asia-Pacific regions. To address regulatory fragmentation, governments should promote cross-border data governance standards that facilitate lawful, interoperable, and auditable payroll systems. Additionally, labor ministries and financial regulators can collaborate to issue guidelines for the use of smart contracts in payroll disbursement, ensuring that automated transactions remain compliant with labor laws and wage standards. Clear regulatory guidance will also encourage organizations to adopt blockchain-BI systems without fear of legal uncertainty. From an ethical and organizational governance perspective, companies should adopt transparent HR analytics practices that align with organizational behavior theories of trust and equity. The review confirmed that employee perceptions of fairness in pay distribution and benefits allocation significantly influence morale, retention, and organizational legitimacy. Blockchain-enabled BI dashboards should be designed to allow employees verifiable access to their payroll histories, benefits records, and compensation benchmarking, thereby reinforcing fairness and accountability. However, to balance transparency with privacy, organizations should implement selective disclosure techniques, encrypting sensitive personal attributes while maintaining verifiable payroll audit trails. Establishing ethical governance committees within organizations can further ensure that payroll innovations do not compromise employee rights or exacerbate inequalities.

A further recommendation is for organizations to explore the convergence of blockchain with IoT and digital twin technologies for enhanced workforce monitoring and simulation. The literature demonstrated that IoT devices improve attendance and safety verification, while digital twins allow simulation of compensation scenarios. By securing IoT data streams through blockchain and analyzing them with BI, organizations can build predictive payroll systems that respond dynamically to real-time workforce conditions. This convergence is particularly valuable in high-risk industries such as petroleum and power, where hazard pay, overtime, and safety-related compensation require transparent, verifiable, and timely adjustments. Companies should pilot such integrated frameworks in specific departments before scaling across the organization to manage complexity and ensure adoption. Finally, scholars and researchers are encouraged to address interdisciplinary gaps linking technology, governance, and workforce data security. While blockchain, BI, and AI have been studied extensively in isolation, integrated research that bridges reliability engineering, organizational behavior, and HRIS remains limited. Future studies should focus on developing unified theoretical frameworks that capture the technical, ethical, and managerial dimensions of secure payroll governance. Longitudinal studies and sector-specific comparative analyses are particularly needed to assess the sustainability, scalability, and employee acceptance of blockchain-enabled BI systems over time. Collaborative research between academia, industry, and regulatory bodies will also be critical in developing best practices that advance both theoretical knowledge and practical applications. In conclusion, the recommendations emphasize the need for organizations to integrate blockchain with BI for secure payroll, regulators to harmonize frameworks across jurisdictions, and scholars to bridge disciplinary divides. By acting on these recommendations, stakeholders can address persistent vulnerabilities in HR and payroll systems while fostering transparent, secure, and equitable workforce data governance.

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