Critical Challenges to Adopt DevOps Culture in Software Organizations: A Systematic Review

MUHAMMAD SHOAIB KHAN[1], ABUDUL WAHID KHAN[1], FAHEEM KHAN[2], MUHAMMAD ADNAN KHAN[3,4], AND TAEG KEUN WHANGBO[2], (Member, IEEE)

[1]Department of Computer Science, University of Science and Technology Bannu, Bannu 28100, Pakistan
[2]Artificial Intelligence Laboratory, Department of Computer Engineering, Gachon University, Seongnam 13120, South Korea
[3]Pattern Recognition and Machine Learning Laboratory, Department of Software, Gachon University, Seongnam 13120, South Korea
[4]Faculty of Computing, Riphah School of Computing and Innovation, Riphah International University, Lahore Campus, Lahore 54000, Pakistan

Corresponding authors: Faheem Khan (faheem@gachon.ac.kr) and Taeg Keun Whangbo (tkwhangbo@gachon.ac.kr)

ABSTRACT DevOps is a set of practices and a cultural movement that aims to break down barriers between development and operation teams to improve collaboration and communication. Different organizations have embraced DevOps principles due to the massive potential, such as a much shorter time to production, increased reliability and stability. However, despite the widespread adoption of DevOps and its infrastructure, there is a lack of understanding and literature on the key concepts, practices, tools, and challenges associated with implementing DevOps strategies. The main goal of this research paper is to explore and discuss challenges related to DevOps culture and practices. Moreover, it describes how DevOps works in an organization, provides a detailed explanation of DevOps, and investigates the cultural challenges that organizations face when implementing DevOps. The proposed paper reveals ten critical challenges that need to be addressed in adopting the DevOps culture. The challenges are further analyzed on the basis of the various continents. According to the findings, the following critical challenges are considered during the implementation of a DevOps culture: lack of collaboration and communication, Lack of skill and knowledge, complicated infrastructure, Lack of management, Lack of DevOps approach, and trust confidence problems.

INDEX TERMS DevOps, culture, challenges, systematic literature review (SLR).

I. INTRODUCTION

Software development techniques are being changed to achieve better collaboration and consistency in projects between the development and operations teams [1]. The emergence of new digital technologies introduces enterprises with opportunities but also brings significant challenges [2]. In the DevOps movement, in the context of quick software delivery, developers provide functional software and hardware to the customer at the earliest possible time without any unwanted delays [3]. DevOps is a set of practices and cultural values whose main objective is to integrate the software industry, eliminate barriers, and improve the collaboration and communication in an effective way between the development team and operation team [4]–[6]. DevOps is a blend of frameworks to enhance cooperation and connectivity between developer personnel and IT operation personnel's to address critical issues during software development [7]. The term DevOps is a combination of the development team (software

developers, programmers, testers, and quality assurance) and the operations team (system administrators, database administrators, network technicians, and experts of software production and management) [8], [9]. It encourages everyone to provide software with special priority over developers, testers, and operations personnel [10]. Development and operational teams are no longer isolated; they integrate and operate in a software development system and are not limited to a single function [11]. The DevOps Movement focuses on enabling communication and collaboration between all stakeholders, which is crucial in delivering software [3]. Culture, practices and tools are the three backbones of DevOps; culture defines a way of thinking with some basic standards. Practices reflect culture's significant success, and numerous tools are required to implement these methods [12], [13]. Agile methods enable IT services to be constantly updated so that businesses can seize market opportunities and minimize the time it takes to meet customer requirements [14]. The concept of DevOps is based on four core values of CAMS, culture, automation, measurement and sharing that affect the current needs of the software development lifecycle [15].

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Despite various sophisticated tools, DevOps is just another buzzword, and there is no concrete way to describe it. Thus, the proposed study believes that a culture of shared responsibility and collaboration between the development team and operation team will deliver software to business stakeholders continuously [16], [17].

DevOps is getting popular with each passing day due to the faster application delivery to the market with low cost and short duration. The integration of development and operational teams promises rapid deployment and testing of software associated with each build cycle. According to Capgemini's annual quality report 2016-17, 88% of the companies used or tested the DevOps principles [18]. Annual 'State of DevOps' reports reveals that as DevOps practices spread, the number of DevOps teams has grown from 19% in 2015 to 22% in 2016 to 27% in 2017 [6], [19]. Organizations have massively embraced DevOps principles due to current customers' demand for highly available, continuous-release, and high-value applications that are useable anytime, anywhere at any platform [20]. Leading ventures such as Google, Netflix, Amazon, LinkedIn, Spotify, Flicker, and Etsy have adopted DevOps practices to release software with a higher pace and better quality [21]–[24]. The main objective of the IT organization is always to bring new and superior quality applications with more features to the user, be its an internal consumer of the organization or a consumer in the market [25].

Despite the growing popularity of DevOps, it is challenging to adopt DevOps techniques because there is no clear overview of DevOps procedures. DevOps needs further investigation into how to adopt DevOps principles in a highly monolithic environment that makes it difficult for organizations to decide which methods to embrace and enhance [26]. Transforming an organization's traditional infrastructure into a DevOps culture affects everyone from management to every team, as the DevOps culture requires learning new tools, new skills, and new social guidelines [27]. Cultural change is the most challenging barrier between development and operation to implement DevOps practices [27]. Culture is an essential element for an IT organization, but it is a vital element of DevOps literature for the successful adoption of DevOps culture [25]. If an organization whose development team is geographically separated from the operations team, it is difficult for them to empathize, collaborate, and invest in improving how they communicate more frequently with teams [28].

With that in mind, the primary purpose of this article is to understand the nature of DevOps culture, recognize the benefits and challenges, and identify different ways to adopt DevOps. According to the authors' best knowledge, despite the growing popularity and adoption of DevOps in organizations, there is little literature, and empirical study of DevOps culture has been conducted and implemented there. In this regard, the proposed research led an SLR to review and explore the various challenges vendor organizations face in the DevOps culture. This work is valuable and a roadmap for practitioners who want to check this topic to address specific organizational issues. Following research questions are formulated through SLR.

RQ No.1 What are the cultural challenges that vendor organizations in DevOps development process should avoid?

RQ No.2 Does the identified challenges varies from continent to continent while adopting DevOps culture?

The rest of the paper is organized as follows: Section 2 describes the background; section 3 explains the research methodology, section 4 describes the results and discussion, section 5 describes the limitation of the proposed research study, and section 6 describes the conclusion and future analysis.

II. BACKGROUND
In modern software development, competition, and rapid technological advancement and automation, technological progress is often identified in a new digital device model that provides a speedy software release to end-users [29].

Software companies are shifting from legacy infrastructure to a new era in digitization, where they provide fast and consistent applications to consumers. Traditional software methodologies are more prolonged, where customers wait for months or even years for new updates and giving feedback after the release. Many software development methods, such as the waterfall model, incremental and agile methodologies, are older and spend more time releasing software to users. The waterfall model or traditional model is a classical model used in the software life cycle. It is effortless to use, and it follows a linear and sequential approach. The software in the waterfall model is monolithic and works with single-layer software in different environments [30]. Each development process has a separate phase, and with the completion of the previous stage, the next step is executed, resulting in a more extended period.

On the contrary, agile methodology combines the incremental and iterative model that splits the application into a small number of iterations. These iterations are completed in one to three weeks [31]. As a result, the agile approach is widely used in static environments but is generally not suitable for complex projects.

The concept of DevOps has emerged to release applications to end-users with quality and instant feedback. DevOps originated at the Agile Conference in Toronto in 2008, where Patrick Debois introduced DevOps as a portmanteau for development and operations. They collaborate and communicate so that they provide services quickly according to the customer demands [22]. However, the literature shows that people, in general, are resistant to change, and they work according to traditional methods [32]. The key to the successful implementation of the DevOps culture depends on the coordination, communication, and teamwork of development and operational personnel. Thompson and Shafter [33], [34] name this ''Wall of Confusion'' that has to be eliminated. The merging of development and operational teams can result in a cross-functional team where different

skilled people share their common goals and information collaboratively [23].

DevOps adoption is not similar for all organizations. When starting DevOps practices, the company does not know various facts regarding the project, products and procedures are not clearly understood [33]. Many challenges are identified when adopting the DevOps approach, developers and the Operational team need to learn new technologies, tools, and methods, and significant efforts are required to start the deployment process automatically [35]. The biggest downside of DevOps maturity models is less documentation to relate DevOps methodology to improving technology delivery and better business outcomes [36]. DevOps and Agile are the same, but in several important facets, they are dissimilar. Agile reflects a change in thinking, while DevOps is a conceptual framework that imposes changes in organizational culture [7]. DevOps does not have procedures of agile methodologies such as scrum and extreme programming; DevOps contains a broad and diverse range of methods and guidelines effectively implemented in a particular environment [37]. The smaller the number of people in a small organization, the less time it will take to adopt new ideas.

In contrast, organizations with complex infrastructure and rules may take longer to embrace the unique culture of DevOps [28]. The major hurdle in DevOps is the organization's apathy, which prevents team members from accessing undisclosed data, making it difficult for business users to do business with them [38]. As a result, more organizations do not implement DevOps properly because it contains more than adopting tools. In addition, the excessive DevOps information sources and less guidance lead to confusion among team members [39]. Leite *et al.* [40], [41] performs the SLR to inspire DevOps adoption and reveals that technical hurdles related to DevOps are more clearly described in the literature. Still, minimal literature studies have paid attention to implementing DevOps culture and their practices in the industry effectively. With the rapid development of technology, DevOps culture needs practically understandable research to provide consumers with reliable capabilities [42].

III. METHODOLOGY

A systematic approach is needed to answer the research questions as mentioned in the previous section. The proposed study uses a qualitative approach to find the limited amount of analyzed literature and extract the desired data. Therefore, the SLR is followed to identify the key challenges, the same methodology used by other researchers [43], [44]. SLR has a long-standing interest in software engineering, and researchers will adopt and adhere to guidelines through Kitchenham and Charter [45]. The SLR differs from the typical literature survey and is a new way of identifying, calculating, and finds the most relevant published studies, using the default protocol of search strings based on research questions. It is noteworthy from the literature that SLRs can

TABLE 1. Genral format for search terms construction.

Intervention	Challenges, barriers, issues, problems
Population	DevOps Culture, Vendor Organization
Outcome	DevOps Culture Solution

TABLE 2. RQ No.1 search terms construction.

Intervention	What culture challenges are avoided by …
Population	Vendor organization in….
Outcome	DevOps Culture Solution

allow practitioners to make informed decisions regarding the selection and adoption of technology [46].

SLR finds more reliable, accurate, and less biased results than the general literature review. The SLR contains three main phases, i.e., planning, conducting, and reporting phases. In the planning phase, there are two steps:
 I. Find the need to review
 II. Develop and validate the SLR protocol
In the conducting phase, the following steps are followed:
 I. Finding primary studies using search terms
 II. Final study selection based on predefined inclusion/exclusion criteria
 III. Evaulate the quality of the research
 IV. Data extraction from a final selection of articles using a predefined data extraction form
 V. Synthesize data extracted from articles
In the reporting phase, the results are drafted and published.

The proposed study has developed an SLR protocol that has been partially accepted and will be published soon.

A. CONSTRUCTION OF SEARCH STRING

After constructing the research questions the following terminologies are assisting for designing to create search terms. Tab. 1 show the genral form of search terms construction and Tab. 2 show details of search terms construction for the RQ No.1

1) TRIAL SEARCH

In order to search the most relevant literature available about DevOps culture, the trial search is carry out in online electronic databases which are IEEE Xplore, ACM Digital Library, Springer Link, Google Scholar, and Science Direct.

(DevOps AND Culture AND Challenges AND vendor)

Now we expand our trial search string for more details:

((DevOps OR "development operations" OR "cross-function collaboration" "software development" OR "product development" OR "IT operation" OR "collaborative culture" OR "continuous integration" OR monitoring OR management OR sharing) AND (culture OR values OR Society OR literature OR lifestyle OR growth) AND (challenges OR problems OR barriers OR obstacles OR issues) AND (vendor OR supplier OR provider OR broker OR developer OR dealer OR agent OR merchant)).

2) RECOGNIZING SEARCH TERMS ATTRIBUTES

For constructing the search string/term the following search approach is used.

a. Research questions are used for the extraction of major terms, by identifying population, intervention and outcome.
b. Alternative spellings and synonyms are found out for the major terms.
c. Keywords are verified in any relevant paper.
d. Boolean operators such as 'OR' for the concatenation of alternative spellings and synonyms and 'AND' for the concatenation for the major terms.

Results for a

RQ No.1: DevOps, culture, challenges, vendor

RQ No.2: practices, culture, challenges, DevOps process

RQ No.3: Practices, culture, challenges, DevOps development

Results for b

1. **RQ No.1**
2. **DevOps:** (DevOps OR "development operations" OR "cross-function collaboration" "software development" OR "product development" OR "IT operation" OR "collaborative culture" OR "continuous integration" OR monitoring OR management OR sharing)
3. **Culture:** (culture OR values OR Society OR literature OR lifestyle OR growth)
4. **Challenges:** (challenges OR problems OR barriers OR obstacles OR issues)
5. **Vendor:** (vendor OR supplier OR provider OR broker OR developer OR dealer OR agent OR merchant)

Results for c

DevOps, DevOps development, DevOps process, DevOps culture, culture, challenges, culture challenges, vendor, vendor organization.

Result for d

1. **RQ No.1**
2. ((DevOps OR "development operations" OR "cross-function collaboration" "software development" OR "product development" OR "IT operation" OR "collaborative culture" OR "continuous integration" OR monitoring OR management OR sharing) AND (culture OR values OR Society OR literature OR lifestyle OR growth) AND (challenges OR problems OR barriers OR obstacles OR issues) AND (vendor OR supplier OR provider OR broker OR developer OR dealer OR agent OR merchant))

3) FINAL SEARCH STRING CONSTRUCTION

The proposed study has developed the following search string to identify the most relevant research articles from the available literature. The following search string was used in five different digital libraries/search engines, i.e., Google Scholar, Springer Link, Science Direct, ACM Digital Library, and IEEE Explore.

((DevOps OR "continuous integration" OR "software automation" OR "cross-function collaboration" OR "continuous deployment") AND (culture OR values OR literature) AND (challenges OR issues OR barriers) AND (vendor OR supplier OR trader).

Tab. 3 show the results of research papers from the five digital libraries.

TABLE 3. Results of various databases using search string.

Name of the Database	Search Result
Google Scholar	6580
ACM Digital Library	114
Science Direct	1233
Springer Link	3543
IEEE Xplore	25
Total	**11495**

B. INCLUSION CRITERIA

The proposed study used the following inclusion criteria to filter relevant literature to extract the desired data. The focus has been on those papers where the challenges and practices of DevOps culture are addressed. In addition, the proposed study has considered those papers written in the English language and electronically available. The following inclusion criteria are defined:

- Research articles that are related to DevOps culture.
- Research articles that address the cultural challenges faced by vendor organizations in the DevOps developing processes.
- Research articles that illustrate ways to solve cultural challenges.
- Research articles that illustrate the interrelation between vendor organization and DevOps culture.
- Research articles that illustrate real-world practices to accept DevOps culture successfully.
- Research articles are added whose title is associated with DevOps culture.
- Research articles are added whose keywords match the keywords as described in the search string.

C. EXCLUSION CRITERIA

Exclusion criteria are used when the research publications are not a concern to this research study and eliminate all unrelated literature not used for the data extraction process. The following exclusion criteria are defined:

- Research articles that are not related to our research questions.
- Research articles that are not associated with DevOps Culture.
- Research articles that are not associated with the vendor organization.
- Research articles that do not explain DevOps culture and its challenges.
- Research articles that do not explain practices in DevOps culture.
- Research articles that do not satisfy DevOps culture and practices in the software development companies.
- Research articles are duplicated in more than one digital library.
- Excluded research articles that are not written in the English language.

TABLE 4. Results of primary and final selected papers.

Name of Database	Search Result	Primary Selection	Final Selection
Google Scholar	6580	184	32
ACM Digital Library	114	31	7
Science Direct	1233	53	6
Springer Link	3543	110	15
IEEE Xplore	25	2	6
Total	11495	380	**66**

TABLE 5. List of identified critical challenges through SLR.

S. No	Challenges	Frequency (N=66)	Percentage
1	Lack of Collaboration and Communication	45	68
2	Lack of Skill and Knowledge	37	56
3	Criticism Practices	33	50
4	Lack of DevOps Approach	31	47
5	Lack of Management	30	45
6	Trust and Confidence Problems	30	45
7	Complicated Infrastructure	23	35
8	Poor Quality	22	33
9	Security Issues	19	29
10	Legacy Infrastructure	15	23

D. STUDY SELECTION

After implementing the inclusion/exclusion criteria, the proposed study found 380 research papers out of 11495 in five digital libraries as the primary choice. Then, after reading the full text of the primarily selected articles in detail and using the inclusion/exclusion and quality testing criteria, the proposed study finally decided on the 66 research papers shown in Tab. 4.

IV. RESULTS AND DISCUSSIONS

A. LIST OF CRITICAL CHALLENGES OF DevOps CULTURE

In this section, the authors discuss the main challenges of the study found through SLR and answer the defined research question 1. Tab. 5 presents a list of 10 critical challenges identified through SLR. The proposed study has considered all those challenges as essential whose frequency is >=20%. The same approach is used by other researchers in their study [47], [48].

The lack of collaboration and communication has been identified as the most critical challenge, with a frequency of 68%. Developers and IT operations teams do not share their common goals and plans, making it difficult to communicate appropriately, resulting in software delays [11]. It might be challenging to communicate effectively when people have distinct professional and personal backgrounds. If they are not properly managed, they may become disoriented and lose their goals. Establishing an environment of mutual cooperation is a big step, as it needs people to evaluate and

rearrange people's perceptions of their teams, organizations and clients. The lack of skill and knowledge in this research study is another significant challenge and constitutes 56% of the published articles. Some organizations do not have as many skilled employees because implementing DevOps practices requires both development and operation skills and knowledge with a mindset change [7]. There is a lack of technical knowledge and a lack of understanding of the key concepts, methods, tooling, and key benefits and challenges of implementing DevOps. Many organizations lack the necessary training and motivation to learn DevOps, and people are only interested in their area of expertise, which creates numerous challenges. Criticism practices have highlighted 50% frequency in the published literature as a critical challenge that harms the DevOps culture. A survey shows that the biggest obstacle to the successful adoption of DevOps is considering team culture to address the human factor as it is more complex than the technical factor [49]. A blaming culture frequently focuses on punishment, bad fights, pointing fingers, and creating negative perceptions that lead to destructive behaviour, causing friction in the work flow. The most important issue in integrating DevOps into an organization is that people oppose attitudes that are typically an impediment to organizational change success.

In this research study, the lack of the DevOps approach (47%) has been recognized as a major issue in adopting DevOps culture. Development and IT operations teams work separately in some organizations and have little experience in the DevOps environment [50]. It is difficult to integrate new practises and tools into organizations and teams because there is a lack of shared understanding of what DevOps entails in academia and the practitioner community, as well as DevOps has not been systematically planned and managed in large-scale projects. Management plays a vital role in the success of any organization. Lack of Management (45%) is also a significant challenge in the list. In large organizations, managing change is essential for handling people when they face fundamental changes in their job roles and encouraging people to do what is necessary for their part [51]. A lack of management empathy between the development and operations teams is to blame for the creation of an environment that leads to project failure. If leaders demonstrate through their actions that information is only a hindrance to their personal interests, then management and DevOps have different priorities, resulting in scheduling conflicts and radical changes in their roles and resource issues. The proposed results also identified "Trust and Confidence Problems (45%)" as another difficult barrier for DevOps culture. In an environment where there is a lack of trust between teams, the risk of job loss and loss of control due to a changing culture identifies as a critical challenge in adopting DevOps [52]. In DevOps, a lack of trust and misunderstanding are major cultural concerns that can lead to a resistance mindset out of fear of losing one's job as shown in Tab. 5. Moving to DevOps is more difficult in these low-trust cultures due to poor socialisation,

insufficient face-to-face meetings and communication, which can result in lost customers and revenue, as well as a negative impact on the organization's reputation. Finally, complicated infrastructure (35%) is a significant barrier that affects the overall performance of an organization.

The use of many new tools complicates the organization's infrastructure and makes it costly for team members, adversely affecting the adoption of DevOps [15], [53]. Moving from general organizational ideals to a more granular level, DevOps faces the most significant hurdles due to its complicated organizational structure and cultural barriers. The most difficult task is transforming into a highly regulated culture, that enable teams to become innovative, dependable, and cost efficient. Another challenge on the list is poor quality, with a frequency of 33%. The operations department lacks confidence in putting software into production from development, because it lacks a clear vision of the results and cannot guarantee product quality. Most teams work on technical debts, and policies do not conform to guidelines that result in poor quality and software release delays [54], [55]. When there is a high level of turnover in an organization, product releases are delayed, resulting in delayed feedback and problem fixes, which can lead to vulnerable software. Security plays a vital role in the success of any organization. The literature found that security is the most significant barrier to adopting DevOps, and studies have identified its 29% frequency. When a team lacks strong securities engineers, some practitioners will have access to restricted data, which can be controversial in some situations, such as financial systems. Some people have access to databases, allowing them to steal sensitive information. The major problem is to allow people inside when they are needed, but to keep them out when they are not. Suppose the security procedures are not considered in advance. In that case, people are the leading cause of the error. They find their self-proclaimed method to implement security inappropriately by ignoring the threats towards the security environment [56]–[58]. The final critical issue on our list is legacy infrastructure and is identified by 23 percent of the literature frequency. When an organization sticks to its traditional practices and lacks the necessary expertise in methods, the danger goes to a culture of tolerance where mistakes are punished politically [59], [60]. Because many compliance frameworks are created for traditional methods, persuading firms of the long-term benefits of these new technology to invest is difficult.

B. DOES THE IDENTIFIED CHALLENGES OF DevOps CULTURE VARY FROM CONTINENT TO CONTINENT?

The proposed study has used the SPSS tool to determine the frequency of various continents for the DevOps culture challenges. Chi-square is used to test the significant difference between the identified challenges based on the continent, if any? The goal was to determine whether the identified challenges were the same across all continents or differed. The chi-square linear by linear association test

is used to analyze these cultural challenges to assess the significance of differences between these cultural challenges across continents. These cultural barriers were compared across six continents (Asia, Europe, North America, South America, Africa, and Australia) and a diverse continent.

Tab. 6 shows the detail of risk/challenges across different continents. It shows that six challenges occurred in Asia, 31 in Europe, 20 in North America, 3 in South America, 1 in Africa, and 5 in diverse continents. Many challenges have zero occurrences in Africa, and some challenges do not exist on other continents. 'Lack of Management,' 'Lack of DevOps Approach,' and 'Security Issues' have the highest frequency of 100% in Africa, indicating that these challenges are the most critical in Africa. Other challenges in Tab. 6 does not exist on the African continent. 'Lack of Skill and Knowledge' and 'Security Issues' have no occurrence in Asia, which means that these challenges are not critical.

According to Tab. 6, three challenges need more attention during the adoption of DevOps culture. 'Lack of Collaboration and Communication,' 'Lack of DevOps Approach,' and 'Criticism Practices' have the highest frequency among all challenges. The proposed study applies Spearman's Rank Correlation as shown in Tab. 7 on critical challenges identified through SLR in two Continents Europe and North America. It shows a strong relationship between these two continents. Its degree of correlation is 0.811, which is an excellent coefficient correlation. The relationship between the two continents (Europe and North America) is shown in Fig. 1 using the SPSS tool.

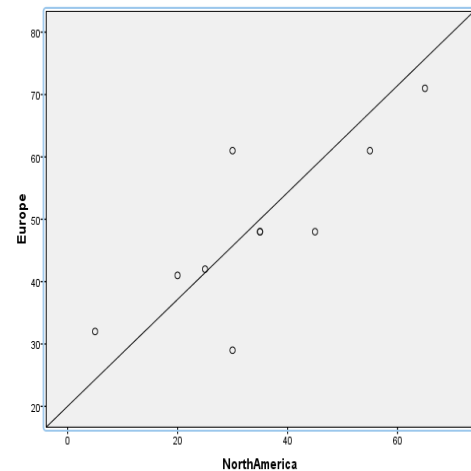**FIGURE 1.** Relationship between the two continents (Europe and North America).

Applying Spearman's rank correlation on Challenges identified in continent Asia and South America in respect of degree of relationship shows that there is a strong relationship between the two continents as shown in Tab. 8. The correlation coefficient between them is 0.612 suggesting that a strong and positive relationship exists.

TABLE 6. DevOps culture challenges, continent based frequency, and percentage.

Challenges	Frequency (N=66)												Chi-square Test (Linear-by-Linear Association) α = .05		
	Asia No=06		Europe No=31		North America No= 20		South America No=03		Africa No= 01		Mixed No=05		X²	df	p
	FRQ	%	FRQ	%	FRQ	%	FRQ	%	FRQ	%	FRQ	%			
Lack of Collaboration and Communication	5	83	22	71	13	65	3	100	0	0	2	40	2.522	1	0.112
Lack of Skill and Knowledge	0	0	21	68	11	55	3	100	0	0	2	40	0.000	1	0.988
Complicated Infrastructure	1	17	15	48	4	20	1	33	0	0	2	40	0.094	1	0.759
Lack of Management	2	33	19	61	6	30	1	33	1	100	1	20	1.771	1	0.183
Lack of DevOps Approach	1	17	15	48	9	45	2	67	1	100	3	60	1.603	1	0.206
Trust and Confidence Problems	3	50	15	48	7	35	3	100	0	0	2	40	0.096	1	0.757
Security Issues	0	0	9	29	6	30	1	33	1	100	2	40	1.807	1	0.179
Criticism Practices	5	83	15	48	7	35	2	67	0	0	4	80	0.115	1	0.735
Legacy Infrastructure	1	17	10	32	1	5	1	33	0	0	2	40	0.049	1	0.825
Poor Quality	2	33	13	42	5	25	0	0	0	0	2	40	0.291	1	0.590

TABLE 7. Spearman's rank correlation in Europe and North America.

	Sample size find through SLR (n=66)			
	Europe (N=31)		North America (N=20)	
	% of occurance	Rank	% of occurance	Rank
Lack of Collaboration and Communication	71	1	65	1
Lack of Skill and Knowledge	68	2	55	2
Complicated Infrastructure	41	7	20	7
Lack of Management	61	3	30	5.5
Lack of DevOps Approach	48	4.5	45	3
Trust and Confidence Problems	48	4.5	35	4.5
Security Issues	29	9	30	5.5
Criticism Practices	48	4.5	35	4.5
Legacy Infrastructure	32	8	05	8
Poor Quality	42	6	25	6

This relationship is shown in the following Table 8. Applying Spearman's rank correlation on Challenges identified in continent Africa and Mixed Continents in respect of degree of relationship shows that there is a strong relationship between the two continents. The correlation coefficient between them is 0.522 suggesting that a strong and positive relationship exists. This relationship is shown in the following Tab. 9.

C. VALIDATION OF IDENTIFIED CRITICAL CHALLENGES THROUGH EMPIRICAL STUDY

To validate our critical challenges, we conducted a questionnaire survey using Google Forms to gather expert feedback.

We provided a link to our Questionnaire Survey to 60 people after they agreed to participate. The online questionnaires were filled up by 34 individuals. We examined each of the 34 responses in greater detail and eliminated four (04) responses due to their non-relevancy. As a result, the final sample has been reduced to 30 responses. As a result, we achieved a retort rate of 30 percent in the study. The details of the survey respondents are given below in Apendix. According to Table 10, all of the DevOps Culture challenges have a maximum occurrence of greater than 50%. Among all DevOps culture challenges, the lack of collaboration and communication has the highest frequency and percentage.

TABLE 8. Spearman's rank correlation in Asia and South America.

| | Sample size find through SLR (n=66) | | | |
| | Asia (N=06) | | South America (N=03) | |
	% of occurance	Rank	% of occurance	Rank
Lack of Collaboration and Communication	83	1.5	100	1.5
Lack of Skill and Knowledge	0	5.5	100	1.5
Complicated Infrastructure	17	4.5	33	3.5
Lack of Management	33	3.5	33	3.5
Lack of DevOps Approach	17	4.5	67	2.5
Trust and Confidence Problems	50	2	100	1.5
Security Issues	0	5.5	33	3.5
Criticism Practices	83	1.5	67	2.5
Legacy Infrastructure	17	4.5	33	3.5
Poor Quality	33	3.5	0	4

TABLE 9. Spearman's rank correlation in Africa and mixed continents.

| | Sample size find through SLR (n=66) | | | |
| | Africa (N=01) | | Mixed Continents (N=05) | |
	% of occurance	Rank	% of occurance	Rank
Lack of Collaboration and Communication	0	2.5	40	3.5
Lack of Skill and Knowledge	0	2.5	40	3.5
Complicated Infrastructure	0	2.5	40	3.5
Lack of Management	100	1.5	20	4
Lack of DevOps Approach	100	1.5	60	2
Trust and Confidence Problems	0	2.5	40	3.5
Security Issues	100	1.5	40	3.5
Criticism Practices	0	2.5	80	1
Legacy Infrastructure	0	2.5	40	3.5
Poor Quality	0	2.5	40	3.5

TABLE 10. Critical challenges.

S No.	Critical Challenges	Agree	Percentage	Disagree	Percentage	Not Sure	Percentage
1	Lack of Collaboration and Communication	24	80	5	17	1	3
2	Lack of Skills & Knowledge	18	60	8	27	4	13
3	Criticism Practices	23	77	3	10	4	13
4	Lack of DevOps Approach	22	73	6	20	2	7
5	Lack of Management	21	70	8	27	1	3
6	Trust and Confidence Problems	19	63	10	33	1	3
7	Complicated Infrastructure	19	63	5	17	6	20
8	Poor Quality	17	57	10	33	3	10
9	Security Issues	21	70	6	20	3	10
10	Legacy Infrastructure	17	57	3	10	10	33

Our findings show that the experts agree with our findings, stating that the lack of collaboration and communication challenges are the most common, with a frequency of 24 and a percentage of 80 percent. The criticism practises challenge has a frequency of 23 and a percentage of 77%, the lack of a DevOps approach has a frequency of 22 and a percentage of 73%, and security issues have a frequency of 21 and a percentage of 70%. Trust and confidence problems and complicated infrastructure challenges have the same frequency of 19 and percentage of 63 percent, whereas the lack of skills & knowledge challenge have the frequency of 18 and percentage of 60 percent, and poor quality and legacy infrastructure challenges have the same frequencies of 17 and percentages of 57 percent.

V. LIMITATIONS

The proposed study used SLR to conduct a systematic review of the literature. The proposed research followed every step of the SLR procedure. In this study, 66 papers are found as a final sample for data extraction. The limitation to this study that DevOps is a new concept means that there is little literature on DevOps culture. In addition, Google Scholar shows only 184 results out of 6580. Another limitation of this study is that in different continents, the concept of DevOps is not followed

due to its complexity, so data analysis is very limited in some continents. The main goal is to identify any differences between these two continents regarding the identified critical challenges. The validity of the results is a crucial DevOps culture challenge, as mentioned in the proposed study. Because of these factors, the proposed research findings require validation from industry practitioners, and it is intended to conduct empirical research in the industry to validate the SLR findings.

VI. CONCLUSION AND FUTURE DIRECTIONS

The proposed study identified a list of ten critical challenges using SLR, as shown in Tab. 3. Six of these challenges were ranked as pressing challenges for the DevOps culture adoption. These vital challenges are: 'Lack of collaboration and communication,' 'Lack of skill and knowledge, 'complicated infrastructure,' 'Lack of management, Lack of DevOps approach, and 'Trust and confidence problems. These critical challenges require appropriate attention for their successful adoption. As a future goal, the proposed study will investigate different SLR practices and conduct an empirical study for industry validation to address the question ''How to resolve the identified challenges?''.

The proposed study also compared these identified challenges in various continents. The primary goal is to provide DevOps organizations with solid DevOps knowledge to assist them in designing and implementing successful DevOps culture adoption. Therefore, the proposed study recommends that DevOps vendors focus on the frequently cited challenges. (RQ1). The proposed study identified differences in various continents in the list of critical challenges for Asia, Europe, North America, South America, and Africa based on the proposed study analysis due to people with different cultural backgrounds and having other preferences.

On the other hand, the proposed study has analyzed various organizations' identified challenges (small, medium, large, mixed, and unknown). Some significant challenges have been observed to be shared by three types of organizations. However, not all significant challenges identified in organizations of varying sizes are the same. The goal here is to provide a road map for DevOps vendors to follow to properly manage the DevOps culture within client organizations.

The proposed study also compared the identified challenges in various databases. Google Scholar, Springer Link, Science Direct, ACM, and IEEE Xplore were used. Google scholar has compiled the majority of the critical challenges. IEEE Xplore reported fewer challenges. Based on the findings of the study, the following objectives have been identified to pursue in the future:

- SLR and empirical research will be used to identify practices for the identified critical challenges
- Finally, the purpose of this research is to develop the DevOps Culture Challenges Model (DC2M) to promote collaboration, understanding, and trust among development and operations teams and reduce barriers between them

APPENDIX
Questionaire Survey Respondents details:

Job Description	Frequency	Cummulative frequency
Assistant Director	1	3.3
Assistant Manager IT	1	6.7
Computer Operator	1	10.0
IT Manager	1	13.3
IT Officer	2	20.0
MIS operator	1	23.3
Network engineer	1	26.7
Phd Student	6	46.7
Relationship Manager	1	50.0
Sales Manager	1	53.3
Senior Info Sec Exert	1	56.7
Seneior Manager Cyber Security	1	60.0
Senior Technical Consultant	1	63.3
Sr. ITs Officer	1	66.7
System Administrator	1	70.0
Teacher	9	100.0
Total	30	

Experience	Frequency	Cummulative Frequency
0	1	3.6
2	1	7.1
3	2	14.3
4	4	28.6
5	3	39.3
6	3	50.0
8	1	53.6
9	1	57.1
10	6	78.6
11	2	85.7
12	1	89.3
20	2	96.4
21	1	100.0
Total	28	

Address	Frequency	Cummulative Frequency
Local	20	66.7
Foreign	10	33.3
Total	30	

Organization Type	Frequency	Cummulative Frequency
National	19	63.3
Multinational	11	36.7
Total	30	

Company Size	Frequency	Cummulative Frequency
Small	6	20
Medium	8	26.7
Large	16	53.3
Total	30	

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MUHAMMAD SHOAIB KHAN is currently pursuing the M.S. degree with the Department of Software Engineering, University of Science and Technology Bannu, Pakistan.

ABUDUL WAHID KHAN received the Ph.D. degree in computer science from the University of Malakand. He is currently working as an Assistant Professor with the University of Science and Technology (UST) Bannu, Pakistan. He is an Active Researcher in global software engineering. He is working on requirement engineering, cloud computing, software outsourcing, DevOps, and software testing.

FAHEEM KHAN received the Ph.D. degree from the University of Malakand, Pakistan. He worked as an Assistant Professor for a period of four years in Pakistan. He is currently working as an Assistant Professor with the Department of Computer Engineering, Gachon University, South Korea. His research interests include computer networking, wireless networks, MANET, VANET, the IoT, and artificial intelligence.

MUHAMMAD ADNAN KHAN received the B.S. and M.Phil. degrees from International Islamic University, Islamabad, Pakistan, by obtaining the Scholarship Award from the Punjab Information and Technology Board, Government of Punjab, Pakistan, and the Ph.D. degree from ISRA University, Pakistan, by obtaining a Scholarship Award from the Higher Education Commission, Islamabad, in 2016. He is currently working as an Associate Professor with the Faculty of Computing, Riphah School of Computing and Innovation, Riphah International University, Lahore Campus, Lahore, Pakistan, and an Assistant Professor with the Pattern Recognition and Machine Learning Laboratory, Department of Software, Gachon University, South Korea. Before joining Gachon University and Riphah International University, he worked in various academic and industrial roles in Pakistan. He has been teaching graduate and undergraduate students in computer science and engineering for the past 13 years. He is guiding five Ph.D. scholars and seven M.Phil. scholars. He has published more than 200 research articles with cumulative JCR-IF more than 380 in international journals as well as reputed international conferences. His research interests include machine learning, MUD, image processing and medical diagnosis, and channel estimation in multi-carrier communication systems using soft computing.

TAEG KEUN WHANGBO (Member, IEEE) received the M.S. degree in computer science from the City University of New York, in 1988, and the Ph.D. degree in computer science from the Stevens Institute of Technology, in 1995. He is currently a Professor with the Department of Computer Science, Gachon University, South Korea. Before he joined Gachon University, he was a Software Developer in Q-Systems which is located in New Jersey, from 1988 to 1993. He was also a Researcher with Samsung Electronics, from 2005 to 2007. His research interests include artificial intelligence, computer vision, healthcare, and AR/VR.

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