

International Journal of Modeling, Simulation, and Scientific Computing  
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## A Multivocal Literature Review on Records Management Potential Components in CRUD Operation for Web Application Development

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Received (Day Month Year)

Accepted (Day Month Year)

In recent years, web application frameworks have been widely practised by many developers to increase programming productivity as the framework are more flexible, rapidly built using CRUD operation, MVC-based, secure and most of them are published under an open-source license which will reduce the final cost of development. Although the CRUD automation in the web application framework boosts the development process, there are many important aspects of a web application absent from the CRUD output. Therefore, this multivocal literature review investigates the records management aspects that are required in modern WA and the perceived benefit of integrating the records management aspect into CRUD operation. The study extracted 284 publications from respectable scientific resources and the grey resources literature created by WA development practitioners outside academic mediums. After a detailed review process, only 14 scientific primary studies and 13 grey studies were considered for this review based on defined inclusion and exclusion criteria. The review shows that the most important aspect required in WA is search, role-based access control, retention, appraisal, search, audit trail, digital archiving, sharing, reporting, inactive files management and several other features. This important aspect has been analyzed and characterized according to its function and features. The method and procedure for integrating the specified aspect into CRUD operation are identified and discussed. Integrating and implementing the specified record management features into CRUD operation will boost the WA development productivity by producing more features as a standard output with integrated records management functions.

*Keywords:* multivocal literature review; web application development; CRUD; electronic record management; web framework.

### 1. Introduction

Web application (WA) development is a critical activity that supports heterogeneous functional aspects such as Create Read Update Delete (CRUD) operations, search, validation, authentication, authorization, internalization, debugging, testing and other function. The web application framework CRUD generator enables the developer to rapidly generate WA skeleton with fundamental functions and features. In regards to CRUD operation relevancy in WA development, equal at-

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tention should be given to potential features of electronic records that should be integrated into CRUD operation to provide more efficient features in WA. As a consequence, in recent years an increased interest has been observed in the WA framework and CRUD operation adoption in WA development. The adoption of the Web Application Framework (WAF) has unlocked new perspectives in terms of WA enrichment towards the development process and time, features, code organization, continuous integration, documentation, learning curve and many others,<sup>1,23</sup> Moreover, the advantages of WAF are the elegance of codes and the ability to minimize the risk of programming errors. WAF conforms to the Don't Repeat Yourself (DRY) principle where all programming logic is coded only once and promotes code re-use.<sup>4</sup> DRY principle prevents code duplication and error, which also facilitates easier maintenance of code and WA.

Generally, WAF focuses on rapid development, promotes code reusability and programming best practices which are great for developers that do not have enough knowledge or discipline to care about the quality of code. WAF has been widely practised by many developers to increase programming productivity as the framework are more flexible, allows rapid development, is MVC-based, secure and most of them are published under an open-source license, which will reduce the final cost of development,<sup>1,25</sup> Since 2000, there have been many open-source WAF that have been released to the public such as CakePHP, Laravel, CodeIgniter and others and most of the web application framework has built-in CRUD generator. The CRUD paradigm is common among WA development as it enables the developer to generate basic WA routine code to all functions such as create, read, update, delete objects and define how objects are related to each other in a WA,<sup>6,78</sup> CRUD enables the developer to create a quick-start application to work as the foundation of the WA solution,<sup>910</sup> Furthermore, CRUD is a very useful time-saver as it generates the skeleton codes for the WA, enables the developer to get faster output and can demonstrate the basic function (input, process and output) to the WA project stakeholder.<sup>11</sup>

Due to recent interest in WAF and CRUD in WA development, there have been several Systematic Literature Reviews (SLR) relating to WA development such as the SLR conducted by<sup>12</sup> that presents an overview of the web application testing or the SLR study performed by<sup>13</sup> that discuss on obstacles and important features of farm management information systems to identify the vital aspect of functions that should be available. There are also SLRs related to the scope of managing electronic health records access control and privilege management using electronic health records system,<sup>14</sup> security and privacy issues,<sup>1516</sup> that provides an overview of electronic records protection. However, there are no SLRs that provide an overview of records management potential components in CRUD operation for web-based record management application development. Therefore, a study was conducted to analyze potential records management features with the method to apply them to CRUD operation. The study was conducted as a type of SLR called Multivocal Literature Review (MLR) in which data from both scientific and grey literature

are included in the reviewing process,<sup>17,18</sup> The inclusion of grey literature can give substantial benefits in certain areas of WA development, features and challenges evidence based on the practitioners' experiences and opinions,<sup>17</sup> citealder2018a. A systematic procedure has been defined to perform MLRs based on the proposed best practices and guidelines,<sup>19,20,21</sup> and the methods together with the procedures of SLRs that take into account the grey literature,<sup>19,22,23</sup>

The contributions of this paper are i) identify records management potential aspect for CRUD operation and WA; ii) collect and analyze the functionality of the potential aspect; iii) classify the aspect based on functions and; iv) observe the perception of usability of the aspect in the context of WA development using CRUD operation. The following is the outline of the paper. The background of this study is presented in Section 2, and the related studies are examined in Section 3. The method for conducting MLR is introduced in Section 4. The review's findings are presented in Section 5, and the findings are discussed in Section 6. The main threats to the study's validity are shown in Section 7. Finally, Section 8 summarizes the article and discusses the conclusions as well as future research projects based on the findings.

## 2. Background

### 2.1. *CRUD*

The CRUD operation enables the developer to generate the fundamental files and codes to form a WA. It parses the database schema and creates code for each table using the MVC pattern based on the database table settings.<sup>24</sup> Most of the CRUD generators in WAF can be executed using the console framework which is accessible from the terminal Command Line Interface (CLI). Although it boosts the development process, the traditional CRUD only generates the fundamental WA functions which still present problems, namely their inadequacy to deal with the form features, authentication and encryption, search, file management and others,<sup>25,26,27</sup> Further enhancement and manual code modification are required to improvise the half-baked generated CRUD, especially in the functional integration which is time-consuming and comprises repetitive coding for each of the CRUD outputs.<sup>27</sup>

A standalone CRUD could not satisfy the development of decent and complex WA since it lacks integrated features to support the functions such as authentication, authorization, files management, search, internationalization, form features, statistic and others,<sup>26,27</sup> Based on the review of previous studies, various solutions have been proposed, for example, using a plugin and third-party components. However, most of the studies' solutions solved the problem separately which is not as an integrated solution that covers all aspects of features required in WA development. Despite offering a full-stack solution, many of the solutions are considered as complex and have a higher learning curve, especially those required and use others dependency components. As a result of the lack of the aforementioned features in

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the CRUD operation, the developer needs to go through a major code modification to integrate the necessary features to enhance the generated CRUD. The integration required more time as the developer need to identify the required features, understand the method and specifications. The developer also needs to test the compatibility of the features before executing the integration process which will affect the development productivity.

There is also an argument that the CRUD operation is not yet to be a complete solution to develop the WA as there is a lot of redundant tasks such as repetitive codes modification for features integration after the CRUD is generated.<sup>27</sup> Coding these steps repeatedly takes a long time and increases development costs.<sup>28</sup> In practice, important aspect integration in CRUD generated WA is a time-consuming process and required multiple programming languages understanding since the features might be written in different languages. It also required significant codes enhancement to include all the necessary WA features such as authentication, search, file management and others.

## 2.2. *Web Application*

WA is application software that leverages the Web paradigm and technologies to store, retrieve and manage information from data sources and deliver it to the users,<sup>29, 30, 31</sup> WA can be considered as a software component that stores and manages information just like a traditional information system, but specifically uses the web paradigm and its associated technologies,<sup>29, 32</sup> It is an information system that exploits the potential offered by world wide web technologies to deliver information and services to the users or other information systems applications. It is also considered as a software system whose main purpose is to publish and maintain data by using hypertext-based principles,<sup>33, 34</sup> WA offers ease of access, maintenance and cross-platform compatibility in contrast with the traditional desktop application, which is installed on a local computer.<sup>35</sup> WA can be characterised as one that uses Web architecture and other technologies (database, browser) to construct an information system that serves organisational needs.<sup>36</sup>

WA is an evolution of web technologies wherein a typical WA, the developer uses a static collection of pages and links these pages to present information using a web browser. This led to the desire to exploit the WA paradigm in Information Systems (IS) is by extending the traditionally non-web application along the lines of the web paradigm. This trend has caused the concept of data application and processing to evolve in the direction of web-based applications,<sup>29, 32</sup> WA reclaims many benefits of multimedia in the presentation of data, access to information, practicality in data processing, speed in sharing, spontaneous data retrieval, assistance in the decision-making process and less software dependency as it only requires a web browser and internet connection,<sup>30, 32, 33</sup> This benefit can be a crucial factor for communities that search and use information. As a result, the benefits lead to application development based on web technologies.

Within a few years, WA adoption has become ubiquitous and it continues to grow unabated at an exponential rate due to the advancement of web technologies, mobile devices and mobile broadband which makes WA more relevant and successful.<sup>29,32</sup> The development of WA is not only about the visual design and user interface (UI), it also involves planning, web architecture and system design methodology, testing, quality assurance, performance evaluation, continual update and maintenance of the WA as the requirements and usage grow and develop,<sup>37,38</sup> With the emergence of WA, tools and platforms for WA development and design also have gone through substantial innovation to enable faster and more effective development.<sup>39</sup> Technically, WA is considered as complex software as it is composed of heterogeneous components which need to be combined to ensure that the WA meets its requirement and functionality.<sup>40</sup> The complexity of information usage and processing has contributed to other related components in WA, procedure; data; and technology has vital roles in WA.<sup>41</sup>

### **2.3. Records Management**

Records management is the efficient, well-organized and systematic control of the creation, receipt, maintenance, use and disposition of records.<sup>42</sup> Record management is a logical and practical approach to the creation, maintenance, use and disposal of records and therefore of the information contained in those records.<sup>43</sup> Today, due to the application of technologies in the daily transaction, data, information and records are born-digital which requires electronic records management procedure. Electronic records management uses automated techniques to manage records regardless of their format,<sup>44,45</sup> Electronic records are information or data files, created and stored in digitized form through the use of computers and applications software.<sup>46</sup> The components of records management include policy and procedure development, inventory records, appraisal, retention, disposition, inactive files management and control, data collection, management of active files, and reports.<sup>47</sup>

The emergence of technologies especially in data and information processing using information systems or web applications provides automation in many aspects and can be more practical with proper record management mechanism application. Record management procedure enables more effective management of current records and can reduce or eliminate record-keeping redundancies and save cost for storage. Electronic records are prone to validity and integrity issues if there is no proper management and protection mechanism, due to the ease of modification and alteration. Role-Based Access Control (RBAC) has been widely applied in records management applications to provide a controlling mechanism through authentication and authorization processes,<sup>48, 49,50</sup> Audit trail in record management tracks every single alteration made to record and it is possible to track and identify changes made together with the account that is responsible for the changes,<sup>51,52</sup> The rapid expansion of born-digital records may cause retrieval problems if there is

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no appropriate search and filtering mechanism. In records management, the components work together to handle issues where a search engine is used to filter the list of records based on metadata and inactive records are archived and not included in active record searching improves the performance of search retrieval. With the proven examples of successful record management procedures and mechanisms in managing born-digital records, this searching procedure should be offered and applied as a fundamental feature in WA through the CRUD operation.

#### **2.4. SLR and MLR**

Systematic Literature Reviews (SLR) were adopted from medical sciences in mid-2000<sup>53</sup> and this method has been replicated in many study fields.<sup>54,55</sup> SLR is valuable as it assists the practitioners and researchers by indexing the evidence and gaps of a particular research scope which may consist of hundreds or thousands of papers,<sup>56, 57, 58,59</sup> Unfortunately, SLRs are unable to offer maximum benefits since they normally focus only on scientific literature while excluding the extensive "grey" literature that is continuously created by WA development practitioners outside academic mediums.<sup>60</sup> In this study, the scientific literature refers to the academic and research work published in journals or conferences which have passed the peer-review procedure. All of the individual works that contribute to SLR are known as primary studies.

In library guidelines, grey literature is defined as unpublished, that is, not available via traditional publishing, unconventional, with little dissemination and not peer-reviewed.<sup>61</sup> The US Interagency Gray Literature Working Group describe grey literature as the foreign or domestic open-source material that usually is available through specialized channels and may not enter normal channels or systems of publication, distribution, bibliographic control, or acquisition by booksellers or subscription agents.<sup>62</sup> Gray literature refers to printed or electronic literature created by the government, education, enterprise and industry and not owned by commercial publishers.<sup>63</sup> This can include documents such as unpublished research or doctoral dissertations, proceedings of conferences, book chapters, records from government and agencies, as well as blog posts, white papers, and recordings of presentations. Recently many researchers have combined the scientific and grey literature in their SLR and it has been known as Multivocal Literature Review (MLR),<sup>19, 22, 23,64</sup>

*"Multivocal literature is comprised of all accessible writings on a common, often contemporary topic. The writings embody the views or voices of diverse sets of authors (academics, practitioners, journalists, policy centres, state offices of education, local school districts, independent research and development firms, and others). The writings appear in a variety of forms. They reflect different purposes, perspectives, and information bases. They address different aspects of the topic and incorporate different research or non-research logics"*<sup>65</sup>

SLR and MLR are two separate approaches for defining, assessing and evaluating the state of the art of a given research question, subject area or interest

phenomenon. Both methods allow researchers to gather all the scientific literature related to a particular subject, but the key difference is that with the details gathered from the grey literature, only the MLR approach enables researchers to provide and complete their insight into a field.

### 3. Related Works

This MLR concentrates on records management WA potential aspect for CRUD operation. An initial study was conducted before performing this MLR to identify the existing secondary studies related to the search scope. To obtain the maximum information about this topic, a detailed search was performed in several online databases (IEEE Explore, Science Direct, AIS publication, ACM Digital Library, Wiley Online Library, SpringerLink, Emerald) which are the most used and preferred academic databases in WA development<sup>66</sup> and records management. These searches were conducted in Oct 2020 using the search string “(A1 OR A2) AND (B1 OR B2 OR B3) AND (C1 OR C2 OR C3 OR C4 OR C5 OR C6 OR C7 OR C8 OR C9)”, where the search terms are shown in Table 1.

As a result of these initial searches, secondary studies related to this research scope was identified. Antonio and Paiva<sup>67</sup> conducted an SLR on role-based access control on health information systems to protect non-authorized access to health records. The SLR included 50 papers that match interests from 10 different countries and discussed role-based access control current trends and limitations. Role-based access control addresses the need for authorization control over objects in records to ensure data is accessible to authorized user groups only. Rekik, Kallel, Casillas, and Alimi<sup>68</sup> conducted a study related to the criteria for web-quality assessment which is very useful for the evaluation of web or WA. This study also identified some web factors that are semantically similar and re-grouped together to reduce conflict and confusing meaning. Rafique, Humayun, Gul, Abbas and Javed<sup>69</sup> conduct an SLR on web application security vulnerabilities detection methods. This paper provided information on validation methods, web application development stages where security should be emphasized and security tools and mechanisms used for detecting vulnerabilities.

As discussed in the previous section, some secondary studies related to WA have been published. The construction of this literature review is based on the Kitchenham SLR principle,<sup>20</sup> while also being channelled by other systematic mappings.<sup>55</sup> No results were obtained when this study focused on WA records management potential aspect. For that reason, the goal of this study is to analyze and characterize the state of the art results in WA records management potential aspect for CRUD operation integration and to identify new research opportunities.

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Table 1. Search terms to identify related secondary studies.

A1. Web application	B1. Components	C1. Systematic review
A2. Records management	B2. Functions	C2. Research review
	B3. CRUD	C3. Systematic overview
		C4. Systematic literature review
		C5. Systematic mapping
		C6. Mapping study
		C7. Systematic mapping study
		C8. Multivocal review
		C9. Multivocal literature review

#### 4. Methodology

The main purpose of this study is to identify, document, analyze and characterize the state of the art of records management WA potential aspect that can be integrated into CRUD operation for WA development. The goal is to identify the potential aspect that needs to be posed by WA, their main features and the perceived benefit of integrating them in WA development using CRUD operation in the WAF as well as identifying new research opportunities.

This study was conducted as an MLR based on best practices and guidelines by Calderón,<sup>19</sup> and methods and procedures of SLR as proposed by Kitchenham,<sup>20</sup> together with the procedure of SLR that take into account the grey literature,<sup>18,22</sup> There are three stages that should be included in the review: planning, conducting and reporting,<sup>19,20</sup> In the first stage, the review protocol is established which defines the procedure for reviewing execution which includes research questions, searching and evaluation strategies, inclusion/exclusion criteria, quality assessment, data collection form and methods of analysis.<sup>19</sup> The second stage emphasizes the protocol execution as it has been defined. The last stage is to elaborate and discuss the report. Figure 1 shows the procedure for executing the MLR. The following subsection defines and discusses the activities involved in each step of the procedure.

##### 4.1. Research Questions

In this step, the study objectives were defined and research questions were identified to guide the review. The research questions help to gather all the data required for observing and assessing the state of the art of the subject under potential records management components in WA scope. The review aims to identify the important aspect of records management components which can enhance the functions and features of WA. For that reason, the goals are i) identify the records management potential aspect for CRUD operation and WA; ii) collect and analyze the functionality of the potential aspect; iii) classify the aspect based on functions and; iv) observe the perception of usability of the aspect in the context WA development using CRUD operation. To achieve these goals, the research questions are addressed as:

- RQ1. What are the potential records management components in the records



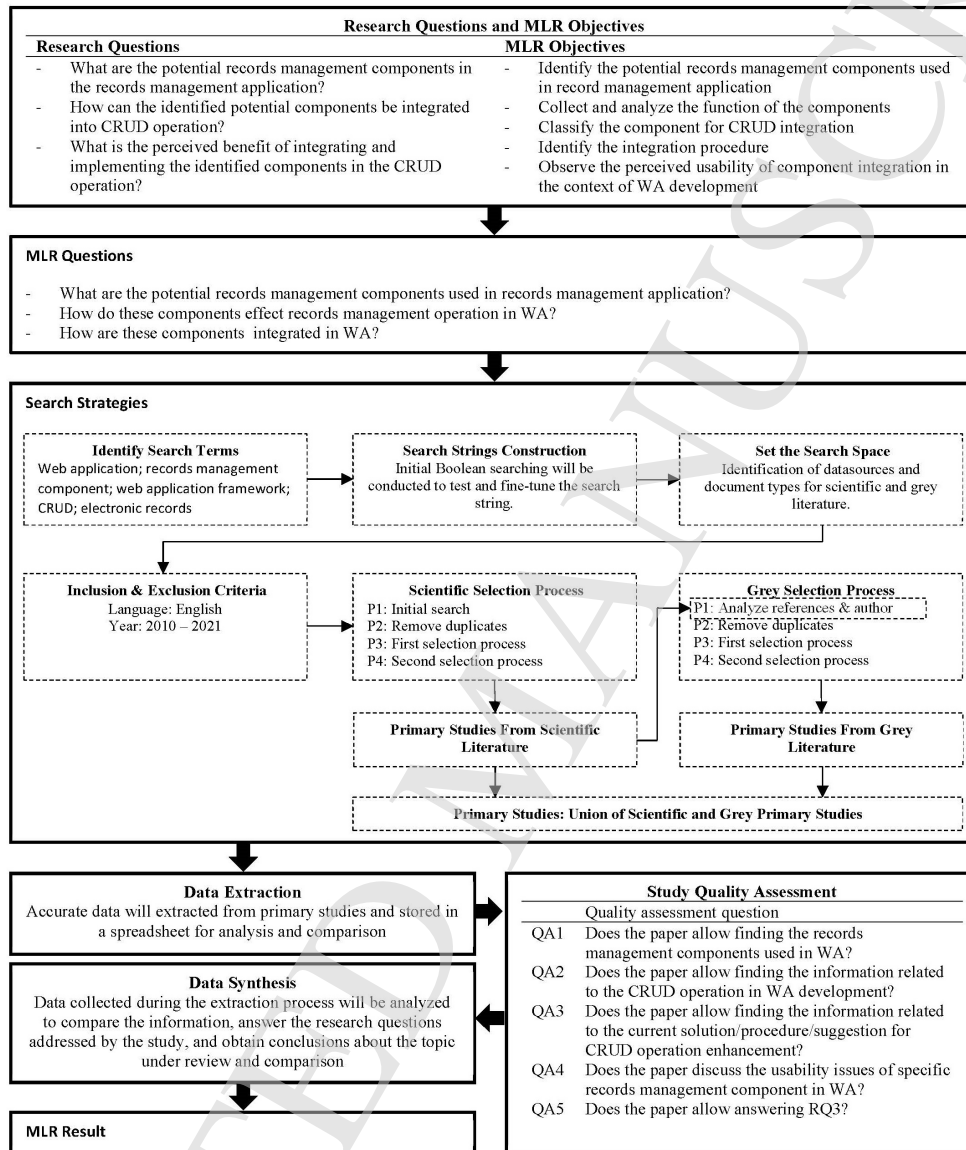


Fig. 1. Procedure for conducting the MLR.

management web application?

- RQ2. How can the identified potential components be integrated into CRUD operation?
- RQ3. What is the perceived benefit of integrating and implementing the identified components in the CRUD operation?

#### 4.2. Search Strategy

This step defined the search and evaluation strategy for performing an exhaustive search for published literature in order to identify primary studies from scientific and grey literature that address the research topics. As a result, the following steps were required: identify search terminology, construct the search string, identify resources used in the searches, and establish the study selection method.

##### 4.2.1. Identify Search Terms

The initial process of the search strategy was to identify the search terms. The terms or the keywords were extracted from the research questions to ensure that the terms were related to the review. It is vital to identify accurate search terms to ensure that most of the relevant literature was included. The main terms for this research were web application, web application framework, records management, function, component, framework, plugin, features, CRUD.

##### 4.2.2. Construct the search strings

The following procedures will be used to generate the search string based on the identified search terms:<sup>70</sup>

- Derive major terms from the research questions by identifying the main concepts
- Identify alternative spellings and synonyms for major terms
- Check the keywords in any relevant papers already found
- Use the Boolean OR to add alternative spellings and synonyms
- Use the Boolean AND to link the major terms

Few initial searches were done to test and fine-tune the search string. With the proposed terms, the search strings were defined based on the following Boolean expression “A1 AND (B1 OR B2 OR B3 OR B4 OR B5 OR B6) AND (C1 OR C2)” and “A2 AND (B1 OR B2 OR B3 OR B4 OR B5 OR B6) AND (C1 OR C2)” based on the search terms listed in Table 2.

Table 2. Search term segmentation.

A1. Web application	B1. Components	C1. CRUD
A2. Records management	B2. Plugin	C2. Usefulness
	B3. Features	
	B4. Development	
	B5. Framework	
	B6. Usability	

##### 4.2.3. Set the search space

The document types and data sources for scientific and grey literature searches were defined in Table 3. The search terms were used to search the title, keywords,

abstract, and content of the publication. The official framework website refers to the website of a web application framework, such as CakePHP, Laravel, FuelPHP, or Symfony, that offer CRUD operation. The official websites for each framework contain a wealth of information about CRUD code automation, including technique, procedure, features, and operation. It's critical to look into the existing CRUD method and capabilities in the WAF.

Table 3. Search space.

	Document types	Data sources
Scientific literature	Published journal papers, conference proceedings, books	IEEE Explore, Science Direct, AIS publication, Emerald, ACM Digital Library, Wiley Online Library, SpringerLink,
Grey literature	Preprints, technical reports, official WAF website and document	Google, Google Scholar, official framework website, ResearchGate, ORCID, ResearcherID

Table 4. Inclusion and exclusion criteria.

Criteria	Details
Inclusion	Studies that discuss WA features
	Studies that discuss records management components and functions
	Studies that present WAF and/or code automation
	Studies that described WA components/features
	Studies that explain CRUD integration
Exclusion	Studies from the year 2010 - 2021
	Studies that main objectives is not related to WA, record management component, and CRUD
	Studies that present record management component but do not show any information about its function
	Studies that discuss WA and CRUD but do not specify the framework domain
	Studies with abstract only without full text
	Non-English-language studies
	Duplicate studies/research (same paper but retrieved from other sources)

The main reason for the aforementioned data source of scientific literature was used was because of the access possibility as the university subscribed to a theme. Moreover, these data sources have loads of publications related to this research scope, and it is a preferred academic database in web technologies studies.<sup>66</sup> The CRUD procedure, method, and output of the existing WAF code automation have also been reviewed.

#### 4.2.4. Establish the inclusion/exclusion criteria

To be included in the report, the inclusion/exclusion guidelines were used to set out the conditions for the papers obtained from the searches, and they must meet the inclusion/exclusion condition. The manuscript that are published must be written

in English. To ensure only state-of-the-art issues on the topic were retrieved, the publication period was set from 2010 until 2020. WA features, WAF, code automation, and CRUD are among the criteria for inclusion. It's critical to investigate the current WAF features and its CRUD code automation generator to identify the methods, procedures, and outputs. The inclusion and exclusion criteria specified in this study are summarized in Table 4.

#### 4.2.5. *Define the scientific selection process*

The scientific selection process underwent four-phase of scientific primary studies selection using the test-retest approach to ensure the reliability and no changes in the quality or construct being measured.<sup>71</sup>

- Phase 1 - Initial search: the identified search terms were executed in respective data sources search engine to find all related studies. The search is limited to the title, keywords, abstract, and content of the publication.
- Phase 2 – Remove duplicates: All relevant scientific papers were imported to Mendeley for reference management and duplicate check. The duplicate appeared when the same papers were retrieved from more than one source. Once the duplicates of the paper were identified, the most completed metadata (abstract, keywords, type, author, full-text, year, volume, issues, page, DOI, and source) papers were taken into account for the next phase selection.
- Phase 3 – First selection process: The paper title and abstract were reviewed and analyzed against inclusion and exclusion criteria. Papers that met the inclusion criteria were tagged as Possible Selected (PS) and, papers that did not present enough information to make a decision is tagged as Fractional Selected (FS). On the other hand, the paper that was clearly out of the inclusion criteria was tagged as a non-selected paper (NS) and was not included in the next selection phase.
- Phase 4 – Second selection process: Articles tagged as PS and FS went through an extensive review of title, abstract and content to ensure that the publication positively contained relevant information for the study review. The selected papers were tagged as Selected (S), and non-relevant papers were tagged (NS).

At the end of the scientific selection process, the publications tagged as Selected (S) papers formed the scientific primary studies retrieved from the scientific literature. The selected papers' relevant information was quoted and extracted to a spreadsheet file using MS Excel to manage all the quoted phrases of the scientific selection process.

#### 4.2.6. *Define grey selection process*

Grey literature is unpublished and non-peer-reviewed articles<sup>61</sup> published via websites, reports, data set, audiovisual, and other platforms [18]. The grey selection process underwent four (4) phases of grey primary studies selection through a test-retest approach.

- Phase 1 - Analyze references and authors: Snowballing technique is conducted on the scientific primary studies' sources to identify any relevant sources. In this context of research, the reference list (backwards snowballing)<sup>72</sup> or the citation in the paper (forwards snowballing)<sup>73</sup> of the scientific primary studies is reviewed to identify relevant papers. In addition, the search string is applied to the Google Scholar search engine. The search aimed to find all information related to the topic under review. Google Scholar was used to conduct the forward snowballing.
- Phase 2 - Remove duplicates: Duplicate and irrelevant grey studies were removed if the information had the same value and attributes.
- Phase 3 – First selection process: The grey studies underwent the same process as phase 3 of scientific studies.
- Phase 4 – Second selection process: The publications classified as possible selected papers (PS) during Phase 3 were analyzed by reading the full text. The grey studies underwent the same process as phase 4 of scientific studies.

At the end of the grey selection process, publications tagged as Selected (S) publications formed the grey primary studies that were the primary studies retrieved from the grey literature. The selected papers' relevant information was quoted and extracted to a spreadsheet file using MS Excel to manage all quoted phrases of the scientific selection process.

#### 4.2.7. *Primary studies*

The scientific primary studies were combined with the grey primary studies. The union of these studies was analyzed to retrieve the required information to address the research questions.

#### 4.3. *Data extraction*

Throughout the MLR process, a substantial amount of data was collected. There were two types of collected data, data collected during the search process and data collected during the extraction process. Lots of general data have been collected during the search process to identify the relevant studies from scientific and grey literature. The data collected during the extraction process was the specific data needed to achieve the objectives of this research. All primary studies tagged as Selected (S) were completely read to collect all necessary information and ensure the data was accurate. The information was stored in a spreadsheet to make it easier to analyze and compare during the synthesis process.

#### 4.4. *Study quality assessment*

The study quality assessment was performed to ensure that the paper was relevant to the purpose of the study and MLR. For assessment, five (5) instruments were constructed to identify the quality of the provided information, as shown in Table

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5. Each question was answered YES (Y) or NO (N). The answers were transformed into a scoring procedure where Y=1 and N=0. The responses to questions are as shown in Table 6.

Table 5. Quality assessment instrument.

Criteria	Details
QA1	Does the paper allow finding the records management components used in WA?
QA2	Does the paper allow finding the information related to the records management component function?
QA3	Does the paper discuss the usability issues of specific records management components in WA?
QA4	Does the paper allow finding the information related to the current solution/procedure/suggestion for CRUD operation enhancement?
QA5	Does the paper allow answering RQ3?

Table 6. Quality assessment response.

Score	Quality assessment response	
QA1	Y N	The paper present the potential records management components used in WA The publication does not present the potential records management components used in WA
	QA2	Y N
QA3		Y N
	QA4	Y N
QA5		Y N

#### 4.5. Data synthesis

The extracted primary studies were systematically analyzed, compared, and investigated to determine whether they answered the research question or not. The results were classified according to the research question addressed, as shown in Table 7.

## 5. Result

The primary studies gathered from grey and scientific literature were used to examine the outcomes of the scientific search method.

Table 7. Extracted data classification.

Data	RQ address
DC1 The potential record management components in WA	RQ1
DC2 The record management function and features in WA	RQ1
DC3 Brief record management component description	RQ1
DC4 CRUD operation for WA development using WAF	RQ2
DC5 A description of plotting potential components in CRUD operation	RQ2
DC6 The technique of integration and CRUD enhancement	RQ2
DC7 Automate the record management function integration	RQ3
DC8 Reduce the development time	RQ3
DC9 Testing and evaluation of CRUD and WA	RQ3

### 5.1. Scientific selection process results

There were four (4) phases in the scientific selection process. In the first phase, initial searching was performed by applying the search string to specified digital data sources. As a result, 284 papers were found that met the search string criteria and was related to this study. In the second phase, all papers were analyzed to check for duplicates and, 124 papers were removed. In the third phase, the paper title and abstract were checked according to the inclusion and exclusion criteria. As a result, the list was reduced to 42 papers that were considered as scientific primary studies. In the last phase, the full text of the papers was reviewed and analyzed to ensure the suitability of the content. As a result, 28 additional papers were excluded. At the end of this scientific selection process, the list of papers retrieved from the scientific selection process included 14 papers. These 14 papers defined the scientific primary studies for the MLR.

Table 8. Evolution of the studies retrieved in each digital resource.

Digital resources	Studies retrieved	Distinct studies retrieved	Studies that passed the first selection process	Primary studies
IEEE Explore	46	29	7	3
Science Direct	49	33	11	2
Web of Science	21	14	1	1
ACM Digital Library	35	18	4	1
SpringerLink	37	19	8	1
Emerald	43	20	6	4
Wiley Online Library	24	6	1	1
AIS Publication	29	21	4	1
	284	160	42	14

Table 8 depicts how the list of publications evolved during the scientific selection process based on each digital resource. This figure represents: first, the number of scientific papers found in each digital resource; second, the numbers of scientific papers that were collected after removing the duplicates; third, the number of scientific papers that passed the inclusion and exclusion criteria; finally, the number of scientific papers that were accepted and included as a scientific primary studies in this MLR.

### 5.2. Grey selection process results

By considering the 14 scientific primary studies retrieved during the scientific selection process, the grey selection process was performed. The four (4) phases in the grey selection process were identical to the scientific selection process except that it included analysis of references and author publications from the scientific selection process result. In the analysis of the first phase, three (3) different techniques were used: forward snowballing (Reference\_FS), backwards snowballing (Reference\_BS), and searching the author publications (Author\_P) of each scientific primary study. As a result, 211 studies were retrieved using the forward snowballing technique, 86 studies using the backwards snowballing technique and 42 studies from the author's list of publications making the total number of grey studies 339 papers. The second phase of the grey selection process started with 339 studies, and 111 papers were removed due to duplication. In the third phase, the paper title and abstract were checked according to the inclusion and exclusion criteria. As a result, the list was reduced to 36 papers that were considered as grey primary studies. In the last phase, the full text of the papers was reviewed and analyzed to ensure the suitability of the content. As a result, 23 additional papers were excluded. At the end of this grey selection process, the list of papers retrieved from the grey selection process was formed by 13 papers. These 13 papers defined the primary studies for the MLR.

Table 9. Evolution of the studies retrieved from grey literature.

Digital resources	Studies retrieved	Distinct studies retrieved	Studies that passed the first selection process	Primary studies
Reference_FS	211	148	18	8
Reference_BS	86	51	11	5
Author_P	42	29	7	1
	339	228	36	13

Table 9 shows the evolution of the list of papers in the grey selection process regarding each technique used in the selection process. This figure represents: first, the number of grey papers found using the aforementioned technique; second, the numbers of grey papers collected after removing the duplicates; third, the number of grey papers that passed the inclusion and exclusion criteria; finally, the number of grey papers that were accepted and included as grey primary studies in this MLR.

### 5.3. Primary studies

The primary studies were defined using the results of the scientific and grey selection processes. The primary studies were formed by 27 papers, 14 from scientific studies and 13 from grey studies. Table 10 shows the list of primary studies details, selection category (scientific/grey – S/G), as well as primary studies identifier (PS\_ID) to



allow unique referencing in the primary studies. All of the retrieved primary studies were published between 2010 – 2021, and most of the studies were mainly focused on the potential components and features of records management in WA. This data indicates that the subject under consideration, records management components and WA, is an emerging research area in which interest is expanding.

Table 10. Primary studies.

PS_ID	S/G	Manuscript	Year	Components
PS_1	G	Ira A. Penn, Gail B. Pennix	2017	Inventory
PS_2	S	Patricia C. Franks	2013	Inventory
PS_3	S	Judith Read, Mary Lea Ginn	2016	Inventory, Retention
PS_4	S	UK National Archive	2012	Retention
PS_5	S	Diamond, Mark	2017	Retention
PS_6	S	Lee, Christopher A.	2019	Appraisal
PS_7	G	Harvey, Ross, Thompson, Dave	2010	Appraisal
PS_8	G	Vellino, André, Alberts, Inge	2016	Appraisal
PS_9	G	International Record Management Trust	2010	Disposition
PS_10	G	Crockett, Margaret	2011	Disposition
PS_11	S	Nai-Wei Lo; Chia-Yi Wu; Yo-Hsuan Chuang	2017	RBAC
PS_12	S	Masanya, Tlou Maggie	2020	RBAC
PS_13	S	Guo, Hao; Li, Wanxin; Nejad, Mark; Shen, Chien Chung	2019	RBAC
PS_14	S	Oladejo, Babatunde; Hadžidedić, Sunčica	2021	Search
PS_15	G	Pauline, Joseph; Shelda, Debowski; Peter, Goldschmidt	2013	Search
PS_16	S	Lemieux, Victoria Louise	2016	Audit trail
PS_17	S	Namukasa, Juliet	2017	Audit trail
PS_18	S	Ingrid et al.	2021	Digital Archiving
PS_19	S	Broussard, Meredith; Boss, Katherine	2018	Digital Archiving
PS_20	G	International Council on Archives	2013	Import-export
PS_21	G	The National Archives United Kingdom	2017	Import-export
PS_22	G	Chen et al.	2019	Share and Report
PS_23	G	Lengstorf, Jason; Wald, Keith	2016	Share and Report
PS_24	G	Duarte et al.	2011	Inactive files MGT
PS_25	S	Rodriguez et al.	2018	CRUD architecture and functions
PS_26	G	Porebski et al.	2011	CRUD integration and services
PS_27	G	Doug Bierer	2016	CRUD methodology

#### 5.4. Study quality assessment

The primary studies were rated in accordance with the criteria established in the quality assessment (QA) questionnaires (refer to Table 5 and 6). Fig. 2 shows the coverage for every QA in the primary studies. Most of the QA is rated as ‘Yes’, and four questions were covered at a rate higher than 70%. QA4 was the question with the lowest yeses (19%) because only 3 primary studies discussed the current CRUD operation together with the enhancement, and the rest of the primary studies focused on different QA. Nevertheless, the main focus of records management potential components for WA was covered at a rate higher than 80% of yeses as shown in Figure 2.

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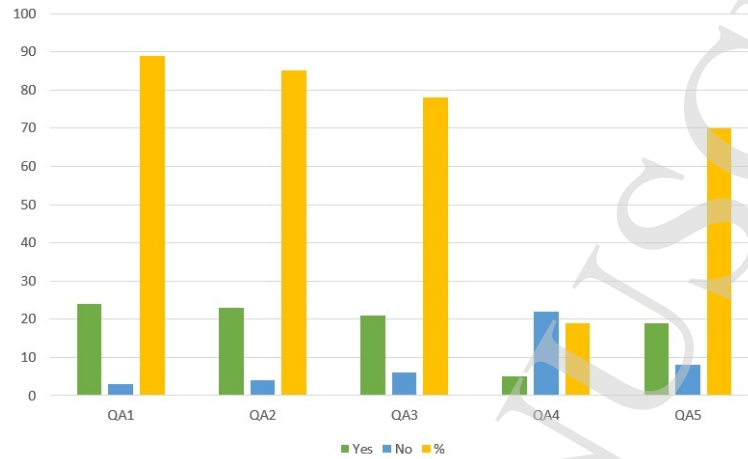


Fig. 2. Quality assessment results per question and type of assessment response.

## 6. Discussion

This section will discuss the MLR findings based on the addressed research question.

### 6.1. RQ1. What are the potential records management components in the records management web application?

The goal of this question was to identify the potential records management components used in the records management web application. It involves the procedures and methods applied to manage the born-digital records. Technically, there are many procedures, methods and policies published by National Archives from different countries. Several published studies have discussed the important features and components that should be present in the records management application. To respond to this question, for each of the collected primary studies, the information related to the potential record management components such as name/title, description of functions and features, types, application domain, and its objectives was identified. Based on the review, it was found that there are 11 different domains of potential record management components for WA, which are:

- Inventory: a descriptive listing of each record series or system, together with an indication of the location, access, and other pertinent data,<sup>43, 7475</sup>
- Retention schedule: list how long each record series must be kept (the retention period), when the retention period starts (the cut-off), and the proper way to dispose of the record once retention is met (the disposition method),<sup>75, 76, 7778</sup>
- Appraisal: the process of determining the archival value and ultimate disposition of records. Appraisal decisions are informed by several factors, including the historical, legal, operational, and financial value of the records,<sup>79, 8081</sup>

- Disposition: the process of destruction of records or the transfer of records to another entity (most commonly an Archives) for permanent preservation ,, <sup>8283</sup>
- RBAC access control: provides role-based access control mechanism in electronic record management applications to offer protection from unauthorized access. Authenticated users with different roles have different authorization or access to the records, <sup>48, 4950</sup>
- Search and retrieval: Enables the user to locate and retrieve records based on specific metadata, words or phrases. It is a vital function in any WA as it enables fast data retrieval via the search parameter, <sup>8485</sup>
- Audit trail: provides log tracking for any changes to the electronic records to ensure validity and integrity, <sup>5152</sup>
- Digital Archiving: transfer and store the valuable records into a repository that makes it non-active but still accessible through the system. It also helps to reduce the cluttered old and non-active records from the system, <sup>8687</sup>
- Sharing: provides the ability to share and transfer the record (internal to external or external to internal) in a single data or bulk data. There are several suggested formats such as CSV, XML and JSON, <sup>88, 89</sup>
- Reporting: provides a summary of the current status of records such as total records, active, inactive and the total required appraisal attention and others, <sup>9091</sup>
- Others: focused on the front-end framework for UI, data visualizer for reporting page, jQuery, DOMPDF and others supporting UI features, <sup>4392</sup>

Most of the existing web application frameworks such as CakePHP, Laravel, Symfony, and FuelPHP have a build-in CRUD generator accessible through the console framework, which can be executed using CLI. The existing CRUD output is limited, and adding the aforementioned features will necessitate a significant amount of code adjustment. These features can be integrated into CRUD operations, allowing records management features to be generated as a standard WA routine code and features bundle. These records management features, when compared to the conventional CRUD, promote more systematic content management for WA. Furthermore, WA prototypes with records management features can be rapidly created with fewer manual code changes.

### **6.2. RQ2. How can the identified potential components be integrated into CRUD operation?**

This research question aim is to gather all information related to the potential records management components that can be integrated into the CRUD operation for WA development. Additionally, the advantages and functions of potential records management components are also identified. As mentioned in the RQ1 discussion, the potential records management components come from various domains also present in different functions and features. Basically, in CRUD operation, it is limited to fundamental WA function generation known as create, read, update and delete. The existing CRUD operation will be enhanced by integrating record man-

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agement aspects and operation such as authentication and authorization, search and filtering, record inventory, archiving, retention schedule, and other related components into WA. However, this process requires integration prosers skills and knowledge together with programming language understanding due to the CRUD generator engine and the WAF structure. It was also found that some of the records management components have been compiled by the open-source community as a plugin package that is compatible with a specific web application framework. However, this plugin is published as a standalone component and is not integrated into the CRUD operation in the WAF.

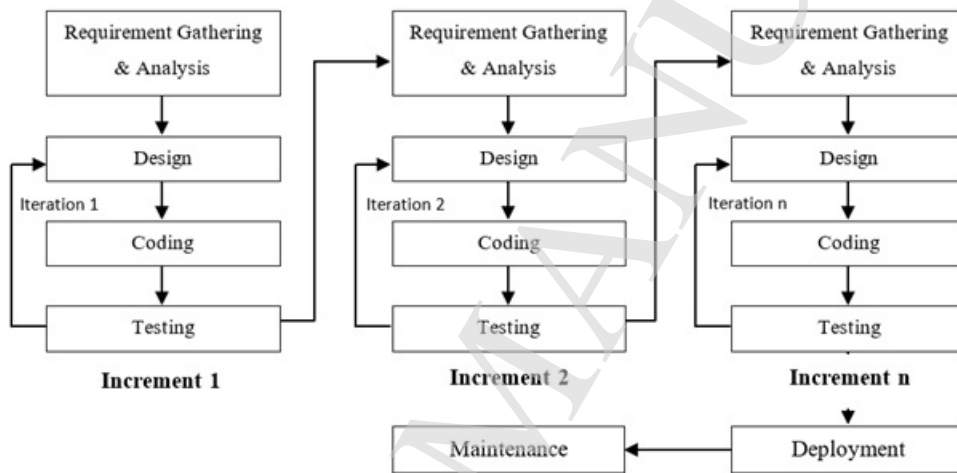


Fig. 3. Agile iterative model<sup>93</sup>

The integration of the components can be realised through a modification of the CRUD generator in the WAF,<sup>4,93</sup> Although the web application framework has a different method of CRUD operation, the console-based CRUD generator is widely used by the web application framework such as CakePHP, Laravel, Symfony, and FuelPHP. Due to the MVC architecture adopted in the web application framework, it is suggested that the integration is performed based on the Agile iteration methodology.<sup>493</sup> The Agile iterative methodology provides a combination of iterative and incremental model,<sup>9495</sup> In the Agile iterative model, the enhancement can be broken into small incremental builds. It is not developed as a complete product on the go. This is important because several features will be integrated into the console framework. The feature integration will be completed one by one and tested based on priority. The agile iterative method is adopted to ensure a systematic enhancement process.<sup>96</sup> In addition, the agile iterative method provides more flexibility in adapting changes, ease of adding new features, and incremental testing.<sup>97</sup> Figure 3 shows the Agile iterative model process flow which can be

used for WA important aspect integration in CRUD operation. The process can be explained as follows:

- Requirement gathering and analysis: each identified component will be analyzed for requirement details, operations and procedures. All necessary details and procedures will be extracted and understand the overall process.
- Design: Defining the component integration method to the CRUD and preparing the integration environment.
- Coding: Integrate identified components for CRUD enhancement. The enhancement will use PHP language, and some modifications to the core files will be affected due to changes in code structure.
- Testing: The identified components will be integrated with the CRUD and executed using CLI. The testing covers the components and code generation together with the functionalities.
- Iteration: Every identified component will undergo the process, and if in the testing phase it appears to have a problem, the development needs to be re-evaluated and modified.
- Increment: In every increment, the different components will be integrated into the CRUD. This is to ensure that every feature is properly integrated, and the CRUD produces a clean code design and a fully functional WA.
- Deployment: The completed enhanced CRUD will be properly arranged and deployed to generate WA with record management components.
- Maintenance: Update the integrated component and CRUD operation to ensure it is up to date.

As most of the frameworks used MVC architecture, the integration process can be executed in a very systematic method. For example, the integration of the audit trail will only focus on modifying the model and controller in the WAF CRUD template structure. On the other integration, such as access control which requires a specific database table e.g: a user table containing user attributes, a database migration command can be used to systematically populate the required database.

### **6.3. RQ3. What is the perceived benefit of integrating and implementing the identified components in the CRUD operation?**

Overall, the integration and implementation of the specified record management component into the CRUD operation will boost the WA development productivity as it is able to produce WA output with integrated records management components and functions. Traditional CRUD is limited only to generating fundamental functions of WA. On the other hand, CRUD with an integrated record management component can produce more features required by the modern WA, especially when it comes to handling born-digital records. Rapid prototyping for WA also can be more practical due to this integration, and human error can be reduced due to

the lack of programming skills for integration and mistakes in coding,<sup>493</sup> The integration also provides a more comprehensive solution for the developer to develop record management WA as it practices out-of-the-box record management functions. The integration contributes to a fully enhanced CRUD together with record management components and features through a systematic integration. The enhancement of the CRUD operation helps to improve record management WA development productivity and ease the development process. The generated CRUD will provide comprehensive output with extra functionality such as RBAC access control, retention schedule, search and filtering, archiving, audit trail and other record management functions which also makes development faster and easier. As for the traditional CRUD operation, the record management component and function need to be integrated after the CRUD operation has been completed, which can lead to time-consuming and error due to human factors or lack of knowledge in integration. Enhanced CRUD operation greatly reduces this issue by integrating and automating everything a developer needs to get started by conveniently bundling the components together. In addition, the use of WAF in record management WA development will become easier due to more automation provided for feature integration promotes a gentle learning curve. Automation reduces the probability of human error and ensures code consistency by eliminating mistakes during the integration of the features. The code consistency and logic are very important in WA development as they can affect the WA performance and may cause other issues if it is not addressed appropriately. The integrated records management features in a web application also promote systematic content management by allowing content to be appraised after a set period of time, archiving inactive content, and providing an audit trail for content changes, along with other features. It also ensures that the digital contents are effectively preserved and no non-essential data are deleted in accordance with specified rules in a timely manner. With more organised data operations and productivity, it also supports solid record management compliance practice for digital information.

### **7. Threats to validity**

This study, as well as with all literature reviews, has many variables that can influence its validity. About the search process, our analysis is constrained by the search terminologies, the search strings, the included journal, and the studies period since they are the variables that limit the work carried out during the search process. To minimize the influence of these factors, the review protocol is designed based on the guideline proposed by Kitchenham<sup>20</sup> and opted to conduct an MLR rather than an SLR to incorporate grey literature in this study. Therefore to complement the review protocol, other SLRs and MLRs in the literature also has been analyzed. In this study, the addition of grey literature helped resolve the scarce works obtained by automated searches in the scientific literature databases. A new selection method was established to systematically examine the grey literature, which allow-

ing researcher to obtain not only the primary studies from the scientific literature but also from the grey literature. The method of selecting the final primary studies outlined may not be viable if the number of papers collected from the scientific literature is too large. The included constraints such as limiting publication period within the inclusion/exclusion criteria and reduction technique within the selection process were purposed to restrict the numbers of studies retrieved. As for the human resource involved in the MLR process, a single researcher was responsible for selecting primary studies, which can threaten the validity due to human error or subjective opinion related to personal interest and knowledge. To minimize these human-related issues, each scientific and grey literature selection process is executed based on the test-retest approach. Before being chosen as primary studies, studies have to undergo two levels of evaluation. Technically, this human-related threat was present in the entire process of MLR, and therefore, one expert researcher in a similar field reviewed the work performed in the MLR process. Finally, it may occur that a primary study does not have adequate information to address all the research questions identified by the review concerning the information derived from the primary studies. A manual search can be performed via the internet search engine to find additional studies that could complement the study's findings.

## 8. Conclusions and future works

Eleven record management components have been found within the topic under review, which is: inventory, appraisal, retention, disposition, RBAC access control, search and retrieval, audit trail, digital archiving, import-export, sharing and reporting and inactive files management. It was found that the aforementioned aspects are very useful in modern WA as the primary studies highlight the record management component and the implication of having these aspects integrated into the CRUD operation. Technically, this integration benefits the record management WA development. The idea is to include proper record management procedures into any WA development to provide a systematic digital-records management method. If there is no proper record management mechanism, it will affect the performance and lead to the information explosion which is caused by improper data and records management procedures in WA. This study also contributes to the overview of the features, function and perceived usefulness of the identified record management components. The result of the record management component, the conclusion of the analysis studies, and the perceived benefits of the findings can conclude that the CRUD operation in the WAF can be enhanced with integrated and built-in potential record management components. This enhancement to the CRUD operation will boost development productivity as the code automation with record management components can be integrated. The developer can focus on other issues in WA development. Nevertheless, the use of WAF in WA development is an emerging research scope where several studies have been published recently. Hence, it is recommended to have more research, and WA development together with CRUD

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flexibility outcomes are needed to observe the full potential of these important aspects in supporting the modern WA requirements. There is a lot of non-CRUD records management software available as open-source or proprietary software that demonstrates a few other features that are useful in managing digital content, such as format converters when exporting or sharing content, automation in retention and appraisal decision workflow, team collaboration, metadata management, multilingual support, and other features that can be integrated into CRUD operation.

### Acknowledgments

The study is financially supported by the Fundamental Research Grant Scheme (Vote No. R.K130000.7856.5F415) awarded by the Ministry of Higher Education of Malaysia (MOHE) and University Teknologi Malaysia.

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