DEPLOYMENT OF RFID-ENABLED DIGITAL SYSTEMS FOR ENHANCED BOOK TRACKING AND INVENTORY MANAGEMENT IN FEDERAL UNIVERSITY LIBRARIES IN NIGERIA

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Abstract

This study examined the deployment of radio frequency identification (RFID)-enabled digital systems for book tracking and inventory management in selected federal university libraries in Nigeria. A descriptive survey design was adopted. The population comprised 120 professional librarians in six selected federal university libraries, one from each geopolitical zone, and all were included through census sampling. A structured online questionnaire, validated by specialists in Library and Information Science, produced a Cronbach's alpha coefficient of 0.76. Of the 120 questionnaires administered, 114 were completed, representing a 95% response rate. Descriptive statistics and Pearson Product-Moment Correlation were used for analysis at the 0.05 significance level. The findings indicated that core RFID facilities were generally available (grand mean = 2.93), utilization was high (grand mean = 3.11), and respondents perceived RFID as effective for book tracking and inventory management (grand mean = 3.26). Librarians also reported a generally adequate level of competence (grand mean = 2.93), although weaknesses were evident in system integration, maintenance, and fault diagnosis. RFID utilization had a strong positive relationship with perceived effectiveness ($r = .617$, $p < .001$). The study concludes that RFID can improve circulation speed, inventory accuracy, collection security, and resource discoverability when supported by reliable infrastructure, sustained funding, technical training, and maintenance arrangements. It recommends phased infrastructure renewal, continuous staff development, performance monitoring, and stronger institutional policies for sustainable RFID deployment.

Keywords: *RFID; book tracking; inventory management; university libraries; librarians' competence; Nigeria*

Introduction

Academic libraries are increasingly expected to provide rapid, dependable and technology-mediated access to information while managing growing hybrid collections and changing patterns of scholarly communication. This expectation has moved automation beyond the computerisation of catalogues and circulation records toward interconnected systems that can identify resources, support self-service and generate operational intelligence. Within the broader development of smart library services, technologies are valuable when they improve accessibility, responsiveness and the quality of users' experiences rather than merely replacing manual routines with electronic ones (Hamad et al., 2023). Consequently, university libraries must evaluate not only whether a digital technology has been installed, but also whether it is available at the points where work occurs, regularly utilised by staff and capable of producing measurable service improvements.

Radio Frequency Identification (RFID) is one of the digital technologies adopted to strengthen the physical management of library collections. An RFID system ordinarily consists of electronically encoded tags attached to library materials, readers or antennas that capture tag data through radio waves, middleware that interprets and transfers the data, and library management software that connects identification events to bibliographic and circulation records. Unlike conventional barcode systems, RFID does not always require direct line-of-sight scanning and can identify several tagged items in a short period. These characteristics make the technology suitable for circulation, shelf reading, stock verification, item identification and security-related operations in libraries (Dadhich, 2020).

The practical importance of RFID lies in the integration of several routine functions within a common technological environment. Staff-assisted or self-service borrowing and return can be completed more quickly; handheld readers can support shelf searching and inventory exercises; and security gates can detect materials that have not been properly issued. When these components are correctly configured and linked to the library management system, they may reduce repetitive scanning, improve the visibility of collection movements and permit librarians to devote more attention to reference, research support and other professional services. The contribution of RFID therefore depends on the coordinated deployment and use of tags, workstations, readers, gates, self-service units and the software interfaces through which transactions are authenticated and recorded (Velmurugan, 2024).

RFID should also be understood as part of a wider smart-library infrastructure rather than as an isolated piece of equipment. Its data may interact with catalogues, circulation databases, institutional networks, cloud services and emerging Internet of Things applications. Such connectivity can support real-time monitoring and more informed management, but it also creates technical demands relating to network stability, device compatibility, data exchange and system maintenance. Contemporary smart-library architecture consequently requires careful integration of sensing devices, communication networks and software-defined controls so that services remain scalable, secure and manageable as institutional needs change (Xu et al., 2024). A library may possess RFID hardware and still realise limited value if the system is poorly integrated, intermittently available or used only for a narrow range of tasks.

The collection and transmission of item and transaction data raise equally important ethical and governance questions. Although tags are generally intended to identify materials rather than individuals, transaction histories or linked databases may allow reading behaviour to be inferred when safeguards are weak. Libraries must therefore apply data minimisation, appropriate access controls, secure system configuration, retention limits and transparent communication with users. They must also assess vendor practices and ensure that confidentiality obligations extend across the complete RFID environment. Professional guidance emphasises that the efficiency associated with RFID must not compromise intellectual freedom, privacy or the confidentiality traditionally protected by libraries (American Library Association, n.d.).

Successful adoption is further shaped by organisational capacity. Reliable electricity and connectivity, adequate budgets, responsive technical support, staff competence, leadership commitment and clear implementation policies influence whether RFID becomes embedded in daily work. Librarians require more than an introductory orientation: they need continuing skills in operating readers and workstations, resolving common errors, interpreting system reports, protecting data and communicating effectively with vendors and institutional information-technology units. Research on connected technologies in university libraries shows that infrastructural limitations, security concerns, skill gaps and weak planning can impede adoption even

when the anticipated operational benefits are widely recognised (Shahzad et al., 2024).

These issues are particularly relevant to Nigerian federal university libraries, where expanding enrolment, substantial print collections and demands for accountable service delivery coexist with uneven funding and infrastructure. RFID has the potential to improve collection control and reduce the time required for circulation and inventory, yet its contribution cannot be assumed from procurement or installation alone. Recent Nigerian scholarship has drawn attention to the value of smart inventory systems while also underscoring the need for institutional readiness, sustainable investment and staff development (Awoyemi, 2025). Against this background, the present study examines the availability and utilisation of RFID facilities, their perceived effectiveness for book tracking and inventory management, and librarians' competence in managing RFID-enabled digital systems in selected federal university libraries in Nigeria. It also determines the relationship between RFID utilisation and the effectiveness of book tracking and inventory management, thereby providing evidence for decisions about technology investment, training and service improvement.

Problem Statement

The deployment of RFID-enabled digital systems offers significant advantages for academic libraries, particularly in enhancing book tracking, improving inventory management, and increasing operational efficiency. However, many federal university libraries in Nigeria still rely on traditional systems such as barcode technology and manual inventory processes, which are often inefficient, time-consuming, and prone to errors. These limitations can lead to inaccurate inventory records, misplaced materials, and reduced access to library resources. Despite the growing demand for efficient and technology-driven library services, the level of RFID deployment in federal university libraries remains inconsistent across regions. Factors such as inadequate funding, lack of technical expertise, and insufficient institutional support have hindered widespread adoption. This study therefore seeks to examine the deployment of RFID-enabled digital systems across selected federal universities in Nigeria and assess their effectiveness in enhancing book tracking and inventory management. The findings will provide insights into existing gaps and inform strategies for improving digital library systems nationwide.

Objectives of the Study

The following objectives guided the study:

1. identify the types of RFID-enabled facilities available in selected federal university libraries in Nigeria;
2. examine the extent of utilization of RFID-enabled systems for book tracking and inventory management;
3. assess librarians' competence in managing RFID-enabled digital systems.

Research Hypothesis

The following null hypothesis was tested at the 0.05 level of significance:

H_0: There is no significant relationship between the utilization of RFID-enabled digital systems and the effectiveness of book tracking and inventory management in federal university libraries in Nigeria.

Literature Review

RFID-enabled library management is founded on automatic identification and data-capture principles. Each tagged item carries a unique identifier that can be read and matched with a bibliographic record, allowing the system to establish what the item is, where a transaction occurred and whether its circulation status is valid. In comparison with barcode and magnetic-strip arrangements, RFID can combine identification, circulation and security functions while enabling multiple-item reading. Experimental and operational assessments have associated this capability with faster stock counting, improved item-location processes and more efficient passage through service points (Huang & Huang, 2019). Nevertheless, these benefits

are contingent on accurate tagging, complete database records and dependable communication between readers and the integrated library system.

Inventory management represents one of the clearest applications of RFID because traditional stocktaking is labour-intensive and may require books to be individually handled or removed from shelves. A handheld RFID reader can scan shelf ranges, identify items recorded in an incorrect sequence and assist staff in locating materials reported as missing. However, a scan is not automatically complete or error-free. Tag placement, the physical position of a book, interference from surrounding materials, reader orientation and the number of scanning passes can affect whether a tag is detected. Evidence from RFID-wand inventory work indicates that placing tags close to the spine and repeating scans can improve read rates, demonstrating that procedural consistency and equipment calibration remain essential to reliable inventory outcomes (Abcouwer & van Loon, 2021).

At the circulation desk, RFID can shorten repetitive processes by reading a stack of materials and updating their loan status within a single workflow. Self-check units may extend service capacity and give users greater control over borrowing and return, while automated return or sorting components can reduce queues and routine staff handling. Security gates can simultaneously verify whether items leaving the library have been properly issued. A case study of RFID application in a special library found that the technology supported circulation, stock verification and security functions, although effective operation required appropriate infrastructure, training and maintenance (Nisha, 2018). Thus, service speed should be assessed together with accuracy, equipment availability, downtime and the ability of staff to respond when transactions fail.

The value of RFID is also influenced by the people who use it. Librarians' competence affects transaction accuracy, troubleshooting, report interpretation and user assistance, while patrons' perceptions of usefulness and ease of use influence acceptance of self-service facilities. Where staff do not understand system workflows, faults may be attributed to the technology, equipment may be underused and parallel manual procedures may persist. A broad investigation of RFID systems in libraries showed that perceived usefulness and ease of use are important to user satisfaction and behavioural intention, linking technical performance with human acceptance (Dwivedi et al., 2013). Continuous training should therefore include practical operation, exception handling, privacy awareness and periodic refresher support rather than a one-time vendor demonstration.

Implementation costs and organisational sustainability remain prominent concerns. Libraries must finance tags, conversion workstations, fixed and handheld readers, security gates, self-service machines, middleware, software integration and replacement parts. Recurring expenditure may include licences, maintenance contracts, equipment upgrades and staff development. Technical challenges can also arise from inconsistent standards, vendor dependence, damaged tags and incomplete interoperability with existing library systems. An assessment of RFID applications and challenges in libraries identified cost, standards, privacy and technical limitations as issues that must be balanced against improvements in circulation, security and stock management (Singh & Mahajan, 2014). A credible deployment strategy must therefore consider total cost of ownership and service continuity, not merely the initial purchase price.

Within Nigerian universities, RFID adoption occurs in an environment where libraries are simultaneously pursuing automation, digital access and more responsive physical services. Institutional differences in funding, electricity supply, network reliability, collection size and information-technology support may produce substantial variation in both availability and utilisation. Nigerian research on Internet of Things applications in

university libraries suggests that connected systems can improve resource monitoring and service delivery but require dependable infrastructure, skilled personnel and sustained administrative support (Victor et al., 2025). These conditions imply that possession of RFID facilities should be distinguished from consistent operational use across circulation, inventory, security and tracking activities.

Collection security is another reason libraries adopt RFID. The technology can combine item identification with an electronic security status, enabling exit gates to signal when a material has not been correctly discharged. It may also improve accountability by creating timely records of circulation actions and helping staff trace items whose shelf and catalogue status do not agree. Early analyses of RFID in libraries nevertheless cautioned that effective security depends on appropriate system design, institutional policy and awareness of privacy implications (Shahid, 2005). RFID should consequently be treated as one layer of collection protection alongside staff procedures, access control, accurate records and regular audits.

The literature generally associates RFID with faster circulation, improved inventory, better shelf control and stronger collection security, but it also shows that outcomes vary with technical quality, staff competence, organisational support and patterns of actual use. Much of the available work describes applications or reports implementation experiences, while fewer studies jointly examine facility availability, extent of utilisation, perceived effectiveness for book tracking and inventory management, and librarians' competence within federal university libraries. There is also a need to distinguish association from causation: a correlation between utilisation and effectiveness can indicate that the variables move together, but it cannot establish that utilisation alone produces the observed effectiveness. The present study addresses this gap by providing a multi-institutional assessment and by determining the relationship between RFID utilisation and perceived effectiveness without making causal claims.

Methodology

The study adopted a descriptive survey research design to examine the deployment and utilization of RFID-enabled digital systems without manipulating the variables. The design was appropriate because it facilitated the collection of data from a large group of respondents at a single point in time and provided an overview of prevailing knowledge, perceptions, and practices. The population comprised 120 professional librarians from six selected federal university libraries. Given the manageable population size, the study adopted a census sampling technique, involving all 120 librarians and ensuring comprehensive representation of the study population. However, 114 librarians completed and returned the questionnaire, and their responses were used for the analysis.

Data were collected using a structured online questionnaire developed in accordance with the study objectives. The instrument covered respondents' demographic characteristics, availability and extent of utilization of RFID facilities, effectiveness of RFID in book tracking and inventory management, and librarians' competence in managing RFID-enabled digital systems. The items were rated on a four-point Likert scale ranging from Strongly Agree (4) to Strongly Disagree (1), with no neutral option to encourage definite responses. Experts in Library and Information Science and related disciplines validated the instrument by assessing the clarity, relevance, and alignment of the items with the study objectives. A pilot study was conducted among 30 librarians who were excluded from the main study. Using Cronbach's Alpha, a reliability coefficient of 0.76 was obtained, indicating acceptable internal consistency.

The questionnaire was administered electronically through Google Forms, while the survey link was distributed through professional WhatsApp platforms of the Nigerian Library Association. This method

enhanced accessibility and enabled librarians from the selected university libraries to participate irrespective of their locations. Participation was voluntary, and respondents were informed about the purpose of the study, assured of the confidentiality of their responses, and notified of their right to withdraw at any stage. Data were analysed using descriptive and inferential statistics. Frequencies, percentages, mean scores, and standard deviations were used to summarise the data and answer the research questions, while Pearson Product–Moment Correlation (PPMC) was used to determine the relationship between RFID utilization and the effectiveness of book tracking and inventory management. The hypothesis was tested at the 0.05 level of significance, and the results were presented in tables for clarity and ease of interpretation.

The results are presented directly according to the four objectives; the research questions are not restated in the results section.

Presentation and Analysis of Results

This section presents the findings in the order of the study objectives. A criterion mean of 2.50 was used for decisions on the four-point scale: an item with a mean of 2.50 or above was accepted as available, utilized, effective, or competent, as applicable, while a mean below 2.50 was interpreted otherwise.

Table 1. Questionnaire response rate

Response status	Frequency	Percentage (%)
Completed and returned	114	95.0
Not returned	6	5.0
Total administered	120	100.0

Table 1 shows that 114 of the 120 professional librarians included in the census completed the questionnaire, yielding a response rate of 95%. The return rate was considered adequate for the descriptive and correlational analyses.

Table 2. Availability of RFID-enabled facilities

RFID facility	Mean	SD	Decision
RFID tags attached to library materials	3.42	0.66	Available
Fixed RFID readers	3.25	0.71	Available
Self-checkout stations	2.84	0.82	Available
Automated book-return stations	2.69	0.87	Available
RFID security gates	3.18	0.75	Available
Handheld RFID readers	2.73	0.84	Available
RFID-enabled staff workstations	3.05	0.77	Available
Shelf-reading or shelf-management devices	2.61	0.86	Available
RFID-integrated library management software	3.21	0.72	Available
Automated sorting equipment	2.34	0.91	Not available
Grand mean	2.93	0.79	Available

The grand mean of 2.93 indicates that RFID facilities were generally available in the selected libraries. RFID tags, fixed readers, integrated management software, and security gates

recorded the highest mean scores, suggesting that deployment concentrated on foundational circulation and security functions. Automated sorting equipment recorded the only mean below the criterion value (M = 2.34), while shelf-reading devices and automated return stations were only moderately available. The pattern implies partial rather than fully integrated automation: basic identification and transaction tools were more common than advanced workflow equipment.

Table 3. Extent of utilization of RFID-enabled systems

Use of RFID system	Mean	SD	Decision
Identifying tagged library materials	3.31	0.68	High
Checking materials in and out	3.38	0.64	High
Conducting stock verification	3.16	0.72	High
Locating misplaced materials	2.92	0.78	High
Detecting unauthorized removal	3.24	0.70	High
Updating inventory records	3.08	0.74	High
Processing returned materials	3.27	0.67	High
Identifying missing items	2.95	0.79	High
Monitoring movement of materials	3.02	0.76	High
Scanning multiple items simultaneously	2.78	0.83	High
Grand mean	3.11	0.73	High

Table 3 reveals a high overall utilization level (grand mean = 3.11). RFID was used most extensively for check-in and check-out, identifying tagged materials, processing returns, and detecting unauthorized removal. Utilization was comparatively lower for simultaneous scanning and locating or identifying missing materials. These differences are consistent with the availability results: routine circulation functions can operate with tags, readers, and integrated software, whereas comprehensive shelf control may require handheld readers, reliable tagging coverage, calibrated reading ranges, and well-maintained database records.

Table 4. Perceived effectiveness of RFID for tracking and inventory

Effectiveness indicator	Mean	SD	Decision
Reduces time required for stock verification	3.39	0.64	Effective
Improves inventory accuracy	3.31	0.68	Effective
Supports the location of misplaced books	3.18	0.73	Effective
Reduces circulation-record errors	3.24	0.70	Effective
Strengthens collection security	3.28	0.69	Effective
Enables simultaneous scanning of items	3.36	0.65	Effective
Improves monitoring of the physical collection	3.12	0.75	Effective
Assists in identifying missing materials	2.96	0.81	Effective
Speeds up borrowing and return transactions	3.41	0.62	Effective
Improves overall operational efficiency	3.35	0.66	Effective
Grand mean	3.26	0.69	Effective

The respondents perceived RFID to be effective across all ten indicators, with a grand mean of 3.26. The highest-rated outcomes were faster borrowing and return transactions, reduced stock-verification time, simultaneous scanning, and improved operational efficiency. Although identifying missing materials had the lowest mean, it remained above the criterion value. The findings suggest that RFID's value is most visible where it replaces repetitive, item-by-item procedures and creates faster links between physical materials and the library database.

Table 5. Librarians' competence in managing RFID-enabled systems

Competence indicator	Mean	SD	Decision
Operate fixed RFID readers	3.25	0.68	Competent
Program and attach RFID tags	3.08	0.74	Competent
Use handheld RFID readers	2.96	0.79	Competent
Manage self-checkout operations	3.17	0.71	Competent
Integrate RFID with library software	2.73	0.84	Competent
Diagnose minor system faults	2.58	0.88	Competent
Generate and interpret RFID reports	2.91	0.80	Competent
Carry out routine maintenance	2.49	0.92	Not competent
Assist users of RFID services	3.34	0.65	Competent
Apply privacy and security procedures	2.79	0.82	Competent
Grand mean	2.93	0.78	Competent

The grand mean of 2.93 indicates that librarians were generally competent in managing RFID-enabled systems. Their strongest areas were assisting users, operating fixed readers, and managing self-checkout services. Competence was weaker in system integration, fault diagnosis, privacy procedures, and maintenance. Routine maintenance was the only item below the criterion mean. This result distinguishes operational familiarity from deeper technical capability: staff may use the system effectively in everyday service without possessing the engineering or vendor-level skills needed to sustain it when failures occur.

Table 6. Relationship between the utilization of RFID-enabled digital systems and the effectiveness of book tracking and inventory management.

Relationship tested	N	r	p-value	Decision
utilization of RFID-enabled digital systems	114	.617	< .001	Reject H0
effectiveness of book tracking and inventory management.	114			

Since the p-value was less than .001, which is below the 0.05 level of significance, the null hypothesis was rejected. This indicates a statistically significant positive relationship between the utilization of RFID-enabled digital systems and the effectiveness of book tracking and inventory management.

Discussion of Findings

Availability and deployment pattern

The study found that core RFID facilities were generally available, particularly tags, fixed readers, security gates, workstations, and integrated library management software. The comparatively low availability of automated sorting equipment and the moderate availability of shelf-reading and return devices indicate that deployment was uneven across the RFID service chain. This finding supports Dadhich's (2020) observation that RFID installations commonly begin with circulation, identification, and security components because they provide immediate operational benefits, while advanced infrastructure is constrained by cost. It also aligns with Awoyemi's (2025) argument that Nigerian academic libraries require strategic investment in smart inventory systems, but face financial, technological, personnel, and cybersecurity limitations.

The practical implication is that the presence of tags and gates should not be treated as evidence of complete RFID transformation. A mature system requires interoperable readers, reliable connectivity and power, software integration, accurate bibliographic records, maintenance support, and sufficient tagging coverage. Where these elements are absent, libraries may operate a hybrid arrangement in which RFID accelerates circulation but manual procedures remain necessary for shelf management, exception handling, and periodic inventory reconciliation. Phased deployment is reasonable, but each phase should be tied to measurable service outcomes and a funded plan for system completion.

Extent of RFID utilization

RFID utilization was high overall and was strongest in routine transaction and security functions. This result is consistent with Velmurugan (2024), who identifies circulation, returns, inventory monitoring, and theft control as central applications of RFID in library and information services. It also corresponds with the implementation reported by Victor, Boyinbode, and Oyelade (2025), where an RFID-integrated Internet of Things library system supported automated borrowing, returns, tracking, and inventory functions and received favourable assessments from users and staff. The present pattern suggests that librarians are more likely to use functions that are embedded in everyday workflows and supported by stable equipment.

Lower utilization of simultaneous scanning, misplaced-item location, and missing-item identification may reflect limited handheld readers, incomplete tagging, weak shelf-management modules, or staff uncertainty about advanced features. Utilization therefore needs to be understood as multidimensional rather than as a simple yes-or-no condition. A library may report that RFID is in use while applying only a fraction of its capabilities. Regular usage audits should measure which modules are active, how frequently they are used, error rates, downtime, transaction time, stock-verification duration, and the proportion of the collection covered by functional tags.

Librarians' competence

Librarians were generally competent in day-to-day RFID operations, especially reader use, user assistance, tagging, and self-checkout management. Their lower ratings for maintenance, fault diagnosis, integration, and privacy procedures reveal an important capacity gap. RFID competence is layered: frontline proficiency concerns routine transactions, while advanced competence involves systems integration, database administration, radio-frequency troubleshooting, data protection, vendor management, and lifecycle maintenance. Libraries that depend entirely on vendors for the latter functions may experience prolonged downtime, escalating support costs, and difficulty adapting the system to local workflows.

The competence result reinforces the need for role-specific professional development. General demonstrations at the point of

installation are insufficient. Circulation staff require operational training; systems librarians require deeper instruction in configuration, interoperability, data quality, security, and diagnostics; and managers require competence in procurement, service-level agreements, performance indicators, risk management, and replacement planning. Training should include practical assessment and periodic refresher sessions, particularly after software upgrades or equipment changes.

Conclusion

RFID-enabled digital systems have considerable potential to improve book tracking and inventory management in federal university libraries in Nigeria. The findings revealed a deployment pattern centred on RFID tags, readers, security gates, workstations, and integrated software, while advanced sorting and shelf-management equipment were less available. Utilization was high in routine circulation and security operations, and RFID was perceived as effective in accelerating transactions, reducing inventory time, strengthening collection security, and improving operational efficiency. A strong positive relationship was found between RFID utilization and perceived effectiveness; however, the correlational design does not permit causal conclusions. Librarians demonstrated adequate operational competence but required stronger capabilities in system maintenance, fault diagnosis, integration, privacy protection, and cybersecurity.

Sustainable RFID transformation therefore involves more than purchasing hardware. It requires complete workflow design, reliable supporting infrastructure, accurate data, trained personnel, maintenance funding, accountable governance, and continuous evaluation. Federal universities should treat RFID as a long-term service system whose value depends on the alignment of technology, people, processes, and institutional support.

Recommendations

Based on the findings of the study, rhe following recommendations were made:

1) Federal university management should adopt phased, costed RFID development plans that move beyond tags and security gates to include adequate handheld readers, shelf-management tools, automated returns, and sorting equipment where collection size justifies them.

2) Libraries should institutionalize role-based training and certification covering routine operations, tag programming, system integration, troubleshooting, privacy, cybersecurity, reporting, and preventive maintenance.

3) Dedicated annual budget lines should cover software licences, replacement tags and readers, spare parts, power backup, connectivity, maintenance contracts, and periodic upgrades.

4) RFID systems should be integrated with the library management system through tested standards and documented procedures so that circulation, inventory, and exception records remain synchronized and auditable.

5) Libraries should establish performance dashboards using indicators such as transaction time, inventory duration, missing-item rate, false alarms, equipment downtime, user satisfaction, and percentage of the collection with functional tags.

Limitations of the Study and Suggestions for Further Research

The descriptive survey design captured respondents' reports at a single point in time and could not establish causal direction among the variables. The study relied on librarians' perceptions rather than direct observation, RFID transaction logs, service-time measurements, inventory discrepancy records, downtime reports, or equipment audits. Consequently, common-method and social-desirability biases may have influenced the estimates. Although the inclusion of six federal university libraries provided geopolitical coverage, the institutions were not analysed separately, thereby limiting the assessment of contextual differences in funding, collection size,

infrastructure, staffing, vendor platforms, and technological capacity. The findings should therefore be interpreted within the scope of the participating libraries and generalized with caution.

However, future studies should use verified field data and combine questionnaires with interviews, observation, RFID transaction logs, downtime records, and inventory discrepancy measures. Longitudinal or quasi-experimental designs could compare service indicators before and after deployment and thereby provide stronger evidence about outcomes. Comparative research should examine differences among geopolitical zones, older and newer universities, collection sizes, vendor platforms, and levels of institutional funding. Studies should also investigate users' experiences of self-service, the privacy and cybersecurity implications of RFID data, total cost of ownership, interoperability with library management systems, and the environmental sustainability of tags and obsolete equipment.

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