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Systematic review of success factors and barriers for software process improvement in global software development

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Abstract: Nowadays, many software development organisations are globalising their work throughout the world. The motivation behind the software globalisation is competitive advantage and business profits that it yields to an organisation. Besides, these organisations are facing various challenges due to the distributed nature of the software development. However, software process improvement (SPI) is one of the biggest issues in the domain of global software development (GSD). The aim of this research study is to identify success factors and barriers to assist GSD organisations for successful implementation of SPI program. Accordingly, a systematic literature review approach was adopted to identify the success factors and barriers. A total of nine success factors and six barriers were identified that could impact SPI. Using the criteria of the factors having a frequency >50% as critical, total four success factors were ranked as critical success factors, i.e. management commitment, staff involvement, allocated resources and pilot projects. Moreover, total four barriers were classified as critical barriers, i.e. lack of resources, inexperienced staff, organisational politics and time pressure.

1 Introduction

Software process improvement (SPI) is an approach used to comprehend the software process and to monitor the implementation of change in that process for the purpose of achieving the particular objectives such as to enhance software development period and budget along with the required efficiency [1]. Stelzer and Millis [2] described that SPI life cycle consists of four steps, i.e. PLAN (planning for process improvement), DO (operate the plan), CHECK (measuring the improvement) and ACT (implement the plan according to the given check).

Different standards and models for SPI have been developed to move organisations towards optimising their software processes and also numerous instruments are developed to evaluate process proficiency. Capability maturity model integration (CMMI) [3] is among the SPI models that have been developed. It is a structured and systematic collection of best practices for process assessment and improvement. Moreover, the International Organisation for Standardisation (ISO) also embarked on the program to form a software process assessment standard. According to Viadiu *et al.* [4] ISO 9000 developed by ISO is a sequence of standards used to verify the quality of the system deployed by an organisation. Moreover, the ISO/IEC 15504 was developed by ISO for SPI under the software process improvement and capability determination (SPICE). SPICE was recognised as a project to come up with draft standards to test and create the awareness of the developing standards [4]. The research signifies that the effort devoted to these standards and models can help in developing a standard software system, decreasing time and cost, improving employee satisfaction and productivity [5–9]. SPI models like capability maturity model (CMM) [10], currently CMMI and standards like ISO's SPICE [4] emphasise on practices to accomplish quality software system. Emam and Koru [11] highlighted that slight attention has been paid to effectively implement these standards and models that have brought partial success to a number of SPI efforts. A study conducted by Niazi *et al.* [12] discussed that researchers show less intention towards an effective strategy to successfully implement the SPI standards. They were keen to have a proper guideline for 'how to implement' rather than 'what to implement'.

There is a long tradition of SPI research in the fields of software engineering and information management systems [2, 5, 8, 13–17]. This research is motivated by an important gap found in SPI literature. Most of the previous research work discussed SPI in the domain of collocated software development [18], but recently most of the software development organisations have adopted global software development (GSD) in order to accomplish various benefits [19–21]. Babar and Niazi [13] shed light that term GSD is extending from emphasising only on cost reduction towards improvement of all the software development aspects. This change gives significant importance to process improvement program in distributed development. In general, the deployment of process improvement in GSD environment requires a long-term approach and need significant resources and time for complete implementation [13]. Ramasubbu [18] demonstrate that distributed team members operate beyond geographical boundaries where communication and coordination is more challenging and the need for implementation of SPI activities is much pronounced. Babar and Niazi [13] reported in their study that SPI team members in GSD face various problems such as developing SPI practices for distributed environments, building relationship between the distributed organisations, overcoming the temporal distance and addressing the cultural aspects. To effectively overcome these problems, the SPI team members need to have deep knowledge of designing and implementing different aspects of process improvement in the GSD domain [13].

Regardless of the significance of SPI implementation process, little investigation has been done in establishing models or techniques in order to efficiently deploy SPI activities in general and findings of success factors and barriers that can affect SPI implementation in a distributed environment in particular. Models and standards like CMMI, CMM, ISO 9000 and ISO/IEC 15504 provide adequate information for 'what activities to improve' but they did not provide a brief explanation 'how to improve' [14]. Organisations willing to deploy process improvement program need in-depth knowledge of success factors and barriers that can affect SPI implementation [13, 15, 18]. So far no study has been found that discussed success factors and barriers towards the effective execution of the process improvement program in the context of the distributed environment.

In this study, we provide an in-depth overview of success factors and barriers that perform a significant role in the implementation of process improvement. Understanding of these factors and barriers

can address the key area for SPI implementation. For this reason, the following research questions have been addressed.

RQ1: What are the success factors and barriers that could affect SPI implementation in GSD?

RQ2: Do the identified success factors and barriers differ from country to country?

2 Background study

SPI offers organisations with a commanding means of evaluating their existing abilities for evolving software systems and accordingly they can identify their weaknesses and strengths. Zahran [22] defined SPI as 'the discipline of defining, characterising, improving and measuring software management, better product innovation, faster cycle time, greater product quality and reduced development costs simultaneously'. Several standards and models have been designed in the last several years, including, CMM [10], currently CMMI [3] and ISO's SPICE [4] for the purpose of enhancing software processes. These standards and models can lead the software organisations to develop quality products [15, 23]. Despite the availability of various process improvement standards, the success rate of SPI implementation is very low [13, 24]. Ngwenyama and Nielsen [25] reported that the failure rate of process improvement activities is 70% and one of the ground causes of this failure is the limited contribution paid towards the process improvement problems [13].

Niazi *et al.* [15] and Ramasubbu [18] highlighted that presently most of the software development organisations are globalising their work in order to compete globally and the practitioners need to know about the importance of SPI implementation in GSD domain. Nevertheless, the nature of process improvement problems is different in distributed environment [13]. Organisations should be attentive towards various challenges faced by SPI activities across geographical boundaries. According to Niazi *et al.* [15], the deployment of SPI in GSD context is more challenging as compared with collocated development, because of geographical, cultural and temporal distances among the development team members. Ramasubbu [18] discussed that most of the studies emphasised process improvement implementation in collocated software development. Prior research work on SPI has not examined the distributed nature of GSD organisations. GSD teams work in a distributed environment where the need for handling SPI implementation is much pronounced [18].

Overall, little empirical research has been conducted on efficient implementation of SPI programs in GSD and slight consideration has been given into success factors and barriers that are vital for successful execution of SPI activities [13, 15, 18]. The main aim of this work is to systematically extract all the available success factors and barriers that could impact the implementation of SPI in the domain of GSD. Various studies emphasised on the significance of key success factors and barriers. Those studies mentioned that the SPI staff should have a deep understanding of the factors that can bring a process improvement program towards successful deployment [13, 15, 18, 26]. It is also vital to evaluate the most critical factors which may have a strong influence on SPI activities in a GSD environment [15], as the literature shows that deployment of process improvement models like CMMI can be challenging because of limited resources and experience required for implementing CMMI practices [16].

In this study, we used systematic literature review (SLR) approach proposed by Kitchenham *et al.* [27] to extract success factors and barriers. The identification of success factors and barriers will decrease the failure rate as well as cost and time of process improvement implementation.

3 Research methodology

The SLR approach has been adopted for classification of success factors and barriers of SPI implementation, whereas a similar method has been used by the authors in [24, 28, 29]. Khan [28] used SLR approach for the identification of critical success factors (CSFs) that can affect the contract management activities in distributed development. The same approach has been adopted by Khan and Azeem [29] for the classification of intercultural issues between the distributed teams.

According to Kitchenham *et al.* [27], SLR is the systematic mode of reporting the outcomes extracted from the literature. SLR method offers a way of classifying, exploring and examining the present studies connected to any questions of interest and research areas [30]. Kitchenham [30, 31] classifies SLR into three main phases, i.e. planning the review, conducting the review and reporting the review. The SLR protocol is the outcome of the planning phase.

Both authors of the article have participated in this SLR study. The first two phases (planning the review, conducting the review) of the SLR were performed by the first author. Second author has reported all the extracted data and properly document the results.

The SLR protocol comprises various key phases as shown in Fig. 1.

3.1 Research problem

Different studies discussed SPI in the context of collocated software development [18]. The distributed nature of SPI is ignored in previous research studies [13, 15, 18]. Generally, small-scale research has been done on the effective implementation of SPI in GSD and less attention has been given to the identification of success factors and barriers that could affect the SPI process [13, 15]. The main contribution of this work is to identify various success factors and barrier that could have a positive or negative impact on the implementation of the SPI program in the context of GSD.

3.2 Research questions

The research questions for this study are discussed as follows:

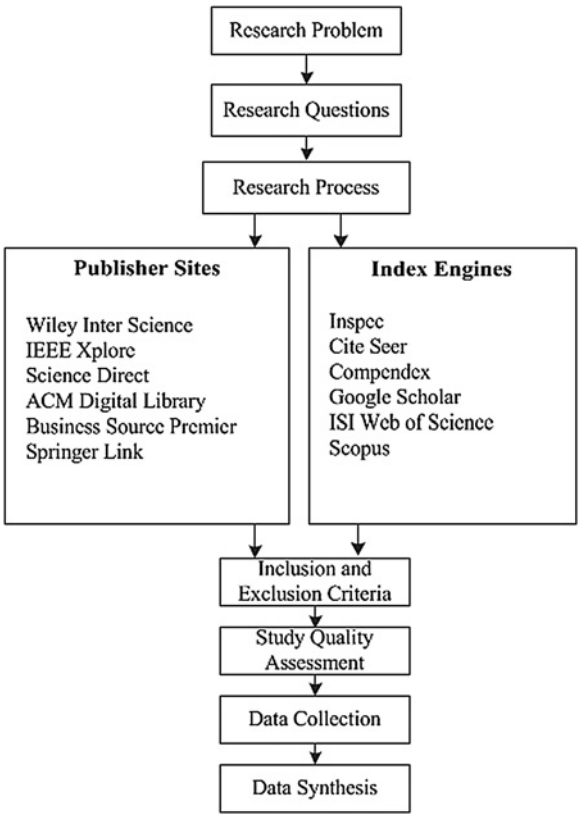

Fig. 1 *SLR protocol*

RQ1: What are the success factors and barriers that could affect SPI implementation in GSD?
RQ2: Do the identified success factors and barriers differ from country to country?

3.3 Research process

Digital databases were chosen based on prior research experience, references or suggestions provided by Chen *et al.* [32]. The databases chosen in this research study included publisher's site and index engines. Publisher's sites consist of published research study from their own database, while index engines contains a listing or index of data published at other publishing sites [32]. Table 1 discussed a list of selected publisher's and index sites.

The search strings used in these databases are based on the major keywords and alternative words of research questions. The keywords and their alternatives are chosen on the basis of available literature in the context of SPI and GSD [24, 28, 33, 34]. List of major keywords and their alternatives are discussed in Table 2.

These keywords and their alternative words are concatenated using Boolean 'OR' and 'AND' operators in order to develop the search strings. All the selected databases were searched using the following search strings: ('factors' OR 'aspects' OR 'items' OR 'elements' OR 'variables') AND ('barriers' OR 'obstacles' OR 'hurdles' OR 'difficulties' OR 'impediments' OR 'hindrance') AND ('SPI' OR 'software process improvement' OR 'software process enhancement' OR 'CMM' OR 'CMMI' OR 'SPICE' OR 'software process enrichment' OR' software process evaluation' OR 'software process assessment' OR 'software process appraisal') AND ('GSD' OR 'global software development' OR 'global software engineering' OR 'distributed software development' OR 'software outsourcing' OR 'Offshore software development').

3.4 Publications selection

The exclusion and inclusion criteria are defined as below.

3.4.1 Inclusion criteria: Those studies were considered that focus on SPI activities in GSD. The selected articles must be available in English and full text articles. These articles must be conferences, journals, workshops and books articles. Those studies definitely have more weight that provided empirical evaluations supported with case studies. It was not about rating any work, in fact it has been attempted to find the relevance of the work according to the proposed domain.

3.4.2 Exclusion criteria: The studies that did not explicitly discussed the SPI success factors, barriers and models or framework have been excluded. Further exclusions of those studies have been made that did not provide significant details of SPI standards and models. The exclusion criteria also comprised of eliminating the duplicate results of articles.

3.4.3 Primary studies selection: During primary studies selection process, various research articles were found and tollgate approach proposed by Afzal *et al.* [35] was used to refine the selection process. Tollgate approach comprised of five phases and is shown in Fig. 2 and described in Table 3.

In the first phase of tollgate approach, a total of 221 articles were selected from all the databases. Articles selection was based on given inclusion criteria.

In the second phase, a total of 173 papers were selected after eliminating the duplicated articles.

In third phase, only those articles were selected whose title and abstract involved keywords related to the proposed research questions. After applying the third phase, total 113 articles were sorted out.

In fourth phase, the inclusion or exclusion was based on the 'introduction and conclusion'. Only those articles were selected which had an empirical background related to SPI and generally related to GSD. After applying this phase, total 71 articles were filtered and preceded to the final phase.

During the final phase, the full text articles selection was done. In this phase, only those articles were selected, which were mainly related to the success factors and barriers of process improvement. A total of 33 articles were extracted as a primary study for this research.

Table 1 Selected sources to be searched

Publisher's sites	**Index engines**
Wiley Inter Science	Inspec
IEEE Xplore	Cite Seer
Science Direct	Compendex
ACM Digital Library	Google Scholar
Business Source Premier	ISI Web of Science
Springer Link	

Table 2 Major keywords and alternative words

Major keywords	Alternative words
factors	factors, aspects, items, elements, variables
barriers	barriers, obstacles, hurdles, difficulties, impediments, hindrance
SPI	SPI, software process improvement, software process enhancement, CMM, CMMI, SPICE, software process enrichment, software process evaluation, software process assessment, software process appraisal
GSD	GSD, global software development, global software engineering, distributed software development, software outsourcing, offshore software development

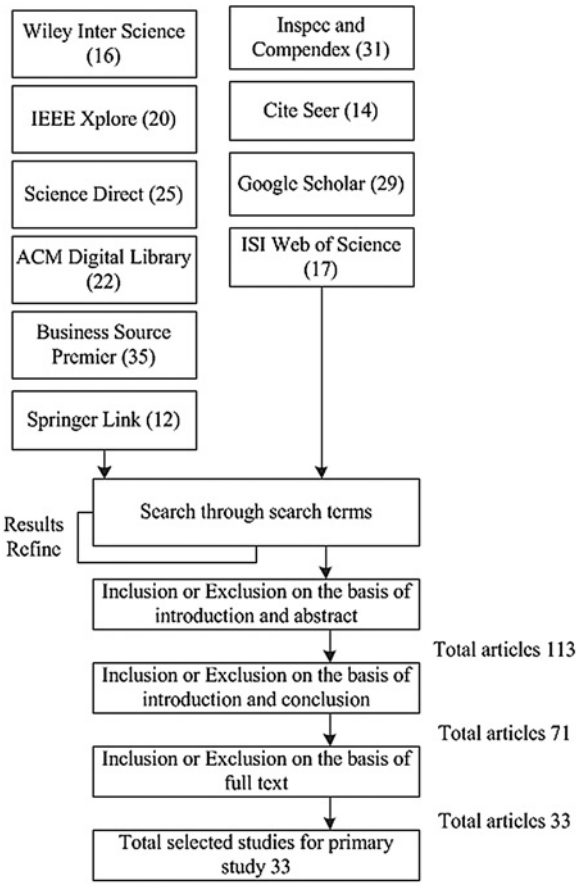

Fig. 2 *Tollgate approach for articles selection*

Table 3 Total selected articles using tollgate approach

E-databases	Search through search terms	Inclusion/exclusion on the basis of title and abstract	Inclusion/exclusion on the basis of introduction and conclusions	Inclusion/exclusion on the basis of full text	Total selected articles for primary study	Percentage of final selcetd articles (n = 33)
Wiley Inter Science	16	13	8	6	3	9.09
IEEE Xplore	20	15	13	11	8	24.24
Inspec and Compendex	31	25	16	11	0	0
Science Direct	25	18	16	13	10	30.30
Cite Seer	14	12	9	7	3	9.09
ACM Digital Library	22	18	11	7	4	12.12
Google Scholar	29	23	13	6	0	0
Springer Link	12	10	8	6	5	15.15
ISI Web of Science	17	14	10	3	0	0
Business Source Premier	35	22	14	8	0	0
total	221	173	113	71	33	100

The results demonstrate that most of the articles related to SPI success factors and barriers are extracted from science direct (30.30%). Science direct is the most common and active digital library to publish articles associated to success factors and barriers. The list of the selected articles is mentioned in Appendix.

3.5 Study quality assessment

The study quality assessment criteria were designed to assess the quality of the selected studies. The quality assessment was performed on the basis of the checklist provided in Table 4. The checklist was developed by following the given procedure in [24, 36, 37].

Those studies which contained answers of the research questions mentioned in the quality checklist are considered as ' yes' and one points were given. Similarly, if a study contained partial information regarding the research questions, then 0.5 points were awarded for that study. The studies that have not answered the questions were awarded with 0 points. After applying the above quality assessment criteria, total 33 articles were included in the final list of the selected primary studies.

We also assess the selected articles through external review, which illustrate that these articles have sufficient quality to consider in this systematic study.

3.6 Data extraction

The first author has listed all the identified success factors and barriers that have a positive or negative effect on SPI implementation. Second author has considered the frequency and percentage of each success factor and barrier in the selected articles.

Table 4 Quality assessment checklist

QA questions	Score	Description
QA1: Is the scope of the study clearly discussed?	1	studies that have explicitly fulfill the quality assessment research questions
QA2: Is the SPI technology used distinctly defined?	0.5	studies that provides partial information concerning the quality assessment research questions
QA3: Are the extracted results can describe the research questions?	0	no information
QA4: Does the study explicitly focused on GSD?		
QA5: Does the study discussed SPI standards and models?		
QA6: Does the adopted research method appropriate to answer the research questions?		

Second author extracted title of each primary study and publisher of each study. Complete list of all the selected 33 primary studies is discussed in Appendix.

3.7 Data synthesis

Second author performed the data synthesis process. In this phase, all the extracted results were brought together and each question was exclusively evaluated against the results.

From selected 33 articles, total of nine success factors and six barriers were identified as shown in Tables 5 and 6, respectively.

4 Results

This section discussed results and analysis for each research question as mentioned in Section 3.2.

4.1 Identified success factors using SLR

To answer RQ1, Tables 5 and 6 presents a list of identified success factors and barriers, respectively. The core objective for RQ1 is to extract all those success factors and barriers that can affect the SPI implementation.

Table 5 and Fig. 3 illustrate the identified success factors along with their frequencies in the selected articles for primary study.

In Table 5, (n = 33) is the total number of selected articles for primary study and these articles are cited in Appendix.

In this section, also the association is discussed between independent variables (identified success factors) and dependent variable (SPI implementation in GSD) as given below.

4.1.1 Management commitment: On the basis of frequency of 'management commitment' (81%), it is the most common success factor for process improvement implementation. According to Sulyman *et al.* [LT2] management commitment is the extent to which the higher and lower level management in an organisation support, finance, realise and participate in SPI program. Sulyman *et al.* [LT2] identified management commitment as a positive influential factor for SPI implementation. Ramasubbu [LT5] emphasised on the commitment and participation of organisational management in SPI implementation activities. He mentioned that management should evaluate and track the contribution of GSD team members in process improvement activities. Goldenson and Herbsleb [LT3] conducted a survey in 56 software companies. They argued that some organisations were successful and others were not and have stated that respondents from organisations with effective SPI efforts inclined to agree that managers actively monitor the SPI program and they allocate sufficient resources for SPI implementation. Rainer and Hall [LT4] conducted a study and

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Table 5 Identified success factors

Sl. No	Success factors	Frequency ($n = 33$)	Percentage	References
1	management commitment	27	81	[LT1, LT2, LT3, LT4, LT5, LT6, LT7, LT8, LT9, LT10, LT11, LT12, LT13, LT14, LT15, LT17, LT18, LT19, LT21, LT23, LT24, LT25, LT26, LT28, LT29, LT31, LT32]
2	staff involvement	21	63	[LT1, LT2, LT3, LT4, LT5, LT8, LT9, LT11, LT12, LT14, LT15, LT17, LT1, LT19, LT21, LT23, LT24, LT26, LT28, LT29, LT31]
3	allocated resources	21	63	[LT1, LT2, LT3, LT4, LT5, LT7, LT9, LT10, LT11, LT12, LT13, LT14, LT15, LT18, LT19, LT21, LT23, LT24, LT26, LT28, LT31]
4	pilot projects	19	57	[LT1, LT2, LT3, LT4, LT5, LT6, LT8, LT10, LT12, LT14, LT15, LT17, LT18, LT21, LT24, LT26, LT28, LT29, LT31]
5	setting SPI goals	16	48	[LT2, LT3, LT4, LT5, LT9, LT11, LT12, LT14, LT15, LT17, LT18, LT19, LT21, LT23, LT29, LT31]
6	team training	13	39	[LT2, LT3, LT4, LT5, LT9, LT10, LT11, LT14, LT21, LT23, LT26, LT29, LT31]
7	information sharing	12	36	[LT1, LT2, LT3, LT4, LT5, LT7, LT9, LT10, LT15, LT17, LT19, LT28]
8	strong relationship	9	27	[LT1, LT2, LT7, LT10, LT12, LT14, LT26, LT28, LT31]
9	SPI awareness	6	18	[LT2, LT3, LT9, LT17, LT21, LT31]

Table 6 Identified barriers

Sl. No	Barriers	Frequency ($n = 33$)	Percentage	References
1	lack of resources	31	93	[LT2, LT3, LT4, LT5, LT6, LT7, LT8, LT9, LT10, LT11, LT12, LT13, LT14, LT15, LT16, LT17, LT18, LT20, LT21, LT22, LT23, LT24, LT25, LT26, LT27, LT28, LT29, LT30, LT31, LT32, LT33]
2	inexperienced staff	29	87	[LT2, LT3, LT4, LT5, LT6, LT8, LT9, LT10, LT11, LT12, LT13, LT14, LT15, LT16, LT17, LT18, LT19, LT20, LT22, LT24, LT25, LT26, LT27, LT28, LT29, LT30, LT31, LT32, LT33]
3	organisational politics	23	69	[LT5, LT6, LT8, LT9, LT10, LT11, LT12, LT13, LT14, LT16, LT18, LT19, LT20, LT22, LT23, LT25, LT26, LT27, LT28, LT29, LT30, LT31, LT32]
4	time pressure	17	51	[LT5, LT6, LT9, LT11, LT13, LT14, LT16, LT20, LT22, LT25, LT26, LT27, LT28, LT29, LT31, LT32, LT33]
5	staff turnover	14	42	[LT6, LT9, LT11, LT13, LT16, LT18, LT20, LT25, LT26, LT27, LT28, LT30, LT31, LT32]
6	lack of formal SPI implementation methodology	13	39	[LT9, LT11, LT13, LT16, LT20, LT25, LT26, LT27, LT28, LT29, LT30, LT31, LT32]

highlighted that management commitment has been considered as one of the most significant human factors.

4.1.2 Staff involvement: The findings of this study also show that 'staff involvement' (63%) is the second most common factor in the extracted list of success factors. It is the degree to which employees of the organisation owns, trust, acquire, perform and believe the SPI program [LT2]. Ramasubbu [LT5] conducted a study in GSD industry and highlighted that without the interest of staff members the implementation of SPI program is impractical. Emam and Koru [LT6] conducted a survey in various organisations and concluded that coordination, commitment and collaboration among SPI team members are important for successful process improvement program. Ramasubbu [LT5] discussed the availability and involvement of SPI team members in GSD. He discussed that the willingness of team members to contribute towards the successful SPI program is an important success factor in a distributed environment.

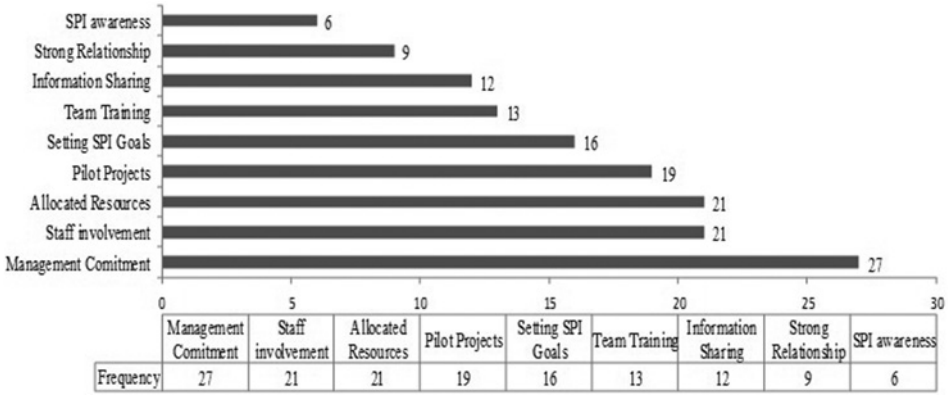


Fig. 3 *Frequency distribution of identified success factors*

4.1.3 Allocated resources: In the findings of this study, 'allocated resources' (63%) was identified as a CSF. According to Sulyman *et al.* [LT2], allocated resources are the dedication of time and resources to process improvement implementation. Niazi *et al.* [LT31] emphasise on the availability of various resources in the form of staff, documentation, time, planning, tools and budget investment. Ullah Khan *et al.* [LT1] conducted an empirical study in offshore outsourcing organisations and acknowledged that organisations must commit their resources and constantly motivates people to contribute. Niazi *et al.* [LT16] organisation should brief the managers towards the allocation of all the required resources in order to achieve long-term SPI benefits.

4.1.4 Pilot projects: In this study, 'pilot projects' (57%) is an affective and CSF as per results. Pilot projects are the testing phase for all the selected models or standards for SPI implementation. According to Kautz and Nielsen [LT8], after appropriate planning and conducting the pilot implementation experiment of SPI models or standards, the results of pilot implementation should be illustrated to other departments to get support and confidence. Niazi *et al.* [LT31] described that small-scale process improvement implementation is necessary to see that how effective it is within a specific department. In order to measure the present process improvement readiness and skills, a pilot implementation is vital for experts [LT31]. Niazi *et al.* [LT11] demonstrate that during pilot implementation, the practitioners can choose the extent of training, resources and commitment, which is needed for implementing the SPI practices across the organisation.

4.1.5 Setting SPI goals: 'Setting SPI goals' (48%) is identified as an important success factor among the identified factors. Sulayman *et al.* [LT2] defined 'setting SPI goals' as the extent to which everyone can make the translation from leading management goals towards the goals that everyone has been asked to accomplish. Setting 'relevant goals' means the efforts for improvement to contribute towards the success [LT2], while setting 'realistic goals' denotes that the goals might be attained in the foreseeable future with a reasonable amount of resources. The purpose of setting SPI goals has been acknowledged as an important factor to accomplish business objectives [LT11]. Petterson *et al.* [LT12] have developed a light-weight process assessment framework. While formulating the framework, several CSFs were discussed. The important factor associated with the study is given as 'setting SPI goals'. Iversen *et al.* [LT13] said that since the SPI program seems costly and time consuming, consequently clearly explained goals and objectives should positively impact the SPI implementation program. Ramasubbu [LT5] suggests that distributed team members should have shared SPI goals and objectives. He emphasised that organisational management should tailor the relevant and realistic goals of process improvement to operational and project level.

4.1.6 Team training: 'Team training' (39%) is an effecive success factor for SPI program. Rainer and Hall [LT14] conducted an empirical study and highlighted that both successful and unsuccessful companies in the sample have mentioned that team training has a positive impact on process improvement. Niazi *et al.* [LT16] points out that training of the GSD team members can enhance the enterprise profile, skills of team members, innovative thinking and deliver employees with the capability of managing SPI activities. Sulayman *et al.* [LT17] figured out that training for all ranks of experts was crucial for success of SPI. It was suggested that team training helps those practitioners who had limited exposure to SPI concepts and experience. Dyba [LT15] and Niazi *et al.* [LT10] suggests that it is important and compulsory that team members who actually participate in an SPI implementation program should be provided adequate training, requisite knowledge and skills.

4.1.7 Information sharing: In this study, 'information sharing' (36%) is also considered as an important success factor. Information sharing is the extent to which SPI team members collaborate and share the information to participate in SPI activities [LT2]. Niazi *et al.* [LT9] conducted an empirical study to investigate the relationship between success factors, barriers and SPI implementation. Respondents from organisations with effective SPI attempts inclined to agree that information sharing among the team members is crucial for the successful SPI program. Khan [LT7] have shed light on effective information sharing and emphasised that team members from various distributed sites should show strong commitment towards sturdy relationship. In the absence of strong relationship, the GSD team members will not be able to share the required information properly [LT5]. Ramasubbu [LT5] identified that in GSD environment, the SPI team members should show strong commitment towards information sharing in order to attain successful planning, coordination and knowledge integration. Team members can appropriately manage the SPI implementation activities on the basis of knowledge exchange, information partnership and information management [LT7].

4.1.8 Strong relationship: The SLR results showed that 'strong relationship' (27%) is an essential factor to successfully deploy the SPI process. It is the extent to which the SPI team members could effectively communicate and collaborate to implement the SPI program [LT31]. According to Ramasubbu [LT5], strong relationship among the distributed teams could help the team members to define new SPI policies, procedures and enhance the existing. Richardson *et al.* [LT18] concluded that not only managing staff, but also a lower level staff should have complete understanding of the factor 'strong relationship'. Niazi *et al.* [LT16] mentioned that without support and trust, the distributed process improvement teams might not be able to complete the SPI tasks within budget and time. Top management should encourage the distributed team members towards belief and willingness to participate in associated SPI activities [LT5]. Moreover, it leads towards team coordination, decision making, risk management and satisfaction [LT7].

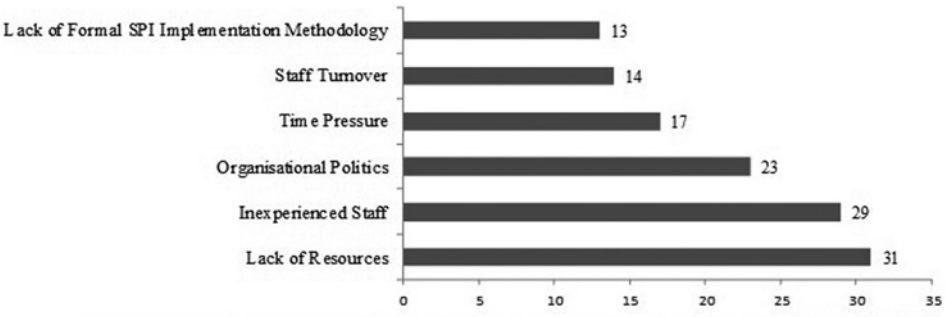
4.1.9 SPI awareness: The finding of this study revealed that 'SPI awareness' (18%) is an important module for SPI implementation. Sulayman *et al.* [LT2] defined SPI awareness as the extent to which the initiatives such as SPI team training and certification support provided to the staff of the organisation. SPI awareness denotes to the process improvement's understanding and knowledge. Kautz and Nielsen [LT8] and Sulayman and Mendes [LT19] said that SPI awareness has significant influence on SPI implementation. It is because of costly as well as a long-term strategy of SPI and it takes time to grasp the actual benefits of SPI program. Sulayman and Mendes [LT19] and Khan *et al.* [LT20] highlighted the importance of awareness and suggested to conduct awareness sessions for team members in distributed environment to enrich mutual understanding and trust regarding process improvement.

The process improvement implementation success depends on process managers and engineers' expertise [LT2]. Bayona-Oré *et al.* [LT21] discussed that if the process manager has good awareness and adequate skills, then there is increased possibility of SPI success and acceptance in the best practice of domain. Otherwise, the SPI execution program finishes with frustration and failure or no change and is not capable to meet the actual aims of the business [LT4].

4.2 Identified barriers using SLR

The main aim of recognising barriers is to comprehend the nature of challenges that could negatively influence the SPI implementation program in GSD. In this section, the relationship among the independent variables (identified barriers) and the dependent variable (SPI implementation program) is highlighted.

Listed identified barriers are demonstrated in Table 6 and explained in Fig. 4 along with the frequency and percentage in the total number of selected articles for primary study.



	Lack of Resources	Inexperienced Staff	Organisational Politics	Time Pressure	Staff Turnover	Lack of Formal SPI Implementation Methodology
Frequency	31	29	23	17	14	13

Fig. 4 *Frequency distribution of identified barriers*

Table 6 ($n = 33$) shows the total number of selected articles for primary study and these articles are cited in Appendix.

4.2.1 Lack of resources: Niazi *et al.* [LT16] defined 'lack of resources' as the extent to which the SPI team members in GSD did not get the sufficient amount of the required resources. The extracted results in Table 6 show that 'lack of resources' (93%) is the most common critical barrier (CB) for SPI implementation. An empirical study conducted by Niazi *et al.* [LT27] demonstrates that almost three-quarters (72%) respondents reported that SPI implementation has often suffered due to lack of sufficient resources. Niazi *et al.* [LT16] discussed cross-cultural barriers in distributed development and highlighted that it is essential to assess and deliver adequate resources otherwise organisation will not be able to accomplish the desired results of the process improvement program.

Kautz and Nielsen [LT8] conducted an empirical study in industry and discussed that team managers were uncertain to allocate resources for SPI activities using their own project budget. Baddoo and Hall [LT25] discussed that in the absence of sufficient resources, the organisation will not be able to achieve the goals and objectives of SPI program. The organisations need to have positive thinking about the SPI program and should provide all the estimated resources [LT23, LT27]. Likewise Ramasubbu [LT5] discussed is his study that GSD organisations should show strong intention towards the allocation of the resources that can confidently affect the success of SPI project.

4.2.2 Inexperienced staff: In this study, 'inexperienced staff' (87%) is the second most cited common barrier. Kautz and Nielsen [LT8] conducted an empirical study and discussed that why SPI implementation was unsuccessful in one company: 'the technical director and staff had no expertise regarding process improvement and they have experienced various hurdles during SPI implementation'. Bayona *et al.* [LT24] emphasises on the experiences of the stakeholders and motivates the team members to have sufficient knowledge to perform SPI activities. Emam and Koru [LT6] discussed that one of the reasons for SPI failure is the lack of experience in the team members regarding process improvement activities.

Rainer and Hall [LT4] described the challenges of managing change for SPI and discussed that process and quality improvement by people are mostly theoretical. They do not comprehend fairly well the prevailing software development processes and the domain in which they are employed. Niazi *et al.* [LT16] discussed in his empirical study that GSD organisations involved in SPI activities could only get success if the staff members have deep knowledge of SPI.

4.2.3 Organisational politics: 'Organisational politics' (69%) is identified as an important barrier during SPI implementation. SPI is considered as a change in the company and usually the team members resist this change. Niazi *et al.* [LT16] discussed that team members consist of geographically distributed individuals and groups who have opposing ideas, aims and objectives. The SPI implementation might fit into goals of one group but not into another's.

Emam and Koru [LT6] have conducted an empirical study in 14 organisations and recognised 'organisational politics' as an important hurdle for process improvement programs. Moitra [LT29] discussed the difficulties and complications of change management for SPI and highlighted that organisational politics is probably one of the major causes that can demolish the change management attempts for SPI implementation.

Iversen *et al.* [LT13] identified other factors in the aspect of organisational politics that can affect SPI implementation, for instance promotion opportunities, reallocation of resources, role ambiguity and low trust.

4.2.4 Time pressure: Findings from literature illustrate that 'time pressure' (51%) is identified as the fourth common barrier. Niazi *et al.* [LT16, LT27, LT32] discussed that operational management feels time pressure as a preeminent hurdle to process improvement execution. In another study, Richardson *et al.* [LT18] discussed case studies for SPI implementation and illuminate time constraint as a vital barrier for SPI implementation. Khan *et al.* [LT28] also discussed time pressure as an imperative barrier for teams working in GSD environment. Mantyla *et al.* [LT22] discussed the time pressure against practicing effective software engineering activities. Under the time pressure, team members made decisions in order to stay on schedule. However, those decisions may not be in the interest of the process improvement program.

In the study of Baddoo and Hall [LT25], time pressure is highlighted as a critical hurdle towards SPI implementation. Operational management quoted that in the absence of all other hurdles, time pressure appears to be the superseding problem for SPI success. Baddoo *et al.* [LT26] found that all groups of practitioners have quoted time pressure as a de-motivator for SPI, i.e. 58% of senior managers, 44% of project managers and 62% of developers.

4.2.5 Staff turnover: 'Staff turnover' (42%) is cited as an important barrier during the implementation of process improvement. Staff turnover is the number or percentage of employees who leave an organisation and are replaced by new staff. Rainer and Hall [LT4] mentioned that due to frequent staff turnover, the cost of SPI implementation can be remarkably increased. Besides the direct cost of employing a replacement, there is an indirect cost related to the loss of key skills, knowledge and experience [LT4].

Rainer and Hall [LT14] has carried out empirical studies with software organisations in order to recognise different requirements of change problems. He collected data from 45 focus groups containing 200 people. Their results demonstrate that staff turnover is a serious challenge for most of the organisations. Hall *et al.* [LT30] analysed data collected from 89 practitioners to show the

effect of high staff turnover on the success of process improvement projects. He suggests that improving the motivation levels of practitioners can decrease the staff turnover.

4.2.6 Lack of formal SPI implementation methodology: The SLR results exhibit that 'lack of formal SPI implementation methodology' (39%) is an important obstacle. Niazi *et al.* [LT16] discussed that the practitioners stressed the necessity to have an SPI implementation methodology in GSD, which consists of complete process deployment strategy, process improvement activities, tasks and measures to be used throughout the process improvement implementation. The majority of the SPI practitioners working beyond geographical boundaries believes that lack of formal SPI implementation strategies are considered as a major barrier for effective execution of process improvement program [LT16]. The reason behind is the lack of attention paid towards the development of an operative SPI implementation methodology [LT16, LT32, LT33].

5 Discussion

This research is premised on the need to give a comprehensive understanding of different success factors and barriers that could play a significant part during SPI implementation in GSD. To conduct this research, only 33 research studies have been found via SLR which focused on SPI success factors and barriers. The specific studies are selected to support the research questions.

5.1 RQ1 success factors and barriers

A number of success factors and barriers have been identified through SLR that could impact SPI implementation program. The identified success factors and barriers are discussed in Section 4. These factors and barriers present some of the crucial areas, needing further research attention in the domain of GSD industry.

After studying the selected articles, total nine success factors and six barriers were identified as discussed in Tables 5 and 6, respectively. In the identified success factors, four success factors were ranked as CSFs. Likewise, a total of four barriers were marked as CBs.

We have followed the criteria of the factors having a frequency ≥50% as critical and the same technique has been used by other researchers [26, 28, 38, 39].

5.1.1 Critical success factors: By using the above approach, the identified CSFs are management commitment (81%), staff involvement (63%), allocated resources (63%) and pilot projects (57%). The identified CSFs are labelled as critical for SPI implementation in GSD because their frequency is ≥50% of all the identified success factors.

5.1.2 Critical barriers: The identified CBs are lack of resources (93%), inexperienced staff (87%), organisational politics (69%) and time pressure (51%). These barriers are critical towards the implementation of SPI program and they can have a more negative influence as compared with the other identified barriers.

Identification of CSFs and CBs allows SPI teams to emphasise their efforts on these factors to successfully implement the SPI program in GSD environment. Those are the key areas where the organisation should give their consideration to deploy the process improvement program. The CSFs and CBs have the greatest influence on SPI implementation as compared with the other identified success factors and barriers.

5.2 RQ2 country-wise comparison of success factors and barriers

Table 7 shows the list of success factors and barriers identified in different countries in order to answer RQ2. All the articles selected through SLR were categorised based on the countries where the empirical study was conducted. The main objective of

Table 7 Classification of success factors and barriers based on countries

Success factors	Countries of the articles selected using SLR ($N = 33$)									X^2 test (linear-by-linear association) $\alpha = 0.05$		
	Pakistan ($n = 4$)	Australia ($n = 5$)	UK ($n = 3$)	USA ($n = 3$)	Malaysia ($n = 2$)	Denmark ($n = 1$)	Norway ($n = 1$)	Mixed ($n = 6$)	Not mentioned ($n = 8$)	$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$	*Df*	*P*
management commitment	4	5	2	2	2	1	1	4	6	1.590	1	0.207
staff involvement	4	5	1	2	1	0	1	3	4	3.628	1	0.057
allocated resources	4	3	3	2	1	0	1	4	3	3.196	1	0.074
pilot projects	2	3	1	1	1	1	1	4	3	0.261	1	0.609
setting SPI goals	4	1	2	0	1	1	1	2	4	0.235	1	0.628
team training	4	0	1	1	1	0	1	3	0	3.892	1	0.049
information sharing	1	1	1	1	1	0	1	2	4	1.178	1	0.278
strong relationship	2	2	1	1	0	1	0	1	1	2.516	1	0.113
SPI awareness	1	0	1	1	1	0	0	1	1	0.119	1	0.730
Barriers												
lack of resources	4	5	3	3	1	1	1	6	7	0.575	1	0.448
inexperienced staff	3	4	3	2	2	1	1	6	7	0.925	1	0.336
organisational politics	2	3	1	3	1	1	1	5	6	1.796	1	0.180
time pressure	2	3	1	2	0	1	1	2	5	0.022	1	0.883
staff turnover	1	3	1	2	1	1	0	2	3	0.160	1	0.689
lack of formal SPI implementation methodology	1	3	2	2	1	0	0	0	4	0.876	1	0.349

this classification is to investigate any difference in these countries with respect to identified success factors and barriers [28, 29]. This is because the success factors and barriers that have an impact on SPI implementation in any country should be taken seriously by the organisations in that particular country [15, 28, 29].

To calculate the significant difference among the identified success factors and barriers found in different countries, linear-by-linear association X^2 test was used. Linear-by-linear association X^2 test is considered ideal because it is more influential than Pearson X^2 test [28, 29]. To check any significant difference, the following hypotheses have been developed:

Null hypothesis (H_0): There is no significance difference among the countries which are used to discuss the identified success factors and barriers.
Alternative hypothesis (H_1): There is a significant difference among the countries which are used to discuss the identified success factors and barriers.

If the significance value '*P*' for any success factor or barrier is >0.05, then the null hypothesis (H_0) will be supported, otherwise the alternate hypothesis (H_1) will be considered [29].

If there is no significant difference for specific success factor or barrier, than there is no substantial difference in articles reported in different countries. Similarly, if there is a significant difference for any success factor or barrier, it means that this specific success factor or barrier is not equally reported in different countries.

Using the selected test for comparison among the success factors and barriers on the basis of countries, Table 7 shows the significant difference for only one success factor, i.e. 'team training' as the value of '*P*' is <0.05. Team training has a high frequency in Pakistan (4 out of 4, 100%) while it has less frequency in other countries. Therefore, we reject the null hypotheses (H_0) and accept the alternate hypotheses (H_1) for success factor (team training).

The alternate hypotheses (H_1) for success factor (team training) will be as follows:

Alternative hypothesis (H_1): The success factor 'team training' got more attention in Pakistan as compared with other listed countries.

On the basis of the above discussion, it can be highlighted that as the majority of the vendor organisations are from Asian countries (Pakistan, India etc.), they consider team training vital in order to avoid any risks related to SPI implementation in GSD. The GSD organisation should properly equip the team members with SPI implementation training in order to get effective SPI implementation outputs.

These results can assist the SPI practitioners and researchers to determine which success factors and barriers should be considered during SPI implementation in their respective countries.

6 Threats to validity

There are several threats towards the design of this study. During SLR phase, most of the data were collected by a single researcher (first author) and it might possible that a single researcher missed some of the relevant research articles. Though both authors tried to alleviate this threat by observing any unclear problems and discuss them together, still there exists a higher risk that a single researcher could be biased and continually extract the wrong data. In the future, it will be ensured to have at least two reviewers for each research article.

For the selected research studies, the possible threat is that their stated success factors and barriers might not have assuredly reported the primary reason. It is challenging for us to alleviate this threat. In the selected research articles, the authors have not discussed the basic reasons why the success factors and barriers were considered.

Total 33 articles were selected for SLR. The majority of the authors were from academia, which might not have the expertise of existing trends in GSD industry. In order to alleviate this threat, it is planned to conduct empirical studies in the GSD industry to validate the identified success factors and barriers.

With the numerous number of research articles on SPI, this research study may have missed some related research papers. However, this is not a systematic omission like other researchers of SLR [28].

7 Conclusions

Using SLR, a list of nine success factors and six barriers have been identified. In the identified nine success factors, total four factors were ranked as CSFs. These CSFs are: management commitment, staff involvement, allocated resources and pilot projects. These factors may lead the organisations towards the successful implementation of SPI program. Similarly, in the identified barriers, total four barriers were ranked as CBs. The identified CBs are: lack of resources, inexperienced staff, organisational politics and time pressure. The reported barriers and success factors in this research work can act as a guide for GSD organisations to successfully execute the SPI program.

In this study, the identified success factors and barriers have also been compared on the basis of different countries as discussed in Table 7. The main objective behind this comparison was to provide an adequate understanding of the SPI implementation in the context of countries. During data analysis on the basis of various countries, a slight difference has been identified between the success factors and barriers. The reason behind this difference is that people from different countries have different backgrounds and priorities.

The findings of this study can possibly result into tackling the implementation of SPI program, which can lead towards the progression and success of the organisation.

8 Future work

The outcomes of this study might be used for future research in GSD context in relation to SPI implementation. The following topics can potentially be part of this study in future:

- Validity of the aforementioned success factors and barriers through empirical study in industry.
- Identification of additional success factors and barriers from industry by conducting empirical study.
- Comparison of success factors and barriers on the basis of different continents.

The ultimate aim is to develop a SPI implementation management model (SPIIMM) for GSD industry. This model will contribute towards the effective management of the SPI program in GSD context. This model will be based on the success factors and barriers as discussed in this article. The outcomes of this article are the first input to our proposed model, SPIIMM.

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10 Appendix

See Table 8

Table 8 Selected articles using SLR

	Tracking number	Citation	Source
1	LT1	Ullah Khan, S., Niazi, M., Ahmad, R.: Critical Success Factors for Offshore Software Development Outsourcing Vendors: An Empirical Study', in Product-Focused Software Process Improvement' (Springer Berlin/Heidelberg, Germany, 2010, vol. 6156), pp. 146–160	Springer Link
2	LT2	Sulayman, M., Mendes, E., Urquhart, C., Riaz, M., Tempero, E.: 'Towards a theoretical framework of SPI success factors for small and medium web companies, Information and Software Technology, 2014, vol. 56, pp. 807–820	Science Direct
3	LT3	Goldenson, D. R., Herbsleb, J. D., 'After the Appraisal: A Systematic Survey of Process Improvement, its Benefits, and Factors that Influence Success' (DTIC Document, 1995)	Cite Seer
4	LT4	Rainer, A., Hall, T.: 'Key success factors for implementing software process improvement: a maturity-based analysis, Journal of systems and software, 2002, 62(2), pp. 71–84	Science Direct
5	LT5	Ramasubbu, N.: 'Governing Software Process Improvements in Globally Distributed Product Development, IEEE Transactions on Software Engineering, 2014, vol. 40, pp. 235–250	IEEE
6	LT6	El Emam, K., Koru, A. G.: 'A replicated survey of IT software project failures, IEEE Software, 2008, vol. 25, pp. 84–90	IEEE
7	LT7	Khan, A. W., Khan, S. U.: 'Critical success factors for offshore software outsourcing contract management from vendors' perspective: an exploratory study using a systematic literature review, IET software, 2013, vol. 7, pp. 327–338	IEEE
8	LT8	Kautz, K., Nielsen, P. A.: 'Implementing software process improvement: two cases of technology transfer'. 33rd Annual Hawaii International Conference on System Sciences, 2000, p. 10	IEEE
9	LT9	Niazi, M., Wilson, D., Zowghi, D.: 'A maturity model for the implementation of software process improvement: an empirical study, Journal of systems and software, 2005, vol. 74, pp. 155–172	Science Direct
10	LT10	Niazi, M., Ikram, N., Bano, M., Imtiaz, S., Khan, S. U.: 'Establishing trust in offshore software outsourcing relationships: an exploratory study using a systematic literature review, IET Software, 2012, 7(5), 283–293	IEEE
11	LT11	Niazi, M., Wilson, D., Zowghi, D.: 'A model for the implementation of software process improvement: A pilot study'. third International Conference on Quality Software, 2003, pp. 196–203	IEEE
12	LT12	Pettersson, F., Ivarsson, M., Gorschek, T., Öhman, P.: 'A practitioner's guide to light weight software process assessment and improvement planning, Journal of systems and software, 2008, vol. 81, pp. 972–995	Science Direct
13	LT13	Iversen, J. H., Mathiassen, L., Nielsen, P. A.: 'Managing risk in software process improvement: an action research approach, MIS Quarterly, 2004, pp. 395–433	ACM Digital Library

Continued

Table 8 Continued

	Tracking number	Citation	Source
14	LT14	Rainer, A., Hall, T. 'A quantitative and qualitative analysis of factors affecting software processes, Journal of systems and software, 2003, vol. 66, pp. 7–21	Science Direct
15	LT15	Dyba, T. : 'An empirical investigation of the key factors for success in software process improvement, IEEE Transactions on Software Engineering, 2005, 31(5), pp.410–424	IEEE
16	LT16	Niazi, M., Babar, M. A., Verner, J. M.: 'Software Process Improvement barriers: A cross-cultural comparison, Information and Software Technology, 2010, vol. 52, pp. 1204–1216	Science Direct
17	LT17	Sulayman, M., Urquhart, C., Mendes, E., Seidel, S.: 'Software process improvement success factors for small and medium Web companies: A qualitative study, Information and Software Technology, 2012, vol. 54, pp. 479–500	Science Direct
18	LT18	Richardson, I., Casey, V., Burton, J., McCaffery, F.: 'Global software engineering: A software process approach: 'Collaborative Software Engineering' (Springer Berlin Heidelberg, Germany, 2010), pp. 35–56): Springer.	Springer Link
19	LT19	Sulayman, M., Mendes, E.: 'Quantitative assessments of key success factors in software process improvement for small and medium web companies'. in Proceedings of the ACM Symposium on Applied Computing, 2010, pp. 2319–2323	ACM Digital Library
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21	LT21	Bayona-Oré, S., Calvo-Manzano, J. A., Cuevas, G., San-Feliu, T.: 'Critical success factors taxonomy for software process deployment, Software Quality Journal, 2014, vol. 22, pp. 21–48	Springer Link
22	LT22	Mäntylä, M. V., Petersen, K., Lehtinen, T. O., Lassenius, C.: 'Time pressure: a controlled experiment of test case development and requirements review. in Proceedings of the 36th International Conference on Software Engineering, 2014, pp. 83–94	ACM Digital Library
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24	LT24	Bayona, S., Calvo-Manzano, J. A., San Feliu, T.: 'Review of Critical Success Factors Related to People in Software Process Improvement: ' Systems, Software and Services Process' (Springer Berlin Heidelberg, Germany, 2013), pp. 179–189	Springer Link
25	LT25	Baddoo, N., Hall, T.: 'De-Motivators of software process improvement: An analysis of practitioner's views, Journal of Systems and Software, 2003, vol. 66, pp. 23–33	Science Direct
26	LT26	Baddoo, N., Hall, T., Wilson, D.: 'Implementing a people focused SPI programme'. 11th European Software Control and Metrics Conference Munich, 2000.	Cite Seer
27	LT27	Niazi, M., Wilson, D., Zowghi, D.: 'Critical barriers for software process improvement implementation: An empirical study'. IASTED Conference on Software Engineering, 2004, pp. 389–395	Wiley Inter Science
28	LT28	Khan, S. U., Niazi, M., Ahmad, R.: 'Factors influencing clients in the selection of offshore software outsourcing vendors: An exploratory study using a systematic literature review, Journal of Systems and Software,2011, vol. 84, pp. 686–699	Science Direct
29	LT29	Moitra, D.: 'Managing change for (SPI) initiatives: A practical experience-based approach, Software Process Improvement and Practice,1998, pp. 199–207	Wiley Inter Science
30	LT30	Hall, T., Beecham, S., Verner, J., Wilson, D.: The impact of staff turnover on software projects: the importance of understanding what makes software practitioners tick'.Proceedings of the ACM SIGMIS CPR conference on Computer personnel doctoral consortium and research, 2008, pp. 30–39	ACM Digital Library
31	LT31	Niazi, M., Wilson, D., Zowghi, D., Wong, B.: 'A model for the implementation of software process improvement: An empirical study: 'in Product-Focused Software Process Improvement' (Springer Berlin/Heidelberg, Germany, 2004) pp. 1–16.	Springer Link
32	LT32	Niazi, M.: 'Software process improvement implementation: avoiding critical barriers, CROSSTALK. The Journal of Defense Software Engineering, 2009, vol. 22, pp. 24–27	Cite Seer
33	LT33	Shah, H., Harrold, M. J., Sinha, S.: 'Global software testing under deadline pressure: Vendor-side experiences, Information and Software Technology, 2014, vol. 56, pp. 6–19	Science Direct