

Enhancing Privacy in eGovernment: A Scoping Review of Data Minimization Techniques

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ABSTRACT

The protection of personal data collected by e-government services plays an important role in balancing privacy and personalization establishing user trust, operational efficiency, and regulatory compliance. This scoping review investigates data minimization techniques used in personalized e-government services, identifying available techniques, and challenges. A key strategy for enhancing privacy involves limiting data collection and processing to what is only necessary for service delivery, particularly in e-government services. The scoping review, following the PRISMA ScR approach, addresses research questions on the current data minimization techniques in e-government services, their impact on personalization, challenges and barriers to implementation, and the perceived benefits from different stakeholders' perspectives. From the formulated research questions covering the objectives of this scoping review it identified 2408 documents using relevant search query statements from available academic databases, after conducting screening and eligibility checks, only 20 documents are included in this review. From the documents, only proportional logic and game theory data minimization technique is used in e-governance systems. The impacts of data minimization techniques to personalization, the barriers and challenges in the implementation of data minimization, and the perceived benefits from the major stakeholders of the e-government systems were identified from the covered documents. This review has provided insights as to the extent of studies which include aspects of data minimization application in various e-government systems. Findings provide direction to future research, policy formulation, and practice, emphasizing gaps and guiding future studies to a more comprehensive understanding of balancing privacy and personalization through data minimization in e-government services.

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1. INTRODUCTION

The protection of personal data being collected by e-government services systems is required, and balancing privacy and personalization is important in establishing user trust, enhancing operational efficiency, and meeting regulatory requirements. Community-level implementation gaps must be bridged to provide the appropriate services [1] with its challenges to ensure that privacy is not compromised, and personalization of services is not hindered. Users' hesitancy to provide data and are being processed through the various digital systems is one gap that needs to be addressed [2][3]. Critical factors in maintaining user trust in e-government services include strategies associated with differential privacy to reconcile privacy with service provision-to-utilization [4]. Transparency in the personalization process is needed to strengthen trust, particularly in politically sensitive contexts that influence perceptions of objectivity and fairness in provision of services [5]. This can be achieved by integrating citizen participation throughout the design and assessment stages [6].

Data minimization is a recognized strategy to emphasize privacy protection within personalized e-government services. This strategy entails limiting data collection and processing solely to those which are needed for service delivery, thereby mitigating the risks associated with data breaches and misuse [7]. The principles of privacy-by-design go well with this approach. Concentrating on the necessary data for service provision narrows the scope of data subject to protection and simplifying adherence to privacy requirements. This concept of open data sharing, where only required data is collected, minimizes the risk of unauthorized access [8].

E-government services can optimize their security resources by prioritizing the protection of smaller datasets through data minimization. This is particularly evident in non-traditional electronic datasets, where the collection of minimal data can avert unnecessary exposure of sensitive health information [9]. Public trust in electronic government initiatives is established by reducing data collection and contributing to meeting privacy obligations [8].

The personalization of eGovernment services represents a fundamental dimension of public administration, as governmental entities endeavor to deliver personalized digital services to their citizens. The deployment of personalized e-government services offers challenges pertaining to data privacy and security, thereby necessitating implementation of data minimization [2]. With the enhanced accessibility of personal data and the application of data analytics, governments facilitate the provision of personalized e-government services that cater to the distinct needs and preferences of individual citizens. This leads to improved service delivery and enhanced engagement of citizens [10]. Also, trust could predict usability in e-government systems [11]. Data minimization is a principle used to protect data that has become a strategy, where collection and processing are done exclusively to support the services provided by the system.

This scoping review aims to investigate available research on data minimization techniques used in personalized e-government services. It identifies best practices and potential challenges around the subject matter. The findings of the scoping review can significantly influence future research, policy, and practice. The review also highlights gaps in research areas, guiding future studies towards a more established body of knowledge. Specifically, this scoping review will answer the following research questions:

1. What data minimization techniques are currently used in e-government services?
2. How do these techniques impact the personalization of e-government services?
3. What are the challenges and barriers in implementing data in e-government services?
4. What are the perceived benefits of data minimization from the perspective of different stakeholders (e.g. citizens, government officials)?

2. RESEARCH METHOD

The scoping review follows the PRISMA-ScR model in providing a systematic and comprehensive approach as defined in reference [12]. Figure 1 below illustrates the review stages.

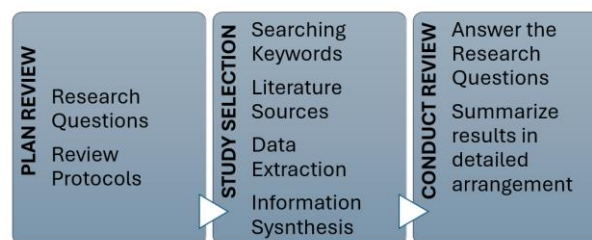


Figure 1. Review stages

The investigative process is generally divided into three distinct stages. In the initial planning stage, the activities of formulating research questions, developing, and validating review protocols are discussed. In the next phase, the author describes the technique of identification of applicable studies, collecting data, and merging information; and in the final phase, recording and reporting of the review is offered.

2.1. Plan Review

In the initial phase of the research methodology, the research questions and the formulation of review protocols are defined with the appropriate search strategies.

2.1.1 Research Questions

In this scoping review, four research questions have been formulated, and intended to be comprehensively addressed through the review.

1. RQ#1: What data minimization techniques are currently used in e-government services?
RQ1 seeks to identify the current state of practice in data minimization within e-government services and helps to evaluate the effectiveness of these techniques to offer a foundation for comparing and evaluating new or alternative methods. This aids in identifying gaps where new techniques could be developed or existing ones improved. This provides a baseline understanding of the existing landscape employed by e-government services to reduce data collection and processing.
2. RQ#2: How do these techniques impact the personalization of e-government services?
RQ2 aims to explore the balance between data minimization and the quality of personalized services in e-government. This aids in developing strategies that ensure high-quality personalization while maintaining privacy.
3. RQ#3: What are the challenges and barriers in implementing data minimization in e-government services?
RQ3 identifies the challenges and barriers in implementing data minimization within e-government services. Policymakers and practitioners can develop targeted solutions to facilitate smoother implementation of data minimization practices.
4. RQ#4: What are the perceived benefits of data minimization from the perspective of different stakeholders (e.g. citizens, government officials)?
RQ4 aims to gather insights and understand the benefits as perceived by citizens, who are concerned about privacy, and government officials, who are focused on service efficiency and compliance. This helps tailor strategies to address specific concerns and maximize the benefits for all involved.

2.1.2 Review Protocols

The comprehensive process of developing and subsequently validating the review protocol serves to underscore the critical importance of methodically searching for relevant academic articles, employing a carefully curated selection of appropriate keywords, in conjunction with thoroughly examining various literature sources that are pertinent to the subject matter under investigation.

2.1.3 Searching Keywords

To ensure that the review comprehensively addresses the subject of this review, an attempt to confine the search to the most significant search terms. It started with the identification of keywords, then did the following methodological steps:

- Identifying the principal distinct terms derived from our research questions.
- Employing variations of the terms.
- Refining search terms by incorporating keywords from scholarly articles.

This review also utilized the primary search and integrated the “OR operator” and “AND operator” to maximize the retrieval of directly relevant literature, as illustrated in Table 1.

Table 1. Inclusion and exclusion criteria description

Item	Search Query Statements
1	((("data minimization" OR "data reduction") AND ("e-government" OR "electronic government") AND ("personalization" OR "customization") AND ("public services"))
2	((("data minimization" OR "data reduction") AND ("e-government" OR "electronic government") AND ("privacy" OR "data protection") AND ("public services"))
3	((("data minimization" OR "data reduction") AND ("personalization" OR "customization") AND ("privacy" OR "data protection") AND ("public services"))
4	((("e-government" OR "electronic government") AND ("personalization" OR "customization") AND ("privacy" OR "data protection") AND ("public services"))
5	"data minimization" AND "e-government" AND "personalization" AND "privacy"
6	"data minimization" AND "e-government" AND "personalization" AND "data protection"
7	"data minimization" AND "e-government" AND "personalization" AND "public services"
8	"data minimization" AND "e-government" AND "privacy" AND "data protection"
9	"data minimization" AND "e-government" AND "privacy" AND "public services"
10	"data minimization" AND "e-government" AND "data protection" AND "public services"
11	"data minimization" AND "personalization" AND "privacy" AND "data protection"
12	"data minimization" AND "personalization" AND "privacy" AND "public services"
13	"data minimization" AND "personalization" AND "data protection" AND "public services"
14	"data minimization" AND "privacy" AND "data protection" AND "public services"
15	"e-government" AND "personalization" AND "privacy" AND "data protection"
16	"e-government" AND "personalization" AND "privacy" AND "public services"
17	"e-government" AND "personalization" AND "data protection" AND "public services"
18	"e-government" AND "privacy" AND "data protection" AND "public services"
19	"personalization" AND "privacy" AND "data protection" AND "public services"
20	("data minimization" AND "e-government" AND "data protection" AND "public services") OR ("data minimization" AND "personalization" AND "privacy" AND "data protection")
21	("data minimization" AND "e-government" AND "privacy" AND "data protection") OR ("data minimization" AND "e-government" AND "privacy" AND "public services")

Item	Search Query Statements
22	("data minimization" AND "personalization" AND "privacy" AND "public services") OR ("data minimization" AND "personalization" AND "data protection" AND "public services")
23	("data minimization" AND "privacy" AND "data protection" AND "public services") OR ("e-government" AND "personalization" AND "privacy" AND "data protection")
24	("e-government" AND "personalization" AND "privacy" AND "public services") OR ("e-government" AND "personalization" AND "data protection" AND "public services")
24	("e-government" AND "privacy" AND "data protection" AND "public services") OR ("personalization" AND "privacy" AND "data protection" AND "public services"))
25	"data minimization" AND "e-government" AND "personalization" AND "privacy"
26	"data minimization" AND "e-government" AND "personalization" AND "data protection"
27	"data minimization" AND "e-government" AND "personalization" AND "public services"
28	"data minimization" AND "e-government" AND "privacy" AND "data protection"
29	"data minimization" AND "e-government" AND "privacy" AND "public services"
30	"data minimization" AND "e-government" AND "data protection" AND "public services"
31	"data minimization" AND "personalization" AND "privacy" AND "data protection"
32	"data minimization" AND "personalization" AND "privacy" AND "public services"
33	"data minimization" AND "personalization" AND "data protection" AND "public services"
34	"data minimization" AND "privacy" AND "data protection" AND "public services"
35	"e-government" AND "personalization" AND "privacy" AND "data protection"
36	"e-government" AND "personalization" AND "privacy" AND "public services"
37	"e-government" AND "personalization" AND "data protection" AND "public services"
38	"e-government" AND "privacy" AND "data protection" AND "public services"
39	"personalization" AND "privacy" AND "data protection" AND "public services"
40	((("data minimization" OR "data reduction") AND ("e-government" OR "electronic government") AND ("personalization" OR "customization") AND ("public services"))

2.1.4 Literature Resources

The chosen databases for finding support articles include the Web of Science, Scopus, ACM Digital Library, PubMed, Science Direct, IEEE CSDL, and IEEE Explorer. These databases exhibit extensive coverage of high-quality articles, notably those indexed by ISI and Scopus. The search terminology was formulated using the advanced search functionalities offered by each of these databases. The search encompassed the timeframe from 2011 to 2024.

Table 2. Inclusion and exclusion criteria descriptions

(a) Inclusion Criteria
Studies that specifically address data minimization techniques in the context of e-government services.
Research explores the balance between data minimization and personalization in e-government services.
Papers discussing the challenges and barriers to implementing data minimization in e-government services.
Studies that provide insights into the perceived benefits of data minimization from the perspective of different stakeholders
Peer-reviewed journal articles, conference papers, and official reports.
Systematic reviews, meta-analysis, and scoping reviews related to data minimization in e-government services.
Studies published between 2014 and 2024 to ensure the review includes the most recent and relevant research.
Studies published in English.
Research conducted in any geographical location
(b) Exclusion Criteria
Studies that do not specifically address data minimization techniques in the context of e-government services.
Research focuses solely on data minimization in private sector services or non-governmental contexts.
Papers that do not discuss the balance between data minimization and personalization, or the challenges and barriers to implementation in e-government services.
Non-peer-reviewed articles, opinion pieces, editorials, and blog posts.
Theses, dissertations, and unpublished manuscripts.
Studies were published before 2011.
Studies published in languages other than English.
Research that does not pertain to e-government services, even if it discusses data minimization.

2.2.1. Study Selection

The entire methodology regarding the selection of studies had initially included 2408 from the search results. Duplicate records were removed using the using the DOI as a unique identifier. A title-based evaluation was then conducted which resulted to 232 returned titles. Further assessment was done which eliminated articles that are not relevant to the research questions and yielded 118 articles. Lastly, only those which included data minimization in the e-governance were included and only 20 articles remained. These 20 articles satisfy the scoping subject of this review.

The inclusion criteria for this scoping review covered articles discussing data minimization techniques in the context of personalized e-government services from 2011 to 2024. The exclusion criteria include studies

not focused on e-government service, studies that do not discuss data minimization techniques, non-English publications, and editorials, opinion pieces and non-peer-reviewed articles.

Electronic databases were searched to identify relevant literature. A comprehensive search strategy using a combination of the keywords “data minimization”, “e-government”, “personalization”, “privacy”, “data protection”, and “public services”. A selection of sources of evidence was done which involved titles and abstract screening, and full-text review.

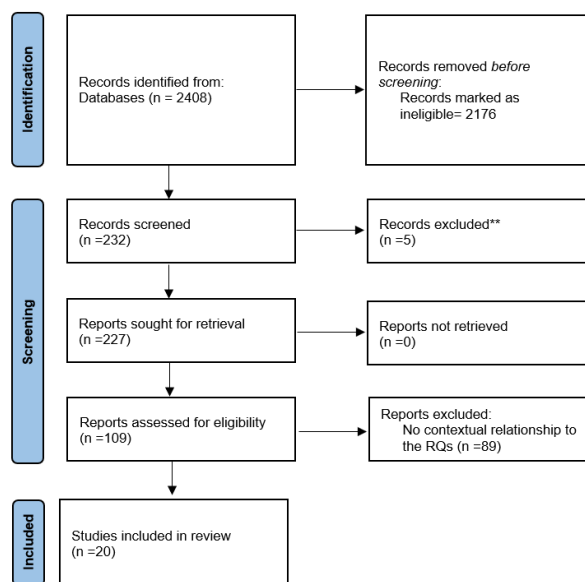


Figure 2. Process of identifying relevant studies

The articles included in the scoping review were primarily due to the close alignment with the key concern for the researcher, namely on data minimization techniques in the context of e-governance. Some of the works even dealt with the application of data minimization techniques such as the ones that dealt with administration-related forms. Such studies created models based on logic and game theory that would help in allowing data minimization but within an appropriate framework of informed consent of the users. Some studies have attempted to examine the extreme ends of data minimization as well as the extreme ends of personalization trying to use minimal personal data in providing tailored services. These studies brought out the need to harmonize data minimization and personalization and therefore cover relevant objectives within the review. Several studies have noted factors and constraints that tend to hinder the application of data minimization in e-governance. These included political factors such as instability issues, technology acceptance factors, infrastructural barriers, and the challenges that come with the shift from being document-to data-oriented in terms of public service delivery. Certain research papers did shed light on how different stakeholders, including citizens and government officials, perceive the benefits of data minimization. These perspectives from different stakeholders informed the review by providing the actual implications of data minimization in practice. Several studies have pinpointed the frameworks or models which guide such implementations within e-government services where minimization of data is required. Such studies described the necessity of architectures for data sharing that support principles of security and privacy such as ‘need-to-know’ and ‘trusted third parties’ access control management.

The studies excluded from the scoping review were mainly because they did not correspond to the theme of the emphasis placed on data minimization techniques as related to e-government service delivery. Numerous studies of this kind were concerned with other dimensions of digital government such as, the relation between human agency and technology efficiency, the role of internet tools in mobilizing citizens, and the role of blockchain in ensuring accountability and transparency. Other research reviewed the role of new technologies such as 5G on mobile government services, the NPG relevance to the implementation of block chain technology and the gap between the digital access of citizens and the services provided at a local government level. Some articles focused on the conceptualization of the challenges posed by GDPR in the context of public blockchains systems, formal methods in e-governance, and identity management in e-service delivery. Some studies were deleted from the review since they did not provide sufficient evidence on data minimization techniques or even data minimization frameworks. Other articles considered technologies in smart cities wherein researchers looked at data protection regulation in blockchain projects and the role of

digital assistants in providing government services which were out of the dimensions of data minimization in e-governance services.

2.2.2 Quality Check

Table 3 presents the quality assessment checklist questions utilized for the evaluation of the studies. These questions were primarily crafted to facilitate the selection process.

Table 3. Quality checklist questions

1.	Does the study have a direct focus on data minimization techniques?
2.	Has the study explored the balance between data minimization and personalization?
3.	Was there a discussion on challenges and barriers to implementation of data minimization?
4.	Is there insight into perceived benefits from the perspective of different stakeholders?

2.2.3 Data Extraction

To obtain data which are needed to address the research questions and contribution, the data-extraction methods are highlighted in Table 4 were used.

Table 4. Data extraction methods

Study Research Contributions
QR1: Data Minimization (DM) Techniques
RQ2: Impact of DM techniques to personalization of e-government services
RQ3: Challenges and barriers of DM implementation
RQ4: Benefits of DM to stakeholders

2.2.4 Information Synthesis

At this stage, the data that were extracted were aggregated to answer the research questions [13]. The narrative synthesis method was used; accordingly, tables were used to present results.

2.3. Conduct Review

Data extracted from the preliminary studies were used to answer the four research questions. The method used by Kumar et.al. [13] was followed.

3. RESULTS

The summary of selected studies is in the detailed arrangement as presented below. A total of 20 studies were included in the review. Of those, 1 study supports RQ1, 16 studies support RQ2, 8 studies support RQ3, and 9 studies support RQ4.

Table 5. Number of studies supporting the RQ

RQ	Studies
RQ1: Data Minimization (DM) Techniques	1
RQ2: Impact of DM techniques to personalization of e-government services	16
RQ3: Challenges and barriers of DM implementation	8
RQ4: Perceived benefits of DM to stakeholders	9

3.1. Data minimization techniques currently used in e-government services

Data minimization within e-government services constitutes a fundamental component of privacy protection. One methodology involves utilization of formal models based on propositional logic and game theory to address the primary challenge of data minimization, particularly concerning administrative documentation [14]. This system confirms that the important data is collected in accordance with privacy requirements like the European General Data Protection Regulation (GDPR). While implementation remains challenging due to concerns brought about by potential impacts on quality of data processing, and the complexities faced by developers, recent technological advancements have significantly improved methodologies, demonstrating that successful deployment of these formal models is increasingly achievable [15]. A practical method was used that minimized the volume of data collected by government entities while legal requirements of collection and processing are being complied in the French welfare benefits [16]. These methodologies demonstrate the efforts to harmonize data minimization and to provide efficient e-government services, thereby safeguarding the privacy of citizens while enhancing the services to citizens [17].

Table 6 below shows the data minimization techniques that were identified from the articles included in this review.

Table 6. Data minimization techniques

Data Minimization Technique Used	Study Reference
Propositional Logic and Game Theory	[14]

From the above table, only propositional logic and game theory was discussed considering the inclusion and exclusion criteria of this study. Other data minimization techniques (such as the formalism for data minimization objectives, informed consent mechanisms, feature selection model, learning curves examination, breadth-based and depth-based minimization, and audit methods using feature imputation) may be explored for appropriate data minimization techniques integration in various e-government services [18]. These additional techniques offer further research and development directions to enhance data minimization strategies beyond the currently discussed model, suggesting great opportunities for innovation and more comprehensive privacy protection.

3.2. Impacts of data minimization techniques to the personalization of e-government services

The personalization of digital services is influenced by methodologies that enhance user engagement and trust. Personalization provides e-government systems to modify and to align individual preferences and interests in service delivery. This increases engagement and trust. The integration of personalization within the e-government services also enables better-informed citizens while providing democratic processes engagement – expressing citizen opinions and decision-making [19]. The General Data Protection Regulation (GDPR) supports the data minimization and purpose limitations in personalization of e-government services by collecting only needed data to extend services without compromising privacy [20]. This approach aligns with the need to improve user experience through proportional application of personal data in provision of services [21]. The personalization of electronic government services is further enhanced by the improvement of system quality, which contributes to a more seamless and effective user experience [22].

These methodologies ensure that electronic government services are not only personalized but also secure and efficient, fostering increased trust and acceptance among users. The implementation of mobile technologies and frameworks such as the Single Digital Gateway and the eIDAS Regulation also plays an important role in the personalization of electronic government services by enabling cross-border data retrieval and user authentication, which promotes a more integrated and user-centric service delivery across the European Union[23].

Table 7 below shows the data minimization techniques' impact on personalization of e-government services.

Table 7. Impact of data minimization techniques to personalization of e-government services

Impact	Study Reference
Reduced Data Collection	[14], [20], [24], [25], [26], [27], [28], [29], [30], [31]
Enhanced Privacy and Trust	[14], [20], [24], [25], [32], [26], [33], [34], [35], [36], [27], [28], [37], [29], [30], [31]
Balancing Utility and Privacy	[14], [20], [24], [25], [32], [26], [33], [35], [36], [27], [28], [37], [29], [30], [31]
Potential for Reduced Personalization	[14], [20], [33], [34], [35], [36], [27], [37], [29], [30], [31]
Ethical Considerations and Fairness	[14], [20], [24], [32], [26], [33], [34], [35], [36], [27], [28], [37], [29], [30], [31], [38]
Improved Data Management	[14], [20], [24], [32], [26], [33], [34], [35], [36], [27], [28], [37], [29], [30], [31], [38]
Focus on Essential Personalization	[14], [20], [24], [25], [32], [26], [33], [34], [35], [27], [28], [38], [29], [30], [31]

The impacts of data minimization techniques to the personalization of e-government services, as identified from the considered academic articles, offers a shade of complex relationship between the two. It show that personalization in e-government is not only about tailoring services but support multiple critical functions which foster both user engagement and democartic participation. This suggests a dimension of civic empowerment to personalization and not simply a convenience factor.

3.3. Challenges and barriers in implementing data minimization in e-government services

Data processing within the e-government services has its challenges and barriers primarily attributable to different data and the complexities offered by integration. The disaggregation of open data, exhibited by differences in content, structure, format, and database technology hinders the formulation of meaningful insights regarding citizen issues [39]. This is further worsened by difficulties inherent in database harmonization which not only incur financial expenses but also introduce legal considerations which emphasize the need for data protection and security [40]. There is a lack of user-centric interface within the e-government platforms which makes it difficult for the average citizen to comprehend and participate in the governance

processes overwhelmed by complex terminology and bureaucratic procedures [39]. Several initiatives are restricted to experimental stage without producing tangible outcomes make the government service provider struggle in providing efficient technology solutions [41]. Concerns related to trust persist as citizens remain apprehensive about the utilization and management of their personal data [42]. These challenges highlight the importance of a comprehensive framework of data stewardship, which requires accountability for data governance, data management, and the assurance of data quality to support the efficient e-government services [41].

Table 8 below shows the different challenges and barriers as reported in the materials considered in this review.

Table 8. Challenges and barriers of data minimization implementation in e-government services

Challenges and Barriers	Study Reference
Accountability and Transparency	[27], [28], [32], [35], [43], [44]
Ethical Considerations	[27], [28], [32], [43], [44]
Human Marginalization	[27], [35], [43]
Complexity of Human-Machine Interaction	[27], [28], [31], [35], [37], [43], [45], [44]
Resistance to Change	[27], [28], [31], [35], [37], [43], [45]
Technological Optimism	[27], [28], [43]
Data Quality and Reliability	[27], [28], [31], [35], [43], [45], [44]
Data protection, privacy, security, and trust	[37]
Integration and interoperability	[37]

The challenges and barriers identified above show that implementation of data minimization in e-government services extend beyond technical issues, but it includes complex administrative, legal, and societal factors. These reveal that challenges are interconnected which create a multi-dimensional barrier to effective data stewardship. This complex undertaking requires a holistic approach that addresses data fragmentation, user-engagement, public trust, and strong governance frameworks.

3.4. Perceived benefits of data minimization from the perspective of different stakeholders

Data minimization offers benefits as perceived by stakeholders, covering the government, and consumers. One advantage is the reinforcement of privacy and security, as the practice of data minimization reduces the volume of personal data collected and retained, in turn mitigating the potential for data breaches and privacy infringements [14]. This aligns privacy regulations such as the General Data Protection Regulation (GDPR), necessitating the collection of only key data to safeguard users' privacy [14]. For consumers, the implementation of data minimization may offer enhanced autonomy and a more encouraging digital experience, as it limits likelihood of surveillance or profiling [32].

Table 9 below shows the benefits of data minimization from stakeholders' perspective.

Table 9. Perceived benefits of data minimization from stakeholders' perspective

Benefits	Study Reference
Citizens	
Enhanced Privacy and Trust	[14], [20], [26], [27], [29], [30], [31], [32], [35]
Reduced Risk of Data Breaches	[14], [20], [26], [27], [29], [30], [31], [32], [35]
Increased Autonomy	[14], [20], [26], [27], [29], [30], [31], [32], [35]
Government Officials	
Improved Data Management	[14], [20], [26], [27], [29], [30], [31], [32], [35]
Increased Public Trust	[14], [20], [26], [27], [29], [30], [31], [32], [35]
Ethical and Transparent Governance	[14], [20], [26], [27], [29], [30], [31], [32], [35]

Since data minimization generally enhances privacy and security, a deeper look of the above reveal distinct yet interconnected benefits by the two stakeholders – citizens and government officials. For the citizens, data minimization not only minimizes risks of data breach but also offers enhanced autonomy and encouraging user experience by limiting likelihood of surveillance and profiling. It directly contributes to increased trust by committing to safeguarding personal data. Government officials are offered operational efficiency and ethical governance suggesting a direction towards a more principled approach to public data handling – aligning with regulatory mandates such as the GDPR. Public trust is also increased leading to greater citizen cooperation and confidence in public services and institutions.

4. DISCUSSION

The findings of this scoping review highlight the critical role of data minimization in enhancing privacy protection within personalized e-government services. The review identifies various techniques,

impacts, challenges, and stakeholder perspectives, providing a comprehensive understanding of the current state of data minimization practices.

Data minimization is implemented primarily to establish a balance between privacy and personalization. This action plays an important role in providing services tailored to the preferences of the users and at the same time complying with the data protection and privacy requirements. Appropriate data minimization techniques are to be identified vis-à-vis the overall system applicability and considerations. This review has identified only one technique – the propositional logic and game theory. However, there are other available techniques of data minimization which can be considered for implementation.

The implementation of data minimization offers various impacts to provide personalization and privacy to users. Inherent to the e-government services, the principle of proportionality is applied and provides reduced data collection where only needed data is gathered for decision-making process in the e-government services. Data minimization assures users of enhanced privacy and trust where users are informed of methods of data handling, fostering a strong sense of security and confidence to use the system. In contrast, potential for reduced personalization can also be experienced, limiting the ability to fit services to individual needs affecting user experience. Limited data can be an outcome of data minimization and may lead to better data management. It also supports fairness and ethical considerations in e-government services as the implementation does not lead to discrimination or unfair treatment of users.

The implementation of data minimization is not free of challenges and barriers. Common to any initiative, resistance to change is seen to oppose the data minimization due established way of doing things. The adoption of new processes and technologies by public service employees and citizens offers challenges in managing organizational change emanating from change workflows which complicates the transition to data-centric systems. The integration of new processes, in this case data minimization, introduces complex challenges in responsibility seen in failure and error, requiring a clear framework for accountability to maintain trust in public services. The move towards data-centered systems requires high data quality and precision. Poor data quality hinders the effectiveness of e-government services. There also exists the risk of excluding digitally disadvantaged populations and equity issues with digital-first services leading to marginalization of certain groups when implementing e-government services. Challenges in ensuring that automated decisions are transparent and understandable to users offered by interactions between human and computers. Over-reliance on technology to solve public administration issues may lead to unrealistic expectations.

Users of e-government services, the subject of data minimization, are the government and the citizens. These two see the benefits from their perspectives of utilization. Citizens' perceived benefits include enhanced privacy and trust, increasing confidence in the system. Less sensitive information is at risk as less data is being collected. Citizens also benefit from increased autonomy as they have more power over their personal data and how it is used. Government officials also benefit from data minimization. Improved data management due to the streamlining of data collection processes. Increased public trust because constituents may feel secure knowing that their data is being handled with care. Data minimization aligns with privacy regulations and ethical standards as it strengthens ethical and transparent governance.

4.1. General Interpretation of Results

The review revealed that data minimization techniques such as propositional logic and game theory are effective means in reducing data collection and processing to enhance privacy. This technique aligns with the GDPR's data minimization principle, and the Philippines' RA 10173 proportionality principle that data collected are to be relevant, limited, and adequate to fulfill the intended purpose. The impact of techniques used is significant in providing balance between privacy and personalized services. Data minimization implementation may face challenges and barriers which include resistance to change that can be addressed with the practice of risk and change management. Diverse stakeholders see distinct benefits brought about by data minimization. The difference may be due to differing expectations of stakeholders – government, and citizens.

4.2. Limitation of the Evidence

One limitation of the evidence included in this review is the narrow focus on specific data minimization techniques. There may be other techniques that were not covered due to the scope of the review. Also, reliance limited on the materials identified may be extended to some practical insights from industry practices.

4.3. Limitations of the review process

The review process itself has limitations, which include potential for selection bias in the inclusion studies. While the search strategy may be comprehensive, it may have missed relevant studies due to the keywords and databases used. Earlier studies on data minimization may be considered.

4.4. Implications of the study

The current review offers significant implications for future research directions, policy, and practice in the field of e-government services which addresses the four key questions contributing to a better understanding of data minimization techniques and their impact on personalized e-government services.

1. The propositional logic and game theory was used to ensure compliance to privacy requirements such as the GDPR. It was identified as one of the data minimization techniques used in e-government services. The identified technique in this review may provide a foundation for comparing and evaluating new or alternative methods. It is encouraged to identify other data minimization techniques to provide implementation options in balancing privacy and personalization.

2. This review revealed techniques in data minimization can significantly impact personalization of e-government services. While data minimization techniques enhance privacy and trust by limiting data collection, it was emphasized that there are challenges in maintaining the quality of personalized services.

3. The review identified challenges and barriers to data minimization implementation including issues related to accountability, transparency, ethical considerations, and complexity of human-machine interactions. Challenges highlight the importance of a framework on data accountability, data management, and data quality.

4. Data minimization offers benefits as seen by the user and the government. Citizens perceive data minimization to provide enhance privacy, reduced data breach risks, and increased autonomy over personal data.

4.5. Future Research

Based on the finding of this review, several future research directions can be suggested:

1. Focus on the development of new data minimization techniques that can effectively be integrated into e-government services.
2. Comprehensive evaluations of the effectiveness of existing data minimization techniques can be a researchable area which can help identify strengths and weaknesses of different approaches.
3. Exploring balance between data minimization and the quality of personalized services can be explored.
4. Identification and addressing implementation of data minimization challenges may include solutions related to accountability, transparency, and ethical considerations.
5. Gather more in-depth insights into the perceived benefits of data minimization which may provide understanding to the strategies that can help to better meet the needs of the stakeholders.
6. Assessment of long-term effects of data minimization can provide valuable insights towards sustainability and effectiveness of data minimization practices.
7. Research focusing on policy and regulatory implications of data minimization in e-government services may be considered.

5. CONCLUSION

The findings of this review offer important implications for future research, policy, and practice. The identification of current techniques, their impacts, challenges, and stakeholder perspectives provided an overview of guiding future studies and informing the development of effective data minimization strategies used in e-government services. This contributes to a more established body of knowledge to support protection of privacy while offering personalized service delivery.

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