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Risk Management in Software Development Projects A Systematic Literature Review

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Abstract-Risk Management is an integral part of every project. Risk management must estimate the risks' significance, especially in the SDLC process, and mitigate those risks. Since 2016, many papers and journals have researched planning, design, and risk control in software development projects over the last five years. This study aims to find the most exciting topics for researchers in risk management, especially in software engineering projects. This paper takes a systematic approach to reviewing articles containing risk management in software development projects. This study collects papers and journals included in the international online library database, then summarizes them according to the stages of the PICOC methodology. This paper results in the focus of research in the last five years on Agile methods. The current issue is that many researchers are trying to explicitly integrate risk management into the Agile development process by creating a comprehensive risk management framework. This SLR helps future research get a theoretical basis to solve the studied problem. The SLR explains the focuses of previous research, analysis of research results, and the weaknesses of the investigation. For further study, take one of the topic papers, do a critical review, and find research gaps.

Keywords: project, risk management, software development, systematic literature review, SLR

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1. Introduction

Uncertainty and extreme competition in the information systems industry increase new challenges and problems in today's growing companies. Cost, deadline, and implementation of development methodologies are severe factors in software development project failure [1]. Risk is part of the project, and managing risk leads to success. Most software development companies view risk differently and less comprehensively [2]. This failure is why risk management in software projects has become a significant concern for many companies. Organizations that adopt risk management strategies positively affect the outcomes of their software projects and typically result in reduced costs, fewer delays, and improved performance [3].

Software engineering is a discipline that covers everything related to the software development process, from the design stage to the implementation stage and post-implementation, so that the software life cycle can take place efficiently and measurably [4]. In (Rudy 2016), the definition of a project, according to PMBOK (Project Management Body of Knowledge), is a temporary effort to produce specific/unique products, services, or results [5]. Risk is an integral part of every project, and risk management is an essential part of the decision-making process at every stage of the project. The success or failure of a project is highly dependent on the approach to the potential emergence of risks that can affect the productivity, quality, timeliness, and or cost of the project [6]. Joshua Partogi also says the extra work that causes software development costs to be more expensive is a risk that can eliminate in a fail-safe environment [7].

Risk management in software development projects describes an integrated engineering approach with methods, processes, and artifacts that continuously identify, analyze, control, and pool risks, to reduce the risk of project failure. The risk management process consists of all the activities necessary to identify risks that may potentially impact the software project [8].

The importance of risk management in software development projects encourages researchers to conduct studies in this field to find a novelty for knowledge and the software industry. However, in every research, it is often asked why the field was chosen and whether the lot is outdated or has the potential to find elements of novelty. Who researched the area (risk management in software development projects), and what were the results?

To answer these problems, a systematic literature review was carried out to identify and evaluate the research, with the object of study in the form of papers published in the last five years until September 2021, when this research was conducted. This paper describes the research focus, analysis of research results, and weaknesses of previous studies so that the results of this literature review are used as a theoretical basis for further research.

2. Method

This paper takes an approach systematically to reviewing the literature on risk management in software development projects. The Systematic Literature Review (SLR) method is well established in medical research and deeper in information technology [9]. The SLR used is an approach by Kitchenham and Charters to identify, assess, and interpret findings on a research topic to answer predetermined research questions [10].

a. Research Question

Research questions are obtained from the PICOC (Population, Intervention, Comparison, Outcomes, and Context), which contains the criteria and scope of the papers included in the literature study, as shown in Table 1. The PICOC method is used to build an evidence-based practice by asking well-structured practical questions.

Table 1 Scope of formulating research questions

	Criteria	Scope
P	Population	Risk management and software development projects
I	Intervention	Limited to research on risk management in software development projects
C	Comparison	n/a
O	Outcomes	Risk management in software development projects dominates trends and topics of research concern.
C	Context	A review of all research containing risk management in software development projects

Based on these criteria and scope, five Research Questions (RQ) were generated or shown in Table 2.

Table 2 Research Questions

	Research Question
RQ1	Does the paper discuss risk management?
RQ2	Does the paper discuss software development projects?
RQ3	What is the main focus of the research?
RQ4	What is the result of the research?
RQ5	Who has researched the most in this field?

b. Search strategy

The search strategy was carried out by determining the search string formulation, searching for data sources from the online database literature, defining the inclusion and exclusion criteria as shown in Table 3, and extracting papers based on the RQ in Table 2.

- Search string is English and combines keywords using Boolean ANDs & ORs [9]. This paper is used search strings like the following: risk management AND (software develop* OR project manage*).
- Literature from the most popular Internet is explored to the broadest possible range for study dan research. The following is a list of digital repository indexes:
  - Springer (link.springer.com)
  - Research Gate (researchgate.net)
  - IEEE Xplore (ieeexplore.ieee.org)
  - Elsevier (elsevier.com)
  - ACM Digital Library (dl.acm.org)
- Inclusion criteria as requirements of relevant research, and exclusion is used to exclude studies or research those not pertinent.

Table 3 Inclusion and exclusion criteria

Inclusion	Exclusion
Articles published in English	Articles published not in English.
Articles published between January 1st, 2016, and September 30th, 2021	Articles published before 1st 2016 and outside inclusion period
Articles included in international journals.	Articles included not in international journals.
Fully accessible papers	Fully inaccessible papers
Articles belonging to the risk management category and software development projects	Articles not belonging to the risk management category and software development projects

3. Result

The following steps are carried out in the search for papers:

1. Enter keywords in the search field in each online repository (link.springer.com, researchgate.net, ieeexplore.ieee.org, elsevier.com, dl.acm.org).
2. Limit search years (2016 - 2021).
3. Perform downloads for articles that can be accessed.

After browsing and searching for sources from online repositories, then extracting papers based on inclusion and exclusion criteria, 54 articles were determined. The list of titles, year of publication, and repository sources can be seen in Table 4.

Table 4 List of Search Results

	Year	Title	Source	Seq
[11]	2016	Causes of Human Errors in Early Risk assessment in Software Project Management	dl.acm.org	1
[12]	2018	Open data standards for open source software risk management routine	dl.acm.org	2
[13]	2019	Risk management in projects based on open-source software	dl.acm.org	3
[14]	2019	Risking: A game for teaching risk management in software projects	dl.acm.org	4
[15]	2020	Risk Management for Software Projects in Banking	dl.acm.org	5
[16]	2016	Categorization and standardization of accidental risk-criticality levels of human error to develop risk and safety management policy	elsevier.com	6
[17]	2017	Climate-Agriculture-Modeling and Decision Tool (CAMDT): A software framework for climate risk management in agriculture	elsevier.com	7
[18]	2017	Framework for risk management software system for SMEs in the engineering construction sector	elsevier.com	8
[19]	2017	A risk management framework for distributed agile projects	elsevier.com	9
[20]	2019	Risk management framework for distributed software team: A case study of telecommunication company	elsevier.com	10
[2]	2019	A framework for risk management in Scrum development process	elsevier.com	11
[21]	2020	Project planning and risk management as a success factor for IT projects in agricultural schools in Serbia	elsevier.com	12
[22]	2021	A risk prediction model for software project management based on similarity analysis of context histories	elsevier.com	13
[23]	2016	Expert's opinions on software project effective risk management	ieeexplore.ieee.org	14
[24]	2016	Experimental evaluation of a novel ISO 14971 risk management software for medical devices	ieeexplore.ieee.org	15
[25]	2016	Corporate risk estimation by combining machine learning technique and risk measure	ieeexplore.ieee.org	16
[26]	2017	Quantitative planning and risk management of Agile Software Development	ieeexplore.ieee.org	17
[27]	2017	Decision support system for risk assessment and management strategies in distributed software development	ieeexplore.ieee.org	18
[28]	2018	A critical analysis of software risk management techniques in large scale systems	ieeexplore.ieee.org	18
[29]	2018	A Software System for Risk Management of Information Systems*	ieeexplore.ieee.org	20
[30]	2018	Agile Software Risk Management Architecture for IoT-Fog based systems	ieeexplore.ieee.org	21
[31]	2018	Exploring Experiential Learning Model and Risk Management Process for an Undergraduate Software Architecture Course	ieeexplore.ieee.org	22
[32]	2018	Modeling information security threats for smart grid applications by using software engineering and risk management	ieeexplore.ieee.org	23
[33]	2018	Intelligent Software Platform and End-Point Software for Risk Management	ieeexplore.ieee.org	24
[34]	2019	Risk Management in Agile Software Development: A Survey	ieeexplore.ieee.org	25
[35]	2019	Agile risk management for multi-cloud software development	ieeexplore.ieee.org	26
[36]	2019	Risk Management Technology of Software Project Sustainability in Fuzzy Conditions	ieeexplore.ieee.org	27
[37]	2019	Risk Catalogs in Software Project Management	ieeexplore.ieee.org	28
[38]	2020	Data-driven Risk Management for Requirements Engineering: An Automated Approach based on Bayesian Networks	ieeexplore.ieee.org	29
[39]	2020	Risk Management in Software Engineering Using Big Data	ieeexplore.ieee.org	30
[40]	2021	Artificial Intelligence based Risk Management Framework for Distributed Agile Software Development	ieeexplore.ieee.org	31
[41]	2021	Adapting a Software Acquisition Curriculum to Instruct Supply Chain Risk Management in a Project-Based Software Development Course	ieeexplore.ieee.org	32

	Year	Title	Source	Seq
[42]	2021	Assessing the Risk of Software Development in Agile Methodologies Using Simulation	ieeexplore.ieee.org	33
[43]	2016	Software risk management: Using the automated tools	link.springer.com	34
[44]	2016	A study on software risk management strategies and mapping with SDLC	link.springer.com	35
[45]	2016	Risk Management During Software Development: Results of a Survey in Software Houses from Germany, Austria and Switzerland	link.springer.com	36
[46]	2016	Software Testing in Clinical Risk Management	link.springer.com	37
[47]	2016	Risk Factor Classification GEMIO in the Planning Phase of Logistic Project Management	link.springer.com	38
[48]	2016	Improving Project Risk Management of Cloud CRM Using DANP Approach	link.springer.com	39
[49]	2017	Concept implementation of decision support software for the risk management of complex technical system	link.springer.com	40
[50]	2017	3PR Framework for Software Project Management: People, Process, Product, and Risk	link.springer.com	41
[51]	2018	Agile risk management using software agents	link.springer.com	42
[52]	2018	Risk Management in Software Engineering: What Still Needs to Be Done	link.springer.com	43
[53]	2018	Application of a risk management tool focused on helping to small and medium enterprises implementing the best practices in software development projects	link.springer.com	44
[54]	2018	Risk Analysis and Management of Software V&V Activities in NPPs	link.springer.com	45
[55]	2019	Adaptation of open up in the scrum framework to improve compliance in scope, risk management and delivery times in software development projects	link.springer.com	46
[56]	2019	Towards risk-driven security requirements management in agile software development	link.springer.com	47
[57]	2021	A Scalable and Automated Machine Learning Framework to Support Risk Management	link.springer.com	48
[58]	2021	Requirement-oriented risk management for incremental software development	link.springer.com	49
[59]	2021	Open Chance and Risk Management Process Supported by a Software Tool for Improving Urban Security	link.springer.com	50
[60]	2016	A Multi-Disciplinary Software Suite for Uncertainty Quantification and Risk Management	researchgate.net	51
[61]	2017	Impact of Risk Management on Software Projects in Nigeria Using Linear Programming	researchgate.net	52
[62]	2019	Drinking Water Quality Risk Management. Risk Analysis of Nitrogen Groundwater Contamination Using Analytica Software	researchgate.net	53
[63]	2021	A Review on Some Pertinent Software Security Risk Management Frameworks	researchgate.net	54

A grouping of articles by database source can be seen in Figure 1.

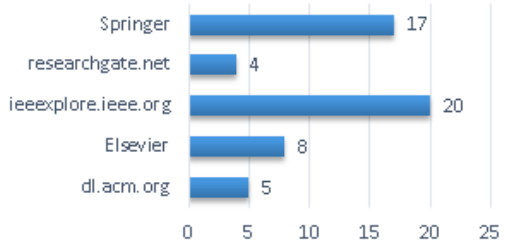

Figure 1 A grouping of articles by database source

After implementing the PICOC methodology for these papers, the results related to the research questions (RQ) presented in the previous section were obtained. Here are the answers to the five questions.

a. Does the paper discuss risk management?

Fifty-four articles can be accessed to carry out a study in the abstract, introduction, and discussion sections. These papers discuss risk management; the following is a mapping based on the year of publication, as shown in Table 5.

Table 5 Mapping based on the year of publication

	2016	2017	2018	2019	2020	2021	Total
Qty	12	8	11	11	5	7	54

b. Does the paper discuss software development projects?

Fifty-four papers or journals discuss risk management, and 20 discuss software development projects. With the help of the Mendeley Reference Manager application, these articles can be categorized into two parts, namely Journal Articles, and Conference Proceedings. Each contribution can be seen in Figure 2.

A total of 20 articles have been studied; each was coded (C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, and C13) for articles in the Conference Proceedings category. And the code (J1, J2, J3, J4, J5, J6, and J7) for articles in the Journal Article category, the bibliographic details can be seen in Table 7.

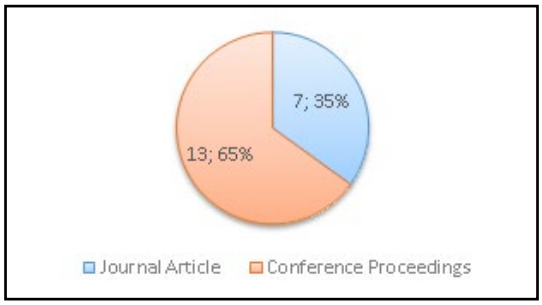

Figure 2 Articles of software development projects

c. What is the main focus of the research?

Table 6 shows the mapping of the primary research focuses from articles published between January 2016 to September 2021.

A total of 12 articles (C3, C5, C6, C10, C11, C13, J1, J2, J3, J4, J6, and J7) focused on Agile as the object of research. Agile methodology is an alternative to traditional linear sequential software development processes such as Waterfall. The term "Agile" in software development methodologies comes from the "Agile Manifesto," compiled in 2001. Among the Agile methods are Extreme programming, Test-driven development, Feature-driven development, and Scrum. In recent years, the software industry has shifted to adopting Agile practices that are responsive and flexible to change instead of traditional methods [64].

Three articles (C8, J5, and J6) specifically examine risk management in the software development process with Scrum. Scrum is based on empiricism and lean thinking. Empiricism asserts that knowledge comes from experience and makes decisions based on observation. Lean thinking reduces waste and focuses on what matters. Scrum uses an iterative and incremental approach to optimize predictability and control risk [65].

The Risk Management Tool includes the second most popular research focus. A total of 8 articles (C4, C5, C6, C13, J2, J3, J5, and J6) were reviewed, and even some articles carried the tools or applications used in risk management. The framework for risk management includes a widely discussed research focus, including eight articles (C5, C7, C8, C9, C11, J1, J4, and J7).

The risks involved in deployment have not gone unnoticed by researchers in the last five years. Five articles (C1, C3, C7, C10, and C12) focused on this issue. Each piece (C3 and C10) focuses on Quality Risks, and the last report (C2) focuses on People Risks. Visually, the trend of research focus is shown in Figure 3.

Table 6 Mapping of research focus

Method	Risk Focus				
	Deployment	People	Tools	Frame-work	Quality
Agile	C3 C10		C5 C6 C13 J2 J3 J6	C5 C11 J1 J4 J7	C3 C10
Scrum			J5 J6	C8	
Traditional	C1 C7 C12	C2	C4 C6	C7 C9	

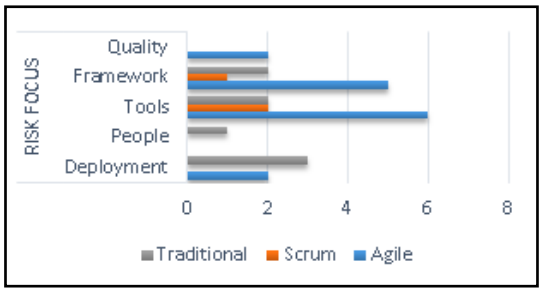

Figure 3 The trend of research focus

Table 7 Bibliographic information

Code	Author	Title	Year	Research Result
C1	B. Roy, R. Dasgupta, and N. Chaki	A study on software risk management strategies and mapping with SDLC	2016	Risk classification by SDLC phase
C2	S. Sharma and B. Ram	Causes of human errors in early risk assessment in software project management	2016	Strauss and Glasser's theoretical approach to human error
C3	K. Ghane	Quantitative planning and risk management of agile software development	2017	The concept for calculating risk value

Code	Author	Title	Year	Research Result
C4	A. Boranbayev, S. Boranbayev, A. Nurusheva, K. Yersakhanov, and Y. Seitkulov	A Software System for Risk Management of Information Systems	2018	Software to improve reliability and fault tolerance
C5	P. Gouthaman and S. Sankaranarayanan	Agile software risk management architecture for IoT-fog based systems	2018	Risk assessment software and framework to assist in identification and planning
C6	Y. M. García, M. Muñoz, J. Mejía, G. P. Gasca, and A. Mireles	Application of a risk management tool focused on helping to small and medium enterprises implementing the best practices in software development projects	2018	Case studies of the application of tools in risk management
C7	T. Hussain	Risk management in software engineering: What still needs to be done	2018	A framework that categorizes risks based on the relative importance and level of control of the project manager
C8	S. Chaouch, A. Mejri, and S. A. Ghannouchi	A framework for risk management in Scrum development process	2019	A framework involved in the deployment of the risk management process in Scrum
C9	W. S. Wan Husin, Y. Yahya, N. F. Mohd Azmi, N. N. Amir Sjarif, S. Chuprat, and A. Azmi	Risk management framework for distributed software team: A case study of telecommunication company	2019	Communication elements within the framework on DSD risk categories
C10	M. Hammad, I. Inayat, and M. Zahid	Risk management in agile software development: A survey	2019	Mitigation strategies used to minimize the impact of risk in the risk management process
C11	D. Ionita, C. van der Velden, H. J. K. Ikkink, E. Neven, M. Daneva, and M. Kuipers	Towards risk-driven security requirements management in agile software development	2019	A framework that can help Agile development teams consider security a priority in software risk
C12	C. M. Tae, P. D. Hung, and L. D. Huynh	Risk Management for Software Projects in Banking	2020	Analyze size, accuracy, time, cost, effort, knowledge, and experience to avoid the risk
C13	A. Puri and S. Sharma	Risk Management in Software Engineering Using Big Data	2020	Big data predictive analytics to make risk predictions in software projects
J1	S. V. Shrivastava and U. Rathod	A risk management framework for distributed agile projects	2017	A framework that categorizes risks in DAD (Distributed Agile Development) projects
J2	A. Aslam et al.	Decision Support System for Risk Assessment and Management Strategies in Distributed Software Development	2017	Tools that serve to make decisions for risk management in the software development process
J3	E. E. Odzaly, D. Greer, and D. Stewart	Agile risk management using software agents	2018	Tools used to support risk identification, assessment, and monitoring.
J4	V. Muntés-Mulero et al.	Agile risk management for multi-cloud software development	2019	The framework is generated from combining the previous risks that are used to mitigate the following risks
J5	A. S. Filippetto, R. Lima, and J. L. V. Barbosa	A risk prediction model for software project management based on similarity analysis of context histories	2021	Atropos model for measuring uncertainty in projects
J6	M. I. Lunesu, R. Tonelli, L. Marchesi, and M. Marchesi	Assessing the risk of software development in agile methodologies using simulation	2021	Model several key risk factors using the Agile development simulator
J7	M. Roy, N. Deb, A. Cortesi, R. Chaki, and N. Chaki	Requirement-oriented risk management for incremental software development	2021	A risk management framework for the ISD (Incremental Software Development) process that provides risk exposure estimates for projects

d. What is the result of the research?

The article (C1) produces a risk classification based on the phases in the SDLC (Systems Development Life Cycle). This allows researchers to apply various conceptual models or risk management frameworks and then analyze the occurrence of risk across all steps of the SDLC so that risk mitigation can be inventoried as quickly as possible [44]. However, the results of this study have not brought up a framework that can be integrated into all phases of the SDLC.

Article (C2) takes the theoretical approach of Strauss and Glaser to detect human errors in information security that can pose risks to the software development process [11]. However, this is only partial mitigation for the overall chances of a project.

In the article (C3), the researcher proposes a concept to calculate the risk value in the software development process using the Agile method based on input parameters with the desired target value limits and the appropriate level of confidence [26]. However, the concept being

carried out does not cover the planning and mitigation strategies that may occur at a value that has exceeded the target limit.

The article (C4) describes the software that has been developed to manage risk in the information system process. It enables developers to identify, evaluate, and neutralize information and other automated systems risks. In addition, the developed system has several other advantages, such as the ability to identify risks at an early stage of development, the convenient interface, and time-saving [29]. However, the addition of tools in the software development process can increase the workload of developers, considering that agencies that are only used half-heartedly will create invalid output results.

Article (C5) proposes an architecture and risk assessment framework system to identify and plan risk management in the software development process using the Agile method. Especially software development in IoT, Fog, and Cloud-based systems [30]. However, the proposed framework does not include an analysis of risk parameters, so further research is needed to create a more effective framework.

The article (C6) presents the results of a case study of the application of tools in essential risk management in two companies. The results of the hypothesis indicate that the use of these tools is helpful for implementation in software engineering projects [53]. However, these results cannot be generalized to other projects in the software development process. Because environmental and ethnic, or cultural factors can affect the results obtained.

The article (C7) examines the risk management process: risk planning; risk identification; risk analysis; risk response; and monitoring and control. This article presents a framework that categorizes risks based on their relative importance and perceived level of control over the project manager. The framework is classified into four quadrants: customer mandate, scope and requirements; execution; and the environment [52]. However, risk analysis becomes very difficult or impractical for large projects because the research only focuses on quantitative aspects and ignores qualitative elements. This makes the framework that is carried out ineffective and can be applied to large projects.

Article (C8) proposes a model of the activities involved in spreading the risk management process in the Scrum framework. The model emerged based on the respondent's questionnaire. The aim is to improve the methodology that maps the risk management principles to increase project success [2]. However, the results need to be verified by testing them in software development scenarios in various Scrum organizations, both on medium and large-scale projects. This risk management framework also needs to be further developed for other Agile methodologies such as Extreme Programming (XP), Dynamic System Development Method, Kanban, and Feature Driven Development (FDD).

The article (C9) adds a communication element to the DSD (Distributed Software Development) risk category. Communication will help grow team members to become aware of the risk, facilitate everyone responsible for managing risk, and understand the basis for decisions made and the reasons behind specific treatments or actions chosen [20]. However, this addition does not cover the categories of other risks.

The article (C10) presents the results of a survey conducted on industry practitioners of software developers using the Agile method. The survey contains the mitigation strategies to minimize risk in the risk management process to various software development life cycle stages. According to an industry survey, scheduled risk and varying requirements are the most experienced by practitioners. Most of the risk mitigation strategies followed involve using tools to communicate with clients, tracking requirements and change requests implemented in the project, and reducing the number of software bugs [34]. The author considers these parameters can be used as material to create a framework for risk management for future research to get more optimal results.

Article (C11) presents a framework to help Agile development teams consider security priority in software risk. The framework was developed and tested on a single software developer in the Netherlands and only applied to mobile and web applications [56]. Therefore, this framework only covers one aspect of risk management, so it is necessary to develop a framework for other elements.

The article (C12) analyzes the size, accuracy, time, cost, effort, knowledge, and experience to avoid or overcome many risks in information system project management at the Bank [15]. However, it does not discuss planning and risk mitigation strategies. In addition, the scope of research is only in the banking sector, so it cannot be confirmed for other industrial sectors.

The article (C13) raised issues in risk management in software engineering using big data. Predictive big data analysis is used to predict risks experienced before in software projects and provide proposals for possible risks that will arise accordingly [39]. However, checking unstructured data will be inconvenient and requires special skills to avoid invalid analysis results.

Article (J1) proposes a framework for risk categories, 'Group Awareness', 'External Stakeholder Collaboration', and 'Software Development Lifecycle' on a DAD (Distributed Agile Development) project. However, the DAD team needs to adopt practices to reduce the impact of spatial distance between stakeholders. Apart from geographic dispersion, other properties, including work culture, enormous project scope, temporal distance, and language barriers, which impact the DAD project, should also be considered to control risk [19]. Therefore, further research is needed to improve this framework.

The article (J2) proposes tools that can help decision-makers during DSD (Distributed Software Development) risk management [27]. However, these proposed tools have not linked the various planning stages with identifying variations in DSS (Decision Support Systems) outputs at different project stages. It is still necessary to add features in distributed development to the risk assessment results.

An article (J3) describes the underlying risk management model in Agile risk tools where software agents support risk identification, assessment, and monitoring. Interaction between agents, agent compliance with defined rules, and how agents react to project environmental data changes. The results show that agents help detect risks and respond dynamically to changes in the project environment, thereby helping to minimize human effort in managing risks in software development projects with Agile methods [51]. However, tools that are not perfect can increase the development team's workload because they can produce inappropriate analysis results.

Article (J4) combines the information gathered from the joint work in the previous process to become a framework used to mitigate the risks that will arise in Agile software development projects [35]. However, the risks that have not appeared before have not been thoroughly analyzed, so there is still a need to improve this framework.

The article (J5) uses the Atropos model to measure the uncertainty in the project with a value that is close to the actual financial impact of the identified risks. Implementation of risk recommendations based on historical similarity analysis of the context by providing advice and considering the characteristics of each new project [22]. However, additional prototypes are needed to compile a complete project history, thus allowing more information to be generated to support more significant risk recommendations and improve analysis of similarity and accuracy of risk recommendations.

The article (J6) introduces a new approach to modeling several key risk factors: project duration, the number of problems applied, and key statistics of problem-solving time. Using an Agile development simulator, this approach includes modeling Agile processes, collecting data from tools used for project management, and performing Monte Carlo process simulations to gain insight into the time and effort expected to complete a project and its distribution. The model parameters that can pose a risk are the error in the estimated effort to be developed, variations in developer assignments for these features, and obstacles related to developer availability and work completion [42]. However, this model still needs improvement by conducting more evaluations on case studies. And scale the model from one team to multiple teams involved in one or more projects.

Article (J7) proposes a risk management framework for the ISD (Incremental Software Development) process that estimates risk exposure for a project. The framework offers appropriate risk reduction strategies and works with the risk assessment module [58]. However, this proposed framework does not yet link the various planning stages with identifying risks at different project stages. It is still necessary to add features in distributed development to the risk assessment results.

e. Who has researched the most in this field?

Researchers who have contributed the most to research on risk management in software development projects can be seen in Table 8.

Table 8 List of Authors

Full Name	Paper	Risk Management	Development Method	Score
Aakash Puri	C13	Tools	Agile	1
Abdulaziz S. Almazyad	J2	Tools	Agile	1
Abid Khan	J2	Tools	Agile	1
Adeel Anjum	J2	Tools	Agile	1
Adeel Aslam	J2	Tools	Agile	1
Agostino Cortesi	J7	Framework	Agile	1
Alexsandro Souza Filippetto	J5	Tools	Scrum	1
Amjad Rehman	J2	Tools	Agile	1
Antonia Mireles	C6	Tools and Framework	Traditional	1
Askar Boranbayev	C4	Tools	Traditional	1
Asma Mejri	C8	Framework	Scrum	1
Assel Nurusheva	C4	Tools	Traditional	1
Azri Azmi	C9	Framework	Traditional	1
Babu Ram	C2	Human error	Traditional	1
Balázs Somosköi	J4	Framework	Agile	1
Bibhash Roy	C1	Deployment	Traditional	1
Chung Min Tae	C12	Deployment	Traditional	1
Coco van der Velden	C11	Framework	Agile	1
Dan Ionita	C11	Framework	Agile	1

Full Name	Paper	Risk Management	Development Method	Score
Darryl Stewart	J3	Tools	Agile	1
Des Greer	J3	Tools	Agile	1
Edzreena Edza Odzaly	J3	Tools	Agile	1
Eelko Neven	C11	Framework	Agile	1
Eric Willeke	J4	Framework	Agile	1
Gloria Piedad Gasca	C6	Tools and Framework	Traditional	1
Henk Jan Klein Ikkink	C11	Framework	Agile	1
Irum Inayat	C10	Deployment and Quality	Agile	1
Jacek Dominiak	J4	Framework	Agile	1
Jezreel Mejía	C6	Tools and Framework	Traditional	1
Jorge Luis Victória Barbosa	J5	Tools	Scrum	1
Kamran Ghane	C3	Deployment and Quality	Agile	1
Kuanysh Yersakhanov	C4	Tools	Traditional	1
Le Dinh Huynh	C12	Deployment	Traditional	1
Lodovica Marchesi	J6	Tools	Scrum	1
Mandira Roy	J7	Framework	Agile	1
Maria Ilaria Lunesu	J6	Tools	Scrum	1
Maryam Zahid	C10	Deployment and Quality	Agile	1
Maya Daneva	C11	Framework	Agile	1
Michael Kuipers	C11	Framework	Agile	1
Michele Marchesi	J6	Tools	Scrum	1
Mirna Muñoz	C6	Tools and Framework	Traditional	1
Muhammad Hammad	C10	Deployment and Quality	Agile	1
Nabendu Chaki	C1, J7	Deployment, Framework	Traditional, Agile	2
Naveed Ahmad	J2	Tools	Agile	1
Nilam Nur Amir Sjarif	C9	Framework	Traditional	1
Novarun Deb	J7	Framework	Agile	1
Nurulhuda Firdaus Mohd Azmi	C9	Framework	Traditional	1
Oscar Ripolles	J4	Framework	Agile	1
P. Gouthaman	C5	Tools and Framework	Agile	1
Peter Matthews	J4	Framework	Agile	1
Phan Duy Hung	C12	Deployment	Traditional	1
Ranjan Dasgupta	C1	Deployment	Traditional	1
Rituparna Chaki	J7	Framework	Agile	1
Roberto Tonelli	J6	Tools	Scrum	1
Robson Lima	J5	Tools	Scrum	1
Seema Sharma	C2	Human error	Traditional	1
Seilkhan Boranbayev	C4	Tools	Traditional	1
Shilpi Sharma	C13	Tools	Agile	1
Smrati Gupta	J4	Framework	Agile	1

Full Name	Paper	Risk Management	Development Method	Score
Sonia Ayachi Ghannouchi	C8	Framework	Scrum	1
Suprika Vasudeva Shrivastava	J1	Framework	Agile	1
Suresh Sankaranarayanan	C5	Tools and Framework	Agile	1
Suriayati Chuprat	C9	Framework	Traditional	1
Syrine Chaouch	C8	Framework	Scrum	1
Tanzila Saba	J2	Tools	Agile	1
Tauqeer Hussain	C7	Deployment and Framework	Traditional	1
Urvashi Rathod	J1	Framework	Agile	1
Victor Muntés-Mulero	J4	Framework	Agile	1
Wan Suzila Wan Husin	C9	Framework	Traditional	1
Yazriwati Yahya	C9	Framework	Traditional	1
Yerzhan Seitkulov	C4	Tools	Traditional	1
Yolanda Meredith García	C6	Tools and Framework	Traditional	1

Only Nabendu Chaki has published two articles (C1 and J7), focusing on research on deployment and quality of risk management in software development projects.

4. Discussion

From January 2016 to September 2021, we see trends in risk management research in software development projects focusing on Agile development methods and risk management tools. Fourteen articles (C3, C4, C5, C7, C8, C9, C11, J1, J2, J3, J4, J5, J6, and J7) carried new frameworks, conceptual models, and software tools.

The current issue, many researchers are trying to integrate risk management explicitly in every process of the software development life cycle in the Agile methodology by creating a comprehensive risk management framework, considering that the Agile and Scrum methods do not have a specific process for risk management [66]. So there is a need to integrate risk management into it explicitly.

Several SLRs have been carried out by other researchers, with the following results:

[67] identified challenges in the context of Global Software Development (GSD) with Software Project Management (SPM) activities that include an integrative framework. The difference with this paper is that the researcher did not examine research on tools in risk management and only examined 15 articles.

[68] research on applying risk mitigation techniques in Agile GSD to increase time efficiency, acquire more resources, lower costs, and maintain a competitive advantage. However, it only focuses on 53 papers discussing Agile methods.

[69] looked for potential studies in 45 articles discussing the identification process in risk management and activation of risk management using the ISO 31000 standard, which differs from this paper which does not compare the use of the ISO standard.

5. Conclusion

There are seven articles (C5, C7, C8, C11, J1, J4, and J7) that are very interesting to be explored further. The framework proposed by these articles deserves to be tested in-depth.

This SLR will be used for further research to strengthen the theoretical basis, compare research results, and describe the shortcomings of previous research.

This literature research is not perfect because the authors have difficulty accessing several international journals fully. Other researchers can use different methods like SPIDER (sample, phenomenon of interest, design, evaluation, research type) to get more significant results.

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