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Systematic literature review and empirical investigation of barriers to process improvement in global software development: Client–vendor perspective

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ABSTRACT

Context: Increasingly, software development organizations are adopting global software development (GSD) strategies, mainly because of the significant return on investment they produce. However, there are many challenges associated with GSD, particularly with regards to software process improvement (SPI). SPI can play a significant role in the successful execution of GSD projects.
Objective: The aim of the present study was to identify barriers that can negatively affect SPI initiatives in GSD organizations from both client and vendor perspectives.
Method: A systematic literature review (SLR) and survey questionnaire were used to identify and validate the barriers.
Results: Twenty-two barriers to successful SPI programs were identified. Results illustrate that the barriers identified using SLR and survey approaches have more similarities However, there were significant differences between the ranking of these barriers in the SLR and survey approaches, as indicated by the results of t-tests (for instance, $t = 2.28$, $p = 0.011 < 0.05$). Our findings demonstrate that there is a moderate positive correlation between the ranks obtained from the SLR and the empirical study ($rs\ (22) = 0.567$, $p = 0.006$).
Conclusions: The identified barriers can assist both client and vendor GSD organizations during initiation of an SPI program. Client-vendor classification was used to provide a broad picture of SPI programs, and their respective barriers. The top-ranked barriers can be used as a guide for GSD organizations prior to the initiation of an SPI program. We believe that the results of this study can be useful in tackling the problems associated with the implementation of SPI, which is vital to the success and progression of GSD organizations.

1. Introduction

A variety of techniques have been introduced for the effective management of the software development process. The most significant of these is software process improvement (SPI), the purpose of which is to refine the steps involved in software development phases [1,2].

Various process improvement models were developed in order to help software organizations to achieve effective management of software development processes. For example, capability maturity model integration (CMMI) [3] consists of structured and methodical practices for process assessment and process improvement. The implementation of CMMI begins with the improvement approach IDEAL (Initiating, Diagnosing, Establishing, Acting, and Learning) model [4]. IDEAL model assist the organization to initiate, plan and implement the SPI program. It provides understandable guideline to continuously and successfully improve the process improvement activities. The Software Engineering Institute (SEI) has also presented a standard method for process improvement called SCAMPI, in order to provide benchmark quality ratings related to CMMI models [5]. The appraisals of SCAMPI assist to evaluate the strengths and weaknesses of the existing processes, highlight the risks related to the development and identify the ratings of capability and maturity level [5].

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The International Organization for Standardization (ISO) has also developed standards and recommendations for process assessment and improvement. For instance, the ISO 9000 series defines the fundamentals of quality management systems and specifies the terminology used in quality management systems [6]. ISO 9000 assists organizations in ensuring that their products fulfill the needs of their customers, and the quality of their products is constantly improved [6]. Similarly, ISO/IEC 15504 is a process improvement standard targeted at software process improvement and capability determination (SPICE) [7]. SPICE was developed to test and promote process improvement standards and models. ISO/IEC 15504 defines the requirements for performing process assessment, in order to implement SPICE. Recently, ISO/IEC 15504 has been revised and replaced by more advanced process assessment and improvement standards, such as ISO/IEC 330XX. The ISO/IEC 330XX series covers the assessment of the SPI programs within an organization, and the maintenance, change management, delivery, and improvement of those processes [8]. Furthermore, information technology infrastructure Library (ITIL) framework has been developed by the UK government with the aim to provide a guideline for delivering quality information technology (IT) services [9]. ITIL consist of best practices in order to set policies to deliver effective IT services, evaluate the IT related activities and improve the proficiency of the IT services by providing the service life cycles [9].

Previous research has indicated that process improvement models and standards can assist an organization in developing high-quality processes, reducing development cost and time, and increasing user satisfaction [10–14]. Emam and Koru [16] and Niazi et al. [17] determined that the key issue of SPI is not a lack of process improvement models and standards, but the unavailability of operatives and techniques to deploy SPI models and standards. They specified the need for more guidelines on "how to implement," rather than "what to implement."

SPI has a long tradition in software engineering and information systems research [2,10,13,18,19–22]. However, most of the previous studies considered SPI in the context of collocated software development [23], rather than global software development (GSD) [24–27]. In GSD, software is developed by teams situated at different geographical locations [1,2,23]. According to Agerfalk et al. [28] 20% of client organizations in the USA, and 20% of the 1000 leading software development organizations, are globalizing their work. Outsourcing development to vendor organizations in low-cost countries has become increasingly important, because of the significant reduction in development costs [29,30]. GSD has been found to be a rapid and inexpensive way to develop software.

Babar and Niazi [18] suggested that the benefits of GSD have broadened from decreasing development costs towards the enhancement of other aspects of software development. This new trend in GSD emphasizes the importance of SPI [27]. Therefore, the deployment of SPI with respect to GSD requires a long-term approach and adequate time and resources for its successful execution [18,27]. Ramasubbu [23] discussed the communication and collaboration difficulties resulting from development teams working in different geographical locations, and these increased the need for the deployment of process improvement programs. Furthermore, SPI teams working in GSD environments face different challenges when developing process improvement practices, establishing relationships among dispersed team members, managing time differences and cultural issues [18]. To efficiently address these challenges, it is necessary for international outsourcing vendor and client organizations to improve the quality of their development processes and techniques [18].

Despite their importance, little consideration has been given to the development of SPI implementation standards and models in general, and factors that can affect the implementation of process improvement in GSD organizations in particular [18–20,23,27].

The importance of SPI in GSD led us to develop an initial software process improvement implementation management model (SPIIMM) that could assist GSD organizations in the measurement and improvement of their software process improvement activities. An initial step in the development of this model is discussed in this paper. In the present study, we identified the barriers that could have negative impact on SPI program in GSD environment.

In this article, we provide a detail overview of the barriers that perform an important during SPI implementation in distributed software development. We present results from the SLR and the empirical study. Understanding of these barriers can improve SPI implementation by assisting practitioners in tackling these barriers prior to implementation. It can also facilitate the successful completion of SPI projects and improve relationships between geographically distributed organizations. Hence, this study will address the following research questions.

RQ1: What barriers to SPI implementation in GSD environments are identified in the literature?
RQ1.1: Are the barriers identified in the literature related to client or vendor organizations?
RQ2: What barriers to SPI implementation in GSD environments are identified in the empirical study?
RQ2.1: Are the barriers identified in the empirical study related to client or vendor organizations?
RQ3. Are there differences between the barriers identified in the literature and those identified in the empirical study?
RQ4: What are the most critical barriers identified in the literature and the empirical study?
RQ5. How can the identified barriers be categorized into a robust framework?

The aim of these research questions is to address barriers to SPI implementation in client and vendor GSD organizations in order to assess and improve SPI programs more effectively.

The remainder of this article is organized as follows: Section 2 covers the motivation for this article. In Section 3, we discuss our chosen research methodology. The findings of the study are briefly reported in Section 4. In Section 5, the results of the research questions are summarized. The limitations of this study are discussed in Section 6. Future directions for this research are discussed in Section 7, and our conclusions are presented in Section 8.

2. Motivation

SPI enables organizations to effectively evaluate their existing software development abilities [27]. Zahran [31] defined SPI as "the discipline of defining, characterizing, improving and measuring software management, better product innovation, faster cycle time, greater product quality and reduced development costs simultaneously."

Significant research has been focused on the development of process improvement standards and models. In order to improve software development processes, several standards and models have been introduced. These include the Capability Maturity Model (CMM) [15], Capability Maturity Model Integration (CMMI) [3], Software Process Improvement Capability Determination (SPICE) [7], ISO/IEC 33001 [8] and ITIL [9]. Standards and models encourage organizations to develop quality software systems [23,24]. However, the success rates for deploying process improvement programs are very low [18,32] (about 30%, according to Ngwenyama and Nielsen [33]). Babar and Niazi [18] attributed this to the limited attention given to SPI activities.

To successfully implement SPI practices, it is vital for their practitioners to have a thorough knowledge of process improvement activities in the context of GSD [20,23,27]. This is especially true

for client organizations in developed countries that outsource software development to reduce costs [34]. On the other hand, vendor organizations can improve their expertise by using novel approaches to fulfill the requirements of their client organizations. Furthermore, it has been reported that organizations that adopt GSD also add value to their clients' supply chains [29]. However, client and vendor organizations face the same challenges: temporal, socio-cultural, and geographical distances [2]. Reportedly, eight out of every ten organizations that have outsourced their software development activities to an offshore vendor have been adversely affected by inadequate planning and poor management by both client and vendor organizations [35].

The challenges associated with applying SPI in the context of GSD are distinct; both the client and vendor organizations should focus on problems arising from the implementation of process improvement activities across geographical boundaries [18]. According to Babar and Niazi [18], the implementation of SPI programs in GSD is more challenging than in collocated environments because of the dispersed nature of GSD projects. According to Ramasubbu [23] and Khan and Keung [27], previous studies have focused on implementing SPI in collocated software development. Therefore, there is a need for research that could highlight the software process improvement issues in the domain of distributed environment. No matter the type (client versus vendor) of organization, team members work beyond geographical boundaries where the implementation of SPI programs is more puzzling [23].

To summarize, little empirical research has been conducted into the execution of SPI programs in distributed environments and the barriers that prevent the successful implementation of SPI in GSD environments [18,20,23]. Recently, Verner et al. [36] conducted a tertiary mapping study and identified the need to investigate the client or vendor nature of software development organizations. Hence, this was addressed in the present study by studying the barriers to SPI in client and vendor organizations in a GSD environment.

3. Research methodology

The research methods selected for this study were a systematic literature review (SLR) and an industrial empirical study (questionnaire survey). An SLR is a type of secondary study in which primary studies (studies which examine a specific research area) are reviewed to identify, analyze, and explore evidence related to the research questions in an unbiased and iterative way [37]. The survey questionnaire was used to collect data from SPI practitioners with GSD experience. Both approaches are briefly discussed in the following sections.

3.1. Systematic literature review

SLRs are used to investigate, categorize, and evaluate the existing literature associated with a particular research area by applying inclusion and exclusion techniques [37,38]. According to Kitchenham and coworker [38,39], an SLR involves three main phases: planning, conducting, and reporting the review (Table 1).

The SLR approach has been used by researchers in a variety of domains [27,32,40,41]. Khan and Khan [40] used an SLR to identify factors that affect contract management activities in GSD environments. Khan and Azeem [41] conducted an SLR study to identify intercultural challenges among distributed teams.

All of the authors participated in the three phases of the SLR. Inter-rater reliability analyses were conducted during the initial and final selection phases of the SLR to remove inter-person bias. The results of the inter-rater reliability analyses are shown in Section 3.1.2.2. We followed all of the steps involved in the three phases of the SLR, as shown in Table 1.

Table 1
SLR Phases.

Phases	Steps
Planning	Research questions
	Data Sources
	Inclusion and exclusion criteria
	Search strings
	Quality criteria for study selection
Conducting	Primary study selection
	Data extraction
	Data synthesis
Reporting	Documenting the extracted results

3.1.1. Phase 1: planning the review

3.1.1.1. Research questions. The present study focused on the barriers to the successful implementation of SPI programs for client and vendor organizations in GSD contexts. This study addressed the following research questions:

RQ1: What barriers to SPI implementation in GSD environments are identified in the literature?
RQ1.1: Are the barriers identified in the literature related to client or vendor organizations?
RQ2: What barriers to SPI implementation in GSD environments are identified in the empirical study?
RQ2.1: Are the barriers identified in the empirical study related to client or vendor organizations?
RQ3. Are there differences between the barriers identified in the literature and those identified in the empirical study?
RQ4: What are the most critical barriers identified in the literature and the empirical study?
RQ5. How can the identified barriers be categorized into a robust framework?

3.1.1.2. Data sources. Suitable repositories were identified based on previous research experience and suggestions provided by Chen et al. [42]. The data sources included:

- IEEE Xplore
- ACM Digital Library
- Springer Link
- Wiley InterScience
- Science Direct
- Google Scholar

The digital libraries differed in their search mechanisms and capabilities; our search strings were tailored accordingly.

3.1.1.3. Search strings. Search strings were formulated using keywords (and alternatives) derived from the research questions and existing literature [18,23,27,29,43].

We used Boolean "OR" and "AND" operators to concatenate the keywords into search strings. The digital repositories were searched using the following string: ("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" OR "information technology outsourcing" OR "IS outsourcing" OR "IT outsourcing") AND ("client software development organizations" OR "client software development companies" OR "client analysis" OR "client perspective" OR "outsourcer" OR "buyer" OR "customer" OR "purchaser" OR "user" OR "consumer" OR "shopper") AND ("vendor software development organizations" OR "vendor software devel-

Table 2
Checklist for quality assessment of the selected research articles.

QA questions	Checklist questions
QA1	Do the research methods address the research questions?
QA2	Does the study discuss any barriers to the implementation of SPI?
QA3	Does the study discuss SPI implementation standards and models?
QA4	Are the data related to SPI?
QA5	Are the results related to the research questions?

opment companies" OR "vendor analysis" OR "vendor perspective" OR "service-provider" OR "dealer" OR "trader" OR "marketer" OR "seller") AND ("client-vendor analysis" OR "client-vendor perspective").

3.1.1.4. Inclusion criteria. The selected reports must be written in English and the full text must be available. They may be reports from journals, conferences, book articles or workshops. We considered reports which discussed process improvement activities in distributed software development environments, particularly those concerning barriers to SPI implementation in GSD. Those research articles certainly have more importance that provides empirical assessments supported with case studies.

3.1.1.5. Exclusion criteria. Articles that did not explicitly discuss SPI in the context of GSD were excluded from this analysis, in addition to those that did not focus on SPI standards or provided insufficient details regarding software improvement processes. Duplicates of the same results were also excluded. Further exclusions have been made in those studies that were written in a language other than English.

3.1.1.6. Quality criteria for study selection. Quality assessment (QA) of the selected articles was performed concurrently with the data extraction phase. A checklist was developed for the quantitative and qualitative assessment of the selected research articles. The guidelines provided in Refs. [32,44,45] were followed in the design of this checklist (Table 2).

For each given item QA1 to QA5, the assessment was carried out as follows:

- Studies addressing all of the checklist questions were assigned a score of 1 point;
- Studies containing partial answers to the checklist questions were assigned a score of 0.5 points;
- Studies not addressing any of the checklist questions were given as score of 0 points.

The selected studies were also assessed through an informal external review to confirm that they were of sufficient quality to be used in the SLR.

3.1.2. Phase 2: conducting the review

3.1.2.1. Primary study selection. The research articles found during primary study selection were refined using the tollgate approach proposed by Afzal et al. [46]. This approach consists of five phases (Table 3 and Fig. 1):

- Phase 1 (Ph-1): searching for relevant articles using search terms.
- Phase 2 (Ph-2): inclusion and exclusion based on title and abstract.
- Phase 3 (Ph-3): inclusion and exclusion based on introduction and conclusions.
- Phase 4 (Ph-4): inclusion and exclusion based on full text.
- Phase 5 (Ph-5): final selection of primary studies to be included the SLR.

Table 3
Selection of articles using the tollgate approach.

E-Databases	Ph-1	Ph-2	Ph-3	Ph-4	Ph-5	% of selected articles ($n = 85$)
Wiley Inter Science	25	24	17	11	6	7
IEEE Xplore	461	390	135	76	16	19
Science Direct	560	511	194	117	15	18
ACM Digital Library	146	112	37	25	9	10
Google Scholar	776	673	232	154	22	26
Springer Link	480	430	176	86	17	20
Total	2448	2140	791	469	85	100

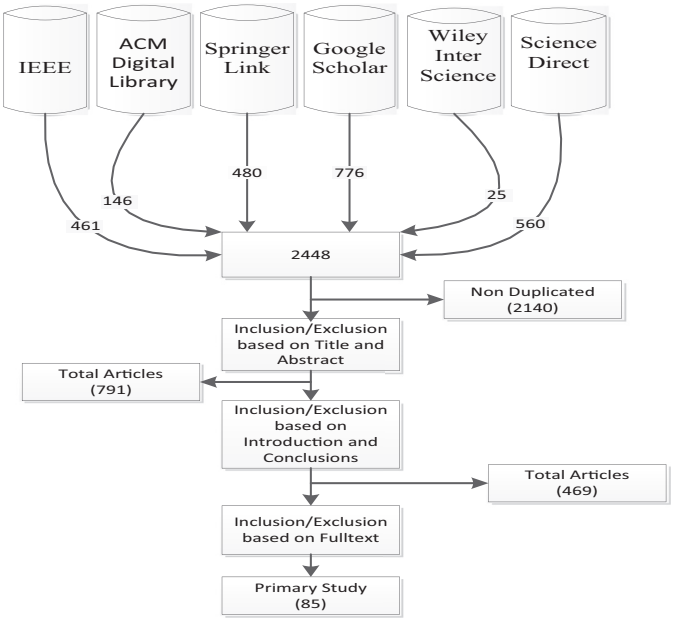


Fig. 1. Tollgate approach for article selection.

Initially, 2448 articles were extracted from the selected online databases by applying the developed search strings (Section 3.1.1.3) and the inclusion and exclusion criteria (Sections 3.1.1.4 and 3.1.1.5, respectively). The tollgate approach [46] resulted in a shortlist of 85 articles to be included in the primary study selection. Finally, the shortlisted papers were assessed using the quality assessment criteria (Section 3.1.1.6). A list of the selected primary studies is given in Appendix C. Each of the selected primary studies was labeled [LT], to indicate their use in the SLR.

3.1.2.2. Data extraction. In order to answer the research questions, we extracted the title, study type, and research method from each article.

Inter-rater reliability analyses were preformed to remove inter-person bias. Three independent external reviewers randomly selected ten articles from the first phase (Ph-1) of the tollgate process [46] and applied the selection phases (Ph-2 to Ph-5) of the tollgate process and the QA criteria. We calculated non-parametric Kendall's coefficient of concordance (W) [47] values to assess inter-rater agreement among the reviewers. The range of W is between 0 to 1, where $W = 0$ indicates complete disagreement and $W = 1$ indicates total agreement between the reviewers. For the ten randomly selected articles, $W = 0.80$ ($p = 0.003$), which indicated significant agreement between the authors and the external reviewers.

3.1.2.3. Data synthesis. A list of barriers to SPI was created using data extracted from the 85 articles remaining after the tollgate process. The research questions were evaluated using the data extracted from the selected articles.

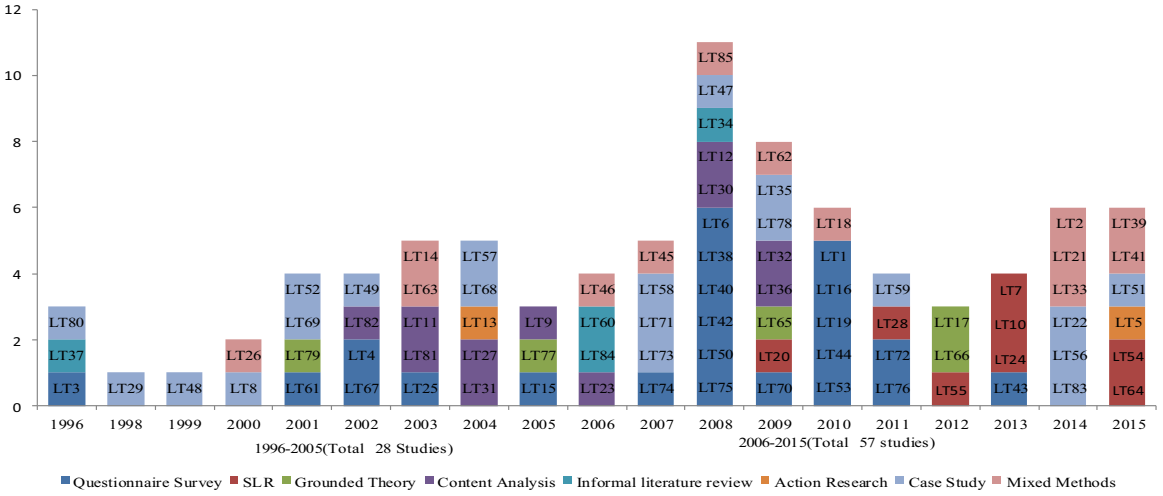


Fig. 2. Temporal distribution of selected articles.

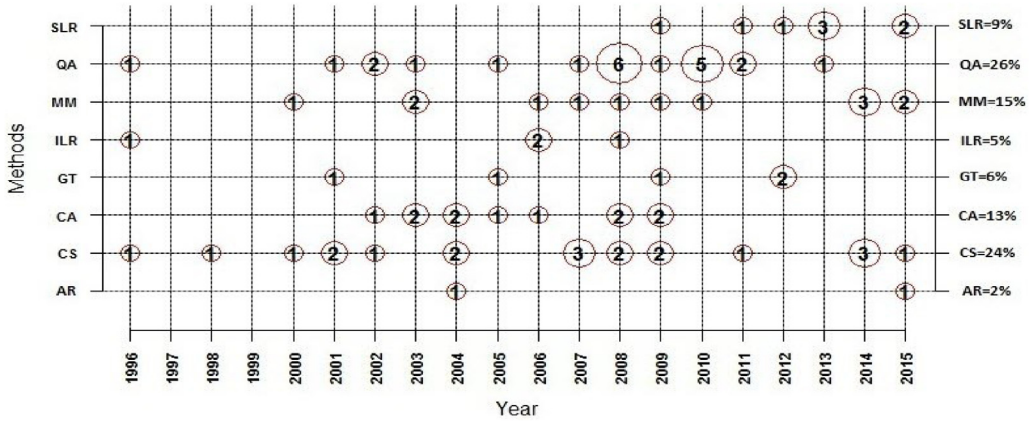


Fig. 3. Research methods used in the selected articles.

3.1.3. Phase 3: reporting the review

3.1.3.1. Quality attributes. Appendix C shows the scores for each of the selected studies determined from the five QA questions given in Table 2 (Section 3.1.1.6). The final QA score for each study was the sum of the scores assigned for each of the QA questions. Because tollgating had already been applied to reject unsuitable studies, therefore 75% of the selected studies scored 50% or above in each of the QA analyses.

3.1.3.2. Temporal distribution of the selected primary studies. A summary of the selected primary studies and their publication years, decades, and research methods is shown in Fig. 2. Of the 85 primary studies, 28 were published in the first decade (1996–2005) and 57 were published in the second decade (2006–2015). Hence, there has been a $>50\%$ increase in the number of research publications related to SPI and GSD over the last decade.

3.1.3.3. Research methods. The selected primary studies consisted of 22 questionnaire surveys (QA), 20 case studies (CS), 13 mixed methods (MM), 11 content analyses, 8 SLRs, 5 grounded theories (GT), 4 informal literature reviews (ILR), and 2 action research (AR) studies. The percentage of research methods used in the selected studies are: QA (26%), CS (24%), MM (15%), CA (13%), SLR (9%), ILR (5%), GT (6%) and AR (2%) as shown in Fig. 3.

In the first decade (1996–2005), 32% of the studies used a case study approach, and the majority was assigned a high quality score. In the second decade (2006–2015) there was a dramatic increase in the proportion of studies using questionnaire surveys. It illustrates that currently most of the research studies are adopting the questionnaire survey approach to conduct empirical studies related to SPI and GSD as shown in Fig. 2.

3.2. Empirical data collection

Based on the SLR findings, we developed an empirical online survey questionnaire to investigate barriers to SPI in the context of GSD. This survey method was capable of obtaining information from a large target population [48]. Moreover, surveys can elicit information that is difficult to obtain using observational techniques [48,49]. We developed a close-ended questionnaire to collect data from practitioners having SPI-related experience in GSD projects. The questionnaire contained additional open-ended questions to enable respondents to discuss additional barriers. The survey questions were based on the 22 barriers identified in the SLR. We used seven-point Likert scale; the possible responses were as follows: “strongly agree,” “moderately agree,” “slightly agree,” “neutral,” “strongly disagree,” “moderately disagree,” and “slightly disagree.” According to Finstad [50], there are no significant disadvantages to incorporating “neutral” into a seven-point Likert scale. Furthermore, most modern researchers believe that it is beneficial, because feeling neutral about a statement or topic is a legitimate response [51]. Not providing a neutral option may force respondents to answer either positively or negatively, resulting in biased data. Finsted [50] also reported that this seven-point scale provided accurate measurements of respondents’ attitudes.

A pilot evaluation of the questionnaire conducted in three GSD organizations. Based on the feedback from this evaluation, the instrument was modified to improve clarity and appropriateness. The final survey questionnaire comprised demographic data, SPI barriers, practices used to overcome the identified barriers. Participants were guaranteed that the information gathered from the questionnaire would be treated as confidential. The data was used for research purposes only and will not be shared with any third parties under any circumstances. A sample of the survey questionnaire is shown in Appendix A.

3.2.1. Data sources

The aim of this research was to investigate barriers to the implementation of SPI programs in GSD environments. Therefore, it was important to collect data from a diverse range of practitioners with SPI-related experience in GSD. The participants of this study were recruited using the snowball technique [52]. They were contacted using a variety of approaches, including email, LinkedIn, Facebook, and through their colleagues. Online data were collected from January 21, 2016 to March 14, 2016 and the entire data collection process of the empirical study last for one month and 23 days. Completed surveys were obtained from 93 experts. The first author manually reviewed the responses to exclude incomplete entries. However, no incomplete responses were found. The majority of the organizations were located in either Asia or Europe. The respondents ranged from software developers to CEOs; all of them had expertise in SPI and GSD. The demographics of the respondents are detailed in Appendix B.

3.2.2. Survey data analysis

A frequency analysis approach was used to organize the descriptive data. Frequency tables were used to present the frequencies and percentages of the data. Frequency analysis is useful for the analysis of variable groups and for both ordinal and numeric data [53]. To evaluate the significance of the identified barriers, we tallied the agreements between respondents regarding each barrier and compared these responses to those for other barriers. This technique has been used by other researchers in a variety of fields [18,29,40,54].

4. Findings

The results and analyses of the SLR and the empirical study are discussed in this section.

4.1. Results from SLR

This section presents the results obtained from the SLR study.

4.1.1. Barriers identified using SLR

A total of 85 primary study articles were identified in the SLR, and 22 barriers were extracted from these articles. To answer RQ1, the frequencies and percentages of the extracted barriers were determined (Fig. 4).

BA14 (lack of organizational support) was found to be the most common barrier to SPI implementation (74%). According to Sulyman et al. [LT2], organizational support is "the extent to which the higher and lower level management in an organization support, finance, realize and participate in SPI program." Ramasubbu [LT5] stressed that the commitment and participation of organizational management is crucial for implementing SPI successfully. Moreover, he indicated that GSD organizations cannot actualize SPI programs without proper support. Herbsleb and Goldenson [LT3] conducted an empirical study of 56 software development organizations. They concluded that if an organization's management did not allocate sufficient resources for SPI implementation then SPI was likely to be unsuccessful. Niazi [LT32] suggested that insufficient managerial support primarily resulted from a lack of awareness among management staff of the significance of SPI.

The SLR results indicated that BA13 (lack of communication) was the second most frequently cited barrier (71%). Agerfalk et al. [LT34] demonstrated that the distribution of development teams across geographical boundaries made communication a vital issue. Communication difficulties hindered the building of trust and confidence. Furthermore, lack of communication can lead to misinterpretations, lack of control, and even communication breakdown [LT35]. Conchúir et al. [LT36] suggest the lack of face-to-face communication can result in other barriers, such as a lack of trust and feedback.

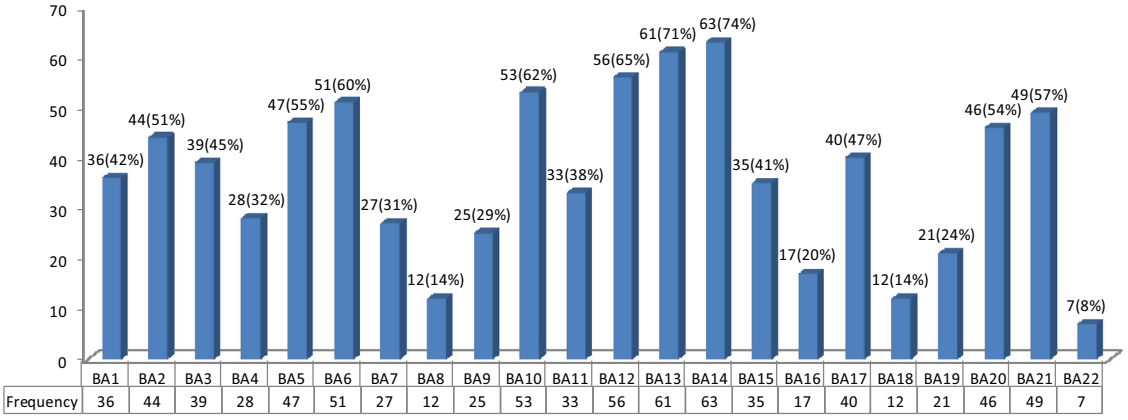
BA12 (lack of resources) was mentioned by 65% of the selected articles. Niazi et al. [LT27] conducted an empirical industrial study which indicated that 72% of the practitioners believed that SPI programs had suffered because of limited resources and time. In an article concerning cross-cultural barriers in GSD organizations, Niazi et al. [LT16] concluded that the successful implementation of SPI programs relies on the necessary resources being provided. Kautz and Nielsen [LT8] found, in an empirical industrial study, that team managers were hesitant to financially support the implementation of process improvement programs using their own funds. They concluded that organizations should adopt a more open-minded and positive attitude towards SPI programs, and support their implementation by providing adequate resources [LT23, LT27]. Similarly, Ramasubbu [LT5] determined that GSD organizations which intended to allocate adequate resources could positively influence the success of SPI projects.

More than 60% of the SLR articles identified BA10 (organizational politics) as a key barrier to the implementation of SPI programs. Team members usually show resistance toward the deployment of SPI activities as they consider them to be a significant change in the organization. Niazi et al. [LT16] discussed the nature of geographically dispersed teams and that their members may have contrasting goals, objectives, and ideas. Hence, the implementation of an SPI program may align with the aims and objectives of some individuals but not with those of others. Moitra [LT29] was concerned with the pitfalls and complications of SPI change management, and reported that organizational politics can undermine the success of process improvement programs. Iversen et al. [LT13] identified particular aspects of organizational politics that can affect the outcomes of SPI projects, for example, promotion opportunities, reallocation of resources and roles, ambiguity, and lack of trust.

BA6 (lack of training) was also a significant barrier to SPI implementation (60%). Wiegers [LT37] indicated that SPI programs can be ineffective if team members do not have adequate SPI training, which can also undermine the entire process improvement effort. Without proper training, SPI team members may be unable to effectively evaluate the need for change. Ross [LT51] found that all of the people involved in an SPI program require a complete understanding of SPI principles, process improvement standards, models such as CMM and CMMI, and software quality.

BA21 (lack of implementation tools and standards) was discussed in 57% of the selected articles. Nasir [LT38] underlined the importance of using the proper tools for SPI implementation, and the necessity of practitioners to have a proper understanding of those tools. Furthermore, Dutra [LT39] agreed that the failure of an SPI program can result from a lack of tools and standards.

BA5 (lack of process improvement knowledge) was cited in 55% of the selected articles. Kautz and Nielsen [LT8] sought to understand why SPI implementation was unsuccessful in a particular organization: "the technical director and staff had no expertise and knowledge regarding process improvement and they have experienced various hurdles during SPI implementation." Bayona et al. [LT24] emphasized the experience of individuals participating in an



S. No	Identified barriers	Frequency	S. No	Identified barriers	Frequency
BA1	Inexperienced staff	36	BA12	Lack of resources	56
BA2	Staff turnover	44	BA13	Lack of communication	61
BA3	Cultural differences	39	BA14	Lack of organizational support	63
BA4	Lack of trust	28	BA15	Temporal distance	35
BA5	Lack of process improvement knowledge	47	BA16	Poor organizational infrastructure	17
BA6	Lack of training	51	BA17	Budget constraints	40
BA7	Lack of feedback	27	BA18	Organizational changes	12
BA8	Personality clashes	12	BA19	Lack of sponsorship	21
BA9	Workload	25	BA20	Lack of formal SPI implementation methodology	46
BA10	Organizational politics	53	BA21	Lack of implementation tools and standards	49
BA11	Time pressure	33	BA22	Stalling on action plan implementation	7

Fig. 4. Barriers identified in the SLR.

SPI program. They recommended that SPI teams develop a deeper knowledge of the implementation of process improvement activities. Emam and Koru [LT6] reported that the lack of sufficient process improvement knowledge may cause the entire SPI program to fail.

About 54% of the articles cited BA20 (lack of formal SPI implementation methodology) as a significant barrier faced by SPI team members. The need for an effective SPI implementation methodology in GSD was highlighted by Niazi et al. [LT16]. They argued that this methodology should consist of a complete process improvement strategy, including process improvement activities, procedures, and progress measures. Most of the SPI experts working in a GSD environment believed that the absence of formal SPI implementation methodologies and techniques could impede the successful execution of SPI activities [LT16]. Fewer SPI implementation standards and models have been developed for use in GSD, than for conventional software development [LT16, LT32, LT33].

BA2 (staff turnover) was discussed in 51% of the selected primary studies. Rainer and Hall [LT4] believed that the cost of SPI implementation could be significantly increased as a result of frequent staff turnover. In addition to the direct cost of employing replacement staff, indirect costs related to the loss of core skills, knowledge, and experience contributed to the total cost of SPI [LT4]. Hall et al. [LT30] collected data from 89 experts and investigated the effect of high staff turnover on the success of SPI projects. They suggested that boosting the motivation levels of practitioners can decrease staff turnover.

BA17 (budget constraints) was significant in more than 40% of the selected articles. Budgetary constraints make it difficult to hire process improvement consultants, although organizational management may strive to successfully implement a process improvement program [LT40]. Niazi [LT42] concluded that the implementation of SPI programs increased pressure on small vendor organizations as a result of budget constraints. Small organizations may not be able to set aside a large budget for SPI activities, because they need to maintain low costs in order to compete with other organizations.

BA3 (cultural differences) was cited in 45% of the selected studies. In GSD, team members may be geographically and culturally distinct. Overcoming these cultural differences is important for the successful implementation of SPI. For instance, client and vendor organizations may not be able to communicate with each other using their native languages [LT43]. Furthermore, misunderstandings may occur as a result of cultural differences, which can create confusion between different teams [LT44].

Around 42% of the articles specified BA1 (inexperienced staff) as a barrier to SPI implementation. Hall and Rainer [LT4] described the challenges of managing change for SPI, including the lack of knowledge of SPI implementers regarding software development processes. Niazi et al. [LT16] reported that GSD organizations which effectively implemented SPI programs had experienced and skillful individuals in their process improvement teams.

Nearly a quarter of the articles indicated that BA11 (time pressure) was a barrier to SPI implementation. Niazi et al. [LT16, LT27, LT32] indicated that time pressure was one of the most significant challenges for organizations who involved in SPI activities. According to Mantyla et al. [LT22], under time pressure, team members made quick decisions in order to stay on schedule. However, those decisions may not be beneficial to the process improvement program. A study conducted by Baddoo et al. [LT26] found that all types of practitioners studied (58% of senior managers, 44% of project managers, and 62% of developers) cited time pressure as a demotivational factor for SPI.

Developing confidence and trust among different teams is also a significant barrier to SPI programs [LT43, LT45, LT47]. This was evidenced in the SLR study, where more than 30% of the selected articles referred to BA4 (lack of trust) as a barrier to successful SPI implementation. Fostering stronger relationships between team members of both client and vendor organizations can improve the outcomes of SPI projects.

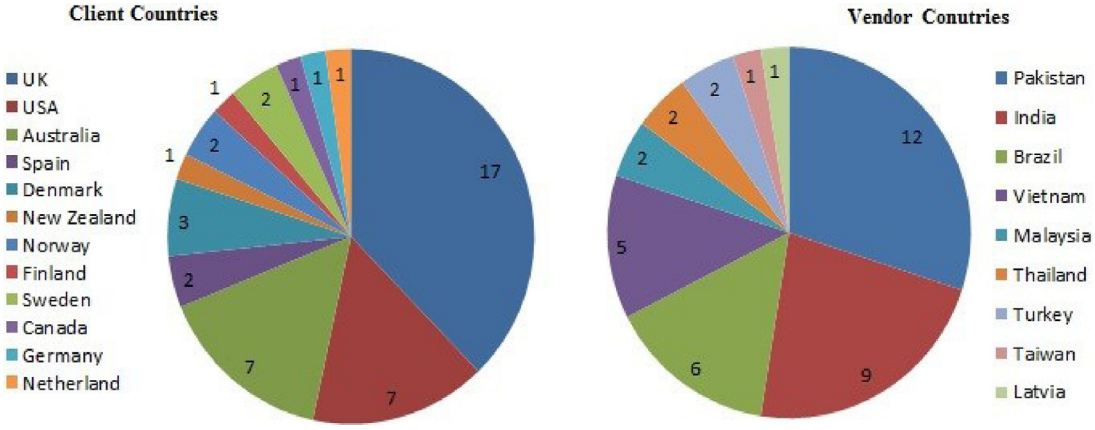


Fig. 5. Classification of client-vendor organizations by country.

Table 4
Fisher's exact analyses of the identified barriers with respect to client-vendor organizations.

S. No.	Barriers	Vendor ($N=40$)		Client ($N=45$)		Fisher's Exact Test $\alpha = 0.05$
		Freq.	%	Freq.	%	
BA1	Inexperienced staff	18	45	18	40	0.666
BA2	Staff turnover	20	50	24	53	0.829
BA3	Cultural differences	19	42	20	44	0.830
BA4	Lack of trust	16	40	12	26	0.249
BA5	Lack of process improvement knowledge	23	57	24	53	0.827
BA6	Lack of training	26	65	25	55	0.506
BA7	Lack of feedback	15	37	12	26	0.353
BA8	Personality clashes	5	12	7	15	0.762
BA9	Workload	12	30	13	28	1.000
BA10	Organizational politics	25	62	28	62	1.000
BA11	Time pressure	17	42	16	35	0.656
BA12	Lack of resources	25	62	31	68	0.648
BA13	Lack of communication	28	70	33	73	0.811
BA14	Lack of organizational support	28	70	35	77	0.464
BA15	Temporal distance	20	50	15	33	0.130
BA16	Poor organizational infrastructure	10	25	7	15	0.294
BA17	Budget constraints	16	40	24	53	0.278
BA18	Organizational changes	7	17	5	11	0.535
BA19	Lack of sponsorship	8	20	13	28	0.451
BA20	Lack of formal SPI implementation methodology	22	55	24	53	1.000
BA21	Lack of implementation tools and standards	24	60	25	55	0.826
BA22	Stalling on action plan implementation	2	5	5	11	0.439

4.1.2. Client-Vendor categorization of SLR barriers

We examined client-vendor relationships by reviewing each of the selected articles in our SLR study. A total of 40 and 45 studies were conducted in vendor and client countries, respectively (Fig. 5).

Verner et al. [36] observed that most of the available literature focused on vendor organizations, rather than clients. Therefore, we implemented Fisher's exact test on the identified barriers to categorize their applicability to vendor and client organizations (Table 4).

The results illustrated that both client and vendor organizations have more similarities than differences in the applicability of the identified barriers. As shown in Table 4, 'organizational politics' (BA10, 62% and 62%), 'lack of organizational support' (BA14, 70% and 77%), 'lack of communication' (BA13, 70% and 73%), 'lack of resources' (BA12, 62%, and 68%), 'lack of formal SPI implementation methodology' (BA20, 55% and 53%), 'lack of process improvement knowledge' (BA5, 57% and 53%), and 'staff turnover' (BA2, 50% and 53%) were the most common barriers in both vendor and client organizations.

'Lack of organizational support' was the most significant barrier in both vendor and client organizations. This is because SPI is a long-term approach, and therefore the support of organizational management is particularly important. Ramasubbu [LT5] conducted an empirical study, which concluded that for the successful execution of an SPI program, it is necessary for upper management to finance, support, and participate in SPI activities. Niazi [LT32] determined that most high-level managers are unaware of the importance of SPI, and hesitate in providing sufficient resources for process improvement activities.

4.2. Results of the empirical study

In this section, we discuss the results of the SPI practitioner survey.

4.2.1. Barriers identified in the empirical study

To answer RQ2, we conducted an online survey of SPI practitioners based on the barriers identified in the SLR. The resulting categorization of the barriers is shown in Table 5. The table is divided into three main categories: 'Positive' (strongly agree (EA), moderately agree (MA), and slightly agree (SA)), 'Negative' (strongly disagree (ED), moderately disagree (MD), and slightly disagree (SD)) and 'Neutral' (NS). The positive category represents the percentage of respondents who agreed with the barriers identified in the SLR. The negative category shows the percentage of those respondents who did not consider the identified barriers to be significant in the context of GSD. The neutral category represents those

Table 5
Barriers identified Barriers from the empirical study.

S. No.	Barriers	Empirical observations ($N = 93$)									
		Positive				Positive				Neutral	
		EA	MA	SLA	%	ED	MD	SLD	%	NS	%
BA1	Inexperienced staff	26	32	21	85	1	2	3	6	8	9
BA2	Staff turnover	22	35	16	78	2	5	8	16	5	5
BA3	Cultural differences	21	24	22	72	4	4	8	17	10	11
BA4	Lack of trust	26	31	20	82	2	1	4	8	9	10
BA5	Lack of process improvement knowledge	23	34	19	82	2	5	4	12	6	6
BA6	Lack of training	25	43	14	88	1	2	2	5	6	6
BA7	Lack of feedback	28	33	21	88	1	2	3	8	3	3
BA8	Personality clashes	21	22	24	72	3	7	4	15	12	13
BA9	Workload	32	24	21	83	1	2	8	12	5	5
BA10	Organizational politics	46	36	11	92	2	2	2	6	2	2
BA11	Time pressure	36	41	18	94	3	0	1	4	2	2
BA12	Lack of resources	49	26	10	91	2	1	1	4	4	4
BA13	Lack of communication	60	20	4	90	2	1	1	4	5	5
BA14	Lack of organizational support	46	27	10	89	2	3	0	5	5	5
BA15	Temporal distance	15	26	22	68	3	4	12	20	11	12
BA16	Poor organizational infrastructure	25	32	18	80	2	1	2	5	13	14
BA17	Budget constraints	22	40	18	86	2	2	2	6	7	8
BA18	Organizational changes	30	33	14	82	1	1	8	11	6	6
BA19	Lack of sponsorship	33	24	20	82	2	3	4	10	7	8
BA20	Lack of formal SPI implementation methodology	44	30	12	92	1	1	2	4	3	3
BA21	Lack of implementation tools and standards	29	43	11	89	1	1	3	5	5	5
BA22	Stalling on action plan implementation	23	34	20	82	2	2	4	9	8	9

respondents who were unsure about the significance of the identified barriers.

The results demonstrate that the majority of the respondents agreed that the identified barriers can negatively affect SPI implementation in GSD environments; all of the barriers exhibit a 'Positive' response of greater than 70%, except for BA15 (temporal distance).

'Time pressure' (BA11, 94%) was considered by the survey respondents to be the most significant barrier to successful implementation of SPI programs [LT32, LT16, LT27]. Richardson et al. [LT18] conducted a GSD case study to investigate the implementation of process improvements in a particular organization. They found that time pressure was a significant barrier to the successful implementation of process improvement. The decisions of the team members made under time pressure may not be in the interests of the process improvement program. Our results show that 'organizational politics' (BA10, 92%) and 'lack of formal SPI implementation methodology' (BA20, 92%) were the second most significant barriers to the survey respondents. Most of the respondents consider organizational politics to be a significant barrier because the majority of GSD team members are from different cultural backgrounds, and may have opposing ideas regarding SPI; the implementation of an SPI program might be in the interests of some individuals, but not necessarily in the interests of all of them. Similarly, the significance of a lack of formal SPI implementation methodology was attributed to the unavailability of process improvement implementation approaches that are applicable to distributed SPI team members.

In the 'Negative' category, 'temporal distance' (BA12, 20%) was deemed to be the least significant barrier. Hence, 20% of the survey respondents did not consider temporal distance to be a barrier to SPI implementation in GSD. This may be attributed to advancements in information and communication technologies, which have mitigated the effects of time differences between distributed GSD teams. The second least significant barrier was found to be 'cultural difference' (BA3, 17%). This indicated that, generally, distributed team members have sufficient understanding of various cultural norms and values.

'Poor organizational infrastructure' (BA16, 14%) was the most significant response in the 'Neutral' category. Thus, a significant proportion of the respondents were unsure about the significance of the infrastructure of their respective organizations on SPI implementation.

4.2.2. Client-vendor categorization of barriers identified in the empirical study

In the survey questionnaire, the respondents were asked to rank define the nature (client or vendor) of their organization in relation to GSD. The results indicated that most of the practitioners were from Asian countries (such as India, China, or Pakistan; Fig. 6). This corresponds with the fact that Asia is a hub for GSD outsourcing.

The results shown in Table 6 demonstrate that the client and vendor organization have more similarities than differences with regards to the identified barriers. In addition, client and vendor organizations either strongly agreed or moderately agreed with the findings of the SLR. However, there were significant differences ($p < 0.05$) evident in two barriers ('inexperienced staff,' BA1, and 'temporal distance,' BA15) between the client and vendor organizations. More vendor organizations (90%) than client organizations (72%) were aware of the importance of inexperienced staff in the implementation of SPI programs. Temporal distance was more significant to vendor organizations (68%) than to client organizations (60%). This may be attributed to the relative availabilities of advanced communication infrastructure, because vendor organizations are usually located in less developed countries. Vendor organizations often have greater budget constraints, which increases the importance of the provision of adequate communication facilities by organizational management to mitigate temporal distance barriers.

We applied the reference model developed by Prikladnicki et al. [67] to GSD organizations in order to assess the significance of the barriers to client and vendor organizations. This reference model enables the exploration of factors that enable multinational and virtual corporations to operate successfully in a distributed environment.

The 22 barriers identified in the SLR were categorized based on their significance to client and vendor organizations, determined from the results of the empirical study (Table 6). For example, 72% of the client organizations considered 'inexperienced staff' (BA1) as a barrier to the implementation of SPI. However, this barrier was

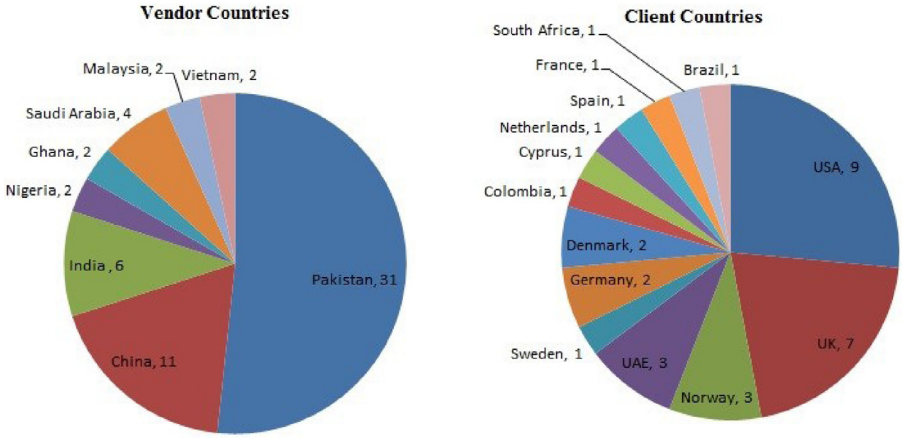


Fig. 6. Classification of client-vendor organizations from the empirical study by country.

Table 6
Client-vendor comparison of barriers identified in the empirical study.

S. No	Barriers	Occurrence in Survey ($N=93$)																
		Client ($N=33$)							Vendor ($N=60$)							Chi-square Test (Linear-by-Linear Association) $\alpha=0.05$		
		Positive			Negative			Neutral	Positive			Negative			Neutral			
		EA	MA	SA	ED	MD	SD	NU	EA	MA	SA	ED	MD	SD	NU	X^2	df	p
BA1	**Inexperienced staff**	**12**	**9**	**3**	**0**	**0**	**2**	**7**	**17**	**20**	**17**	**1**	**3**	**1**	**1**	**4.507**	**1**	**0.034**
BA2	Staff turnover	10	10	8	0	1	2	2	9	25	9	2	4	6	5	0.003	1	0.959
BA3	Cultural differences	10	8	8	1	1	2	3	10	17	13	3	4	6	7	0.202	1	0.653
BA4	Lack of trust	12	12	5	0	0	2	2	15	18	14	2	2	2	7	1.226	1	0.268
BA5	Lack of process improvement knowledge	8	13	5	1	1	2	3	18	21	11	1	4	3	2	0.442	1	0.506
BA6	Lack of training	8	15	5	0	2	1	2	17	28	9	1	1	0	4	0.279	1	0.597
BA7	Lack of feedback	7	15	8	0	1	1	1	20	17	15	1	1	4	2	0.053	1	0.818
BA8	Personality clashes	9	6	9	1	2	3	3	11	16	15	3	5	1	9	0.223	1	0.637
BA9	Workload	12	9	6	1	1	2	2	19	17	14	0	1	6	3	0.000	1	0.992
BA10	Organizational politics	15	13	4	0	0	0	1	27	20	6	2	2	2	1	0.028	1	0.867
BA11	Time pressure	13	12	8	0	0	0	13	21	26	8	3	1	1	21	2.398	1	0.122
BA12	Lack of resources	20	8	3	1	0	0	1	29	19	5	2	1	1	3	0.441	1	0.507
BA13	Lack of communication	26	4	2	0	0	0	1	37	14	1	3	1	1	3	3.811	1	0.005
BA14	Lack of organizational support	18	11	2	0	0	0	2	28	17	7	2	3	1	2	0.637	1	0.425
BA15	**Temporal distance**	**4**	**9**	**7**	**0**	**1**	**6**	**6**	**11**	**17**	**13**	**3**	**3**	**8**	**5**	**5.066**	**1**	**0.024**
BA16	Poor organizational infrastructure	7	10	10	0	0	1	5	17	22	7	2	1	2	17	1.992	1	0.158
BA17	Budget constraints	8	13	8	1	1	0	2	15	25	10	1	1	3	5	0.228	1	0.633
BA18	Organizational changes	12	13	3	0	0	3	2	16	22	9	1	1	7	4	0.007	1	0.934
BA19	Lack of sponsorship	12	11	7	0	0	1	2	20	13	13	2	3	5	4	0.441	1	0.506
BA20	Lack of formal SPI implementation methodology	14	11	6	0	0	1	1	32	17	5	1	1	2	2	0.044	1	0.833
BA21	Lack of implementation tools and standards	12	12	4	0	0	2	3	18	30	6	1	1	2	2	1.158	1	0.282
BA22	Stalling on action plan implementation	8	15	5	0	1	1	3	16	20	12	2	1	3	6	0.159	1	0.690

significant to 90% of the vendor organizations. Therefore, BA1 was assigned to the vendor organizations category.

We calculated the percentages for all of the barriers and conceptually mapped them to client and vendor categories, as shown in Fig. 7. The mapping results demonstrated that most of the barriers were more significant to client organizations than to vendors. It is vital for the client organizations to successfully address all the barriers in their respective category. Similarly, we have classified nine barriers in the vendor organizations category. It advances the knowledge to emphasize on the specific barriers identified in the category of vendor organizations.

4.3. Comparison of SLR and empirical study results

In this section, we discuss the comparison of the results of the SLR and the empirical study, as shown in Fig. 8. The aim of this

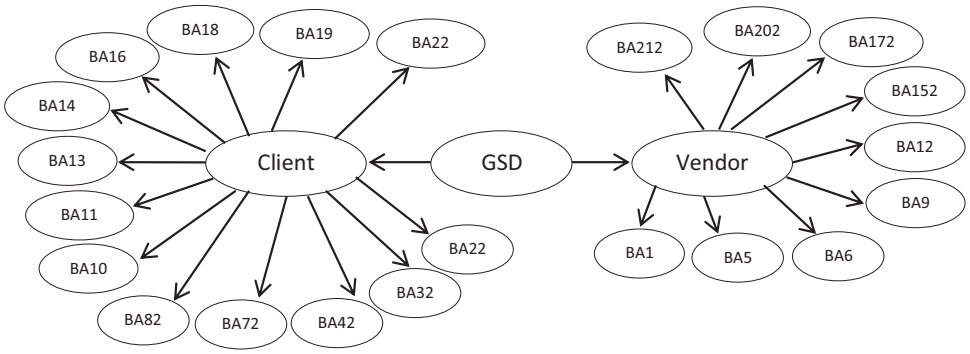
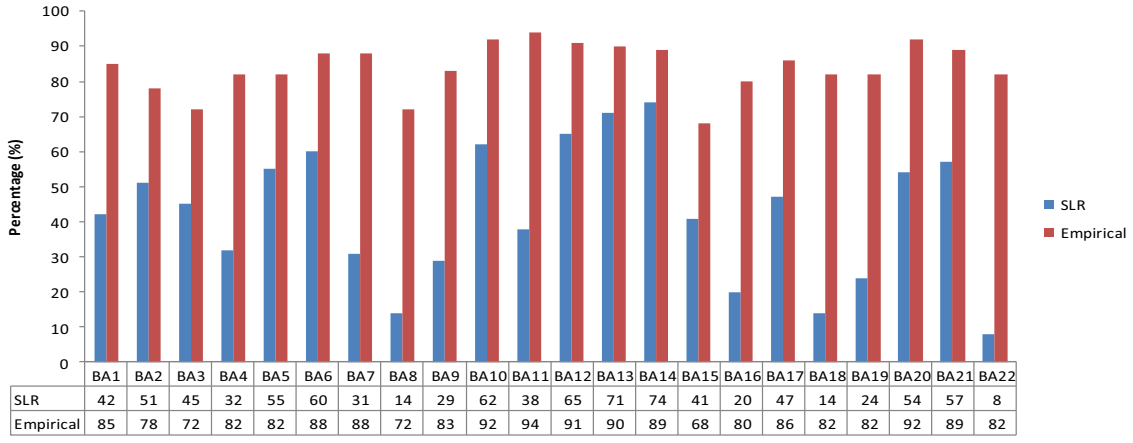


Fig. 7. Conceptual mapping of the identified barriers to either client or vendor organizations.



	BA1	BA2	BA3	BA4	BA5	BA6	BA7	BA8	BA9	BA10	BA11	BA12	BA13	BA14	BA15	BA16	BA17	BA18	BA19	BA20	BA21	BA22
SLR	42	51	45	32	55	60	31	14	29	62	38	65	71	74	41	20	47	14	24	54	57	8
Empirical	85	78	72	82	82	88	88	72	83	92	94	91	90	89	68	80	86	82	82	92	89	82

Fig. 8. Comparison of the barriers identified in both the SLR and the empirical study.

Table 7
Barriers identified from the empirical study.

S. No	Barriers	Occurrence in SLR ($N=85$)		Positive occurrence in survey ($N=93$)		Average rank
		%	Rank	%	Rank	
BA1	Inexperienced staff	42	12	85	8	10
BA2	Staff turnover	51	9	78	12	11
BA3	Cultural differences	45	11	72	13	12
BA4	Lack of trust	32	15	82	10	13
BA5	Lack of process improvement knowledge	55	7	82	10	9
BA6	Lack of training	60	5	88	6	6
BA7	Lack of feedback	31	16	88	6	11
BA8	Personality clashes	14	20	72	13	17
BA9	Workload	29	17	83	9	13
BA10	Organizational politics	62	4	92	2	3
BA11	Time pressure	38	14	94	1	8
BA12	Lack of resources	65	3	91	3	3
BA13	Lack of communication	71	2	90	4	3
BA14	Lack of organizational support	74	1	89	5	3
BA15	Temporal distance	41	13	68	14	14
BA16	Poor organizational infrastructure	20	19	80	11	15
BA17	Budget constraints	47	10	86	7	9
BA18	Organizational changes	14	20	82	10	15
BA19	Lack of sponsorship	24	18	82	10	14
BA20	Lack of formal SPI implementation methodology	54	8	92	2	5
BA21	Lack of implementation tools and standards	57	6	89	5	6
BA22	Stalling on action plan implementation	8	21	82	10	16

comparison was to determine the similarities and differences between the two data sets.

Table 7 shows the average rankings of the barriers identified using both SLR and empirical data. The data obtained in the empirical study was categorized as 'Positive,' 'Negative,' or 'Neutral,' as described above (Section 4.2.1). An open-ended question was present in the survey questionnaire to enable the identification of additional barriers by the respondents. However, no additional barriers were reported that could have a significant effect on SPI programs in GSD. The positive occurrences of the survey responses are shown in Table 7.

To evaluate the significance of the differences between the rankings of barriers identified in the SLR and survey studies, we performed a correlation data analysis using Spearman's rank-order correlation.

Spearman's correlation coefficient was found to be 0.567, indicating a moderate positive correlation between the rankings obtained from the SLR and the empirical data. The significance value,

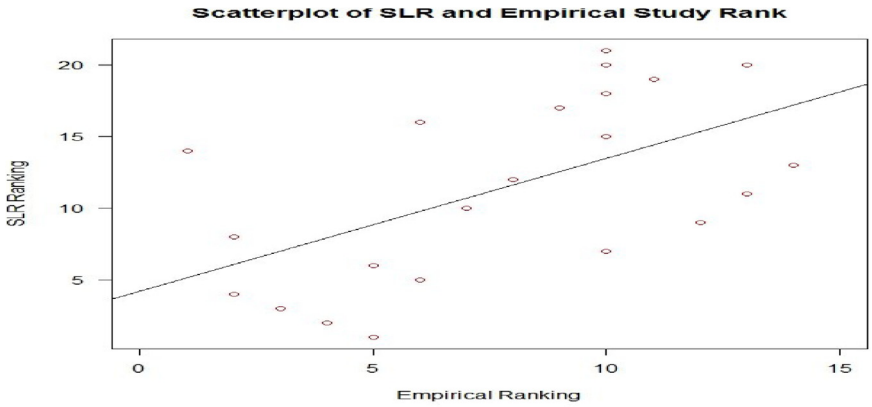


Fig. 9. Scatterplot of the barrier rankings obtained from the SLR and empirical study.

Table 8
Rank-order correlation between SLR and the empirical study.

			SLR_Rank	Empirical_Rank
Spearman's rho	SLR rank	Correlation coefficient	1.000	0.567**
		Sig. (2-tailed)	0.0	0.006
		N	22	22
	Empirical rank	Correlation Coefficient	0.567**	1.000
		Sig. (2-tailed)	0.006	0.0
		N	22	22

Table 9
Group statistics.

	Group	*N*	Mean	Std. deviation	Std. error mean
Factor	SLR	22	11.4091	6.35205	1.35426
	Survey	22	7.7727	3.90277	0.83207

$p = 0.006$, demonstrates that this correlation is statistically significant. These results are shown in Table 8 and depicted as a scatter plot in Fig. 9.

In addition to Spearman's correlation analysis, we performed independent *t*-tests to evaluate the mean difference between the SLR and the empirical study (Tables 9 and 10).

Using Levene's test, we calculated the significance of the differences between the barrier rankings from the SLR and the empirical study. As shown in Table 10, the *t*-test results were $t = 2.28$ and $p = 0.011 < 0.05$, demonstrating that there is a significant difference between the rankings. For example, BA22 ('stalling on action plan implementation') was ranked 21st in the SLR, but ranked 10th in the empirical study. Thus, BA22 was deemed to be of greater significance by practitioners than in the literature. Similarly, the rankings of BA18 (organizational changes), BA19 (lack of sponsorship), BA16 (poor organizational infrastructure), and BA20 (lack of formal SPI implementation methodology) differed significantly between the SLR and the empirical study.

4.4. Critical barriers

The concept of the critical factors was introduced by Rockart [62], in order to identify the information needs of a chief executive. This concept is based on the perception factors derived from management literature [63]. Niazi [64] defined critical factors as the areas upon which organizational management must focus to achieve specific business goals. Giving insufficient attention to these areas can undermine the performance of a business [64,65]. Critical factors may differ, as they depend upon an individual's position within an organization and the geographical location of managers; critical factors may also change over time [62,64,66].

We used the following criterion to determine the criticality of a specific factor:

- If a factor has a frequency ≥50% in both the literature and an empirical study, then it is considered to be a critical factor.

This criterion has been used by researchers in various fields [40,55–57]. In the present study, it was used to determine the critical barriers (CBs) to SPI implementation, regardless of the differences between the two data sets. These CBs were used to develop the factors component of the proposed SPIIMM model (Section 7). A total of nine barriers were categorized as CBs to SPI implementation: BA2 (staff turnover), BA5 (lack of process improvement knowledge), BA6 (lack of training), BA10 (organizational politics), BA12 (lack of resources), BA13 (lack of communication), BA14 (lack of organizational support), BA20 (lack of formal SPI implementation methodology), and BA21 (lack of implementation tools and standards).

4.5. Categorization of the identified barriers into a robust framework

Ramasubbu [23] developed a framework to categorize and map the issues of SPI implementation in the domain of global software development. He organized process improvement activities into six different categories: project administration, coordination, software methodology, human resources management, knowledge integration, and technology factors [23]. Because the present study is sim-

Table 10
Independent sample *t*-tests.

		Levene's test for equality of variances		*t*-test for equality of means						
		F	Sig.	*t*	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% Confidence interval of the difference	
									Lower	Upper
Factor	Equal variances assumed	7.116	0.011	2.288	42	0.027	3.63636	1.58946	0.42871	6.84401
	Equal variances not assumed			2.288	34.877	0.028	3.63636	1.58946	0.40919	6.86353

Table 11
Categorical Classification of the identified barriers.

S. No	Categories	Barriers
1	Project administration	• Inexperienced staff • Staff turnover • Organizational politics • Lack of organizational support • Budget constraints • Lack of sponsorship • Stalling on action plan implementation
2	Coordination	• Cultural differences • Lack of trust • Lack of feedback • Personality clashes • Lack of communication
3	Software methodology	• Lack of formal SPI implementation methodology
4	Human resources management	• Lack of training • Workload • Time pressure • Lack of resources • Organizational changes
5	Knowledge integration	• Lack of process improvement knowledge
6	Technology factors	• Poor organizational infrastructure • Temporal distance • Lack of implementation tools and standards

ilar to that of Ramasubbu [23], therefore we mapped the identified barriers into the same six categories.

The 22 identified barriers were analyzed and assigned to one of the six categories (Table 11). All of the authors were involved in the mapping process.

The mapping of the identified barriers has both industrial and research implications. The barriers identified in the SLR and the empirical study serves as a knowledge base for practitioners and researchers. The classification of the barriers provides a robust framework to enable the researchers and practitioners to focus on the most critical areas for process improvement in a GSD environment. It will also assist SPI teams in the development of effective strategies and policies to mitigate process improvement barriers in GSD.

5. Discussion

The aim of the present study was to identify barriers to successful SPI implementation in GSD. The ultimate goal of this research is to develop a model to measure and improve process improvement readiness in GSD organizations.

In order to answer RQ1, we identified a total of 22 barriers to the effective implementation of SPI from 85 articles selected for the SLR. The identified barriers represent areas where SPI team members should focus in order to successfully execute process improvement programs.

To address RQ1.1, we classified the barriers into either client or vendor organizations (Table 4). The results demonstrated that client and vendor organizations have more similarities than differences in regards to the identified barriers. We identified 'organizational politics' (62% and 62%), 'lack of organizational support' (70% and 77%), 'lack of communication' (70% and 73%), 'lack of resources' (62% and 68%), 'lack of process improvement knowledge (57% and 53%)', 'lack of formal SPI implementation methodology' (55%, and 53%) and 'staff turnover' (50% and 53%) as the most common barriers in both vendor and client organizations respectively.

To address RQ2 and RQ2.1, we analyzed the survey data by examining the positive, negative, and neutral responses. Significant differences were observed between clients and vendor organizations for only two barriers ('inexperienced staff' and 'temporal distance').

For RQ3, we applied Spearman's correlation analysis to the barrier rankings determined from the SLR and the empirical study. The rankings exhibited moderate correlation coefficient (rs $(22) = 0.567$). The results of a t-test ($t = 2.28$ and $p = 0.011 < 0.05$) indicated that there is a significant difference between the rankings determined from the SLR and the empirical study.

To answer RQ4, we determined the criticality of each particular barrier using the criterion described in Section 4.4. Nine barriers were identified as CBs: "BA2: staff turnover", "BA5: lack of process improvement knowledge", "BA6: lack of training", "BA10: organizational politics", "BA12: lack of resources", "BA13: lack of communication", "BA14: lack of organizational support", "BA20: lack of formal SPI implementation methodology" and "BA21: lack of

Table 12
Summary of research questions.

Research question	Discussion
RQ1: What barriers to SPI implementation in GSD environments are identified in the literature?	Inexperienced staff; staff turnover; cultural differences; lack of trust; lack of process improvement knowledge; lack of training; lack of feedback; personality clashes; workload; organizational politics; time pressure; lack of resources; lack of communication; lack of organizational support; temporal distance; poor organizational infrastructure; budget constraints; organizational changes; lack of sponsorship; lack of formal SPI implementation methodology; lack of implementation tools and standards; stalling on action plan implementation.
RQ1.1: Are the barriers identified in the literature related to client or vendor organizations?	Organizational politics (62%, and 62%), lack of formal SPI implementation methodology (53%, and 53%), lack of organizational support (70% and 77%), lack of communication (70% and 73%), lack of resources (62% and 68%), lack of process improvement knowledge (57% and 53%), and staff turnover (50% and 53%) were the most common barriers identified by both the vendor and client organizations, respectively. There was no significant difference between the barriers identified by the client and vendor organizations.
RQ2: What barriers to SPI implementation in GSD environments are identified in the empirical study?	All of the 22 barriers identified in the SLR.
RQ2.1: Are the barriers identified in the empirical study related to client or vendor organizations?	All of the 22 barriers identified in the SLR. However, we found significant differences between the client and vendor organizations for two barriers (inexperienced staff and temporal distance).
RQ3. Are there differences between the barriers identified in the literature and those identified in the empirical study?	The rankings obtained from the SLR and the empirical study had moderate correlation (rs $(22) = 0.567$). The Spearman rank-order correlation was statistically significant ($p = 0.006 < 0.005$).
RQ4: What are the most critical barriers identified in the literature and the empirical study?	The CBs common to both the SLR and the empirical study were as follows: staff turnover, lack of process improvement knowledge, lack of training, organizational politics, lack of resources, lack of communication, lack of organizational support, lack of formal SPI implementation methodology, and lack of implementation tools and standards. These barriers had frequencies $\geq 50\%$ in both the SLR and the empirical study.
RQ5: How can the identified barriers be categorized into a robust framework?	The 22 identified barriers were assigned to six categories related to SPI challenges in GSD environments. The results presented in Table 11 show that the greatest proportion of the barriers were assigned to the "project administration" category.

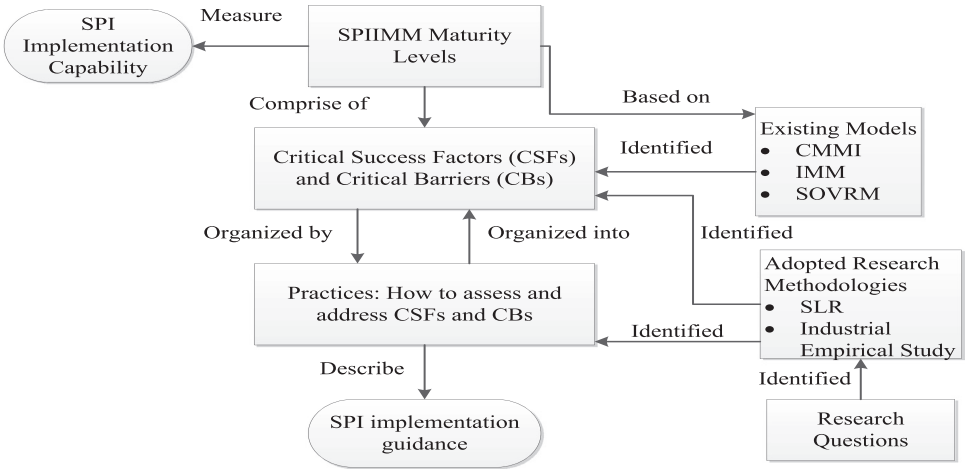


Fig. 10. Architecture of the SPIIMM model.

implementation tools and standards." These barriers were deemed to be critical because their frequencies were ≥50% of all of the identified barriers.

For RQ5, we assigned the identified barriers to six main categories of SPI challenges. The largest proportion of the barriers were assigned to the 'project administration' category (Table 11). Hence, 'project administration' is the most significant area to address in the implementation of SPI programs. The second most important categories were found to be "coordination" and "humans resources management."

6. Threats to validity

There are several threats to the validity of this study. A possible threat to its internal validity is that for any given SLR article, the primary causes of the reported barriers may not have been adequately described. It is difficult for us to mitigate this threat, because the origins of the barriers were not formally identified.

Construct validity represents whether or not a measurement scale accurately describes the attributes being measured. The factors considered in this study were derived obtained from an extensive body of literature [58--60,39] and through discussions with SPI experts. The feedback from the experts indicated that all of the selected factors were related to their work. Internal validity refers to the overall evaluation of the results. The outcomes of the pilot study provided an acceptable level of internal validity. External validity refers to the generalization of the research outcomes [61]. In this study, we are unable to generalize the outcomes, because most of the respondents were from Asian countries. Therefore, the results are not necessarily representative of respondents from other regions. However, we are certain that the data sample was sufficiently representative.

Finally, some relevant research studies may have been missed as a result of the large number of publications regarding process improvement and GSD. However, this is not a systematic omission, as in other published SLRs [40].

7. Future work

The ultimate goal of this research is to develop a software process improvement implementation management model (SPIIMM) for use in GSD. This model will assist SPI practitioners in assessing and measuring their process improvement readiness prior to SPI implementation.

We used the existing process development models (CMMI [3], IMM [64], and SOVRM [65]) to structure the SPIIMM, as shown in Fig. 10. The SPIIMM consists of three main components:

- SPIIMM maturity levels;
- SPIIMM factors (critical success factors (CSFs) and critical barriers (CBs));
- SPIIMM assessment.

Fig. 10 illustrates the relationships between the SPIIMM components and indicates how the findings of the SLR and the empirical study can assist in the development of the three core components. The maturity levels component indicates the process improvement capability of an organization. Each maturity level consists of different CSFs and CBs. Various different practices are required to effectively address each CSF and CB. The SPIIMM assessment component is used to evaluate the maturity levels of an organization.

The results of the present study only contribute to the SPIIMM factors (Critical success factors (CSFs) and Critical barriers (CBs)) component of the model, as shown in Fig. 10.

We believe that this research will provide practitioners with a strong foundation on which to develop new SPI practices for use in GSD.

8. Conclusions

Presently, most software development organizations are globalizing their development activities. The rapid increase of GSD motivated us to identify barriers that can undermine the SPI programs. We used SLR and survey questionnaire approaches to identify a total of 22 barriers. The CBs in both types of studies were found to be staff turnover, lack of process improvement knowledge, lack of training, organizational politics, lack of resources, lack of communication, lack of organizational support, lack of formal SPI implementation methodology, and lack of implementation tools and standards. These critical barriers can be used as guides for the implementation of process improvement programs in GSD organizations.

We classified the identified barriers based on their significance to client and vendor organizations. The results demonstrated client and vendor organizations experienced similar barriers to SPI implementation. The main objective of the client-vendor classification was to provide an overview of the barriers faced in implementing SPI programs in client and vendor organizations. Most of the survey respondents positively agreed with the findings of the SLR. In addition, we found that there was a moderate correlation between the rankings of the barriers in the SLR and the empirical study. Furthermore, we identified significant differences between the rankings of the barriers in the SLR and the empirical study. We recommend that both client and vendor organizations consider how to address their respective barriers to the effective implemen-

tation of SPI programs. GSD researchers and practitioners can use the results presented here to prioritize barriers in client or vendor organizations.

We believe that the findings detailed in this paper can be used to address problems associated with the implementation of process improvement activities, which is vital to the success and progression of GSD organizations.

Appendix A

Questionnaire survey

Section- A1 (Respondent Information)			
Full Name (optional)		Job Title / Position	
Have you ever been participated in an outsourcing/ offshoring GSD project?	Yes ☐	No ☐	
	Not sure ☐	Other	
Working Experience (Years) in Global Software development and Software Process Improvement related projects.			
What is the scope of your company?	Client ☐	Vendor ☐	
	Not sure ☐	Other	
Email Address			
Current address of your organization including country			
How many years of industry/academia experience do you have in your field?			
Have you ever participated in Software Process Improvement Project?	Yes ☐	No ☐	
Section- A2 (Organization Detail)			
Name of Organization (Optional)			
What is the primary business function of your organization? (You may tick more than one)	Global/offshore Software development ☐	Collocated Software development ☐	
	Research ☐	Other	
Please specify the size of your organization.	Small ☐	Medium ☐	
	Large ☐	Not sure ☐	
Please specify the number of employees in your organization.	Less than 20 ☐	21-100 ☐	
	101-200 ☐	Greater than 200 ☐	
Please specify the type of your organization	National ☐	Multinational ☐	
	Not sure ☐	Other	
Does your organization adopted Software Process Improvement standards or models? (CMMI/ISO)	CMMILevel-1 (Initial) ☐	CMMILevel-2 (Managed) ☐	
	CMMILevel-3 (Defined) ☐	CMMILevel-4 (Quantitatively Managed) ☐	
	CMMILevel-5 (Optimizing) ☐	ISO ☐	
	Not sure ☐	Other ☐	
How long has your process improvement program been in operation? (Years)			

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Section B- Software process improvement barriers and their best practices
The aim of this section is to specify barriers that could negatively impact the implementation of the Software Process improvement program in Global Software Development. We have extracted various barriers from the literature using Systematic Literature Review (SLR) approach.
Please rank each barrier according to your own understanding and experience.

Extremely Agree (EA), Moderately Agree (MA), Slightly Agree (SA), Neutral (NU), Slightly Disagree (SD), Moderately Disagree (MD), Extremely Disagree (ED)

Barriers	EA	MA	SA	NU	SD	MD	ED
Inexperienced Staff	☐	☐	☐	☐	☐	☐	☐
Staff Turnover	☐	☐	☐	☐	☐	☐	☐
Cultural Difference	☐	☐	☐	☐	☐	☐	☐
Lack of Trust	☐	☐	☐	☐	☐	☐	☐
Lack of process improvement knowledge	☐	☐	☐	☐	☐	☐	☐
Lack of Training	☐	☐	☐	☐	☐	☐	☐
Lack of Feedback	☐	☐	☐	☐	☐	☐	☐
Personality clashes	☐	☐	☐	☐	☐	☐	☐
Work Load	☐	☐	☐	☐	☐	☐	☐
Organizational Politics	☐	☐	☐	☐	☐	☐	☐
Time Pressure	☐	☐	☐	☐	☐	☐	☐
Lack of Resources	☐	☐	☐	☐	☐	☐	☐
Lack of Communication	☐	☐	☐	☐	☐	☐	☐
Lack of Organizational Support	☐	☐	☐	☐	☐	☐	☐
Temporal Distance	☐	☐	☐	☐	☐	☐	☐
Poor Organizational Infrastructure	☐	☐	☐	☐	☐	☐	☐
Budget Constraints	☐	☐	☐	☐	☐	☐	☐
Organizational Changes	☐	☐	☐	☐	☐	☐	☐
Lack of Sponsorship	☐	☐	☐	☐	☐	☐	☐
Lack of formal process improvement Implementation Methodology	☐	☐	☐	☐	☐	☐	☐
Lack of Implementation Tools and Standards	☐	☐	☐	☐	☐	☐	☐
Stalling on Action Plan Implementation	☐	☐	☐	☐	☐	☐	☐
Add barriers apart from the listed ones							

Section-C
Best practices for SPI barrier in GSD (available from authors)

Appendix B

Empirical study respondents' information

S.No	Job title	Experience	Country	Primary business function	Scope of the company	Size	Adopted SPI standards/models	SPI in operation (Years)
1.	Software Engineer	5	Nigeria	Collocated software development	Vendor	Medium	Not sure	10
2.	Software Engineer	2	China	Collocated/Global software development	Vendor	Large	Not sure	4
3.	Researcher	5	China	Collocated software development	Vendor	Large	Not sure	0
4.	Researcher	8	Pakistan	SPI Consultancy	Vendor	Medium	CMMILevel-2 (Managed)	3
5.	Researcher	12	China	Software Engineering research	Vendor	Small	Not sure	2
6.	Researcher	8	Saudi Arabia	Research Institute	Vendor	Medium	CMMILevel-3 (Defined)	2
7.	Researcher	1	China	Global Software Development	Vendor	Medium	CMMILevel-4 (Quantitatively Managed)	5

(*continued on next page*)

S.No	Job title	Experience	Country	Primary business function	Scope of the company	Size	Adopted SPI standards/models	SPI in operation (Years)
8.	Researcher	18	Pakistan	Collocated software development	Vendor	Small	CMMILevel-2 (Managed)	5
9.	Senior process executive	>4	India	Global Software Development	Vendor	Large	CMMILevel-4 (Quantitatively Managed)	4–7
10.	Researcher	4	Pakistan	Research Institute	Vendor	Medium	Not sure	5
11.	Professor emeritus	46	Norway	SPI research	Client	Large	ISO	10
12.	Researcher	20	Cyprus	Research Institute	Client	Small	No	0
13.	Professor	18	Saudi Arabia	Research	Vendor	Large	CMMILevel-3 (Defined)	5
14.	Researcher	10	Pakistan	Research	Vendor	Medium	HEC, Pakistan	10
15.	Researcher	3	Pakistan	Research	Vendor	Small	Not sure	0
16.	Researcher	4	Pakistan	Research	Vendor	Medium	Not sure	0
17.	Software Applications Developer	4	China	Telecommunications	Vendor	Large	CMMILevel-4 (Quantitatively Managed)	4
18.	CEO	5	Pakistan	Global Software Development	Vendor	Small	Nil	0
19.	CTO	22	Netherlands	Global Software Development	Client	Medium	Nil	0
20.	Software Engineer	1	China	Collocated/Global software development	Vendor	Medium	CMMILevel-4 (Quantitatively Managed)	2
21.	IT In charge	<1	UAE	Global Software Development	Client	Medium	Nil	0
22.	SPI consultant	40	USA	SPI consulting	Client	Small	Nil	0
23.	Consultant	20	China	Global Software Development	Vendor	Large	CMMILevel-3 (Defined)	3
24.	Software Developer	3	Nigeria	Collocated Software Development	Vendor	Medium	ISO	2–3
25.	Researcher	35	UK	Research	Client	Large	Nil	0
26.	Researcher	4	Malaysia	Research	Vendor	Large	Not sure	0
27.	CEO	5	Pakistan	Global Software Development	Vendor	Small	CMMILevel-1 (Initial)	<1
28.	Project Manager	4	Pakistan	Collocated/Global software development	Vendor	Small	CMMILevel-1 (Initial)	1
29.	Professor	7	Pakistan	Research	Vendor	Large	Not sure	5
30.	Web Developer	2	Pakistan	Collocated/Global software development	Vendor	Medium	CMMILevel-2 (Managed)	Nil
31.	Software Engineer	3	Pakistan	Collocated software development	Vendor	Small	CMMILevel-1 (Initial)	2
32.	Research	5	China	Research; Education	Vendor	Large	Not sure	2
33.	Senior SPI Consultant	42	UK	Consultancy & Training	Client	Small	Provide CMMI Consultancy to other companies	4
34.	Manager	11	Vietnam	Collocated Software Development; BPO, Data Entry, Image Processing	Vendor	Small	CMMILevel-3 (Defined)	8
35.	Global Process Lead	12	UK	Process Leadership	Client	Large	ISO	6
36.	Interim Manager	27	USA	Interim Management of Software Development	Client	Small	ISO	25
37.	Assistant Vice President	27	China	Finance	Vendor	Not sure	Self-developed	15
38.	SEO executive	3	Pakistan	Collocated/Global software development	Vendor	Medium	CMMILevel-1 (Initial)	<1
39.	Professor	15	Denmark	Research	Client	Small	Nil	0
40.	Chief operating officer	9	Pakistan	Global Software Development/web development and design	Vendor	small	CMMILevel-1 (Initial)	1
41.	Senior web developer	5	Pakistan	Global Software Development	Vendor	Medium	Not sure	Nil
42.	Software Engineer	2	Pakistan	Collocated/Global software development	Vendor	Small	CMMILevel-1 (Initial)	<1

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S.No	Job title	Experience	Country	Primary business function	Scope of the company	Size	Adopted SPI standards/models	SPI in operation (Years)
43.	Manager	7	Pakistan	Collocated/Global software development	Vendor	Medium	Not sure	Nil
44.	Senior Executive Consultant	15	USA	Business Function	Client	Large	Other	15
45.	Software Engineer	1	China	Collocated Software Development	Vendor	Medium	Not sure	Nil
46.	SPI Practitioner	11	India	Collocated Software Develop-ment/Consulting services	Vendor	Medium	Not sure	Nil
47.	Researcher	8	Saudi Arabia	Research	Vendor	Large	Not Sure	Nil
48.	Software Developer	4	Pakistan	Global software development	Vendor	Medium	CMMILevel-2 (Managed)	Nil
49.	Process Management Consultant	30+	UK	Consultancy	Client	Large	Multiple	5
50.	VP and CTO, Namcook Analytics LLC	45	USA	Consultancy/Research	Client	Small	CMMILevel-3 (Defined)	15
51.	Professor	30	Colombia	Research	Client	Small	Not Sure	Nil
52.	Professor	8	Pakistan	Global Software Devel-opment/Research	Vendor	Small	Not Sure	Nil
53.	Social Media/Admin Assistant	2	Pakistan	Collocated/Global software development	Vendor	Small	Not Sure	Nil
54.	iOS Developer	2	Pakistan	Collocated/Global software development	Vendor	Small	Not Sure	Nil
55.	Professor	23	Norway	Research	Client	Medium	Not Sure	Nil
56.	CMMI Lead Appraiser	30	Germany	Global Software Development	Client	Medium	CMMILevel-2 (Managed)	Nil
57.	Senior Software Project Manager	20	Vietnam	Automotive Software	Vendor	Small	CMMILevel-3 (Defined)	13
58.	Researcher	25	India	Research	Vendor	Large	Nil	Nil
59.	Quality Assurance	3	Pakistan	Global Software Development	Vendor	Medium	CMMILevel-3 (Defined)	3
60.	Chairman and MD	40	India	Collocated Software Development	Vendor	Small	Not initiated	0
61.	Researcher	<1	Sweden	Research	Client	Small	Not Sure	Nil
62.	Professor	10	Pakistan	Research	Client	Large	Not Sure	Nil
63.	Professor	30	UAE	Global Software Development/ Banking & Insurance	Client	Large	CMMILevel-1 (Initial)	2
64.	Agile Coach / Consultant	7	Malaysia	Consultation / Coaching / Training	Vendor	Medium	Not Sure	Nil
65.	Senior Developer	2	Pakistan	Collocated Software Development	Vendor	Small	Not Sure	Nil
66.	Researcher	9	China	Research	Vendor	Medium	Not Sure	Nil
67.	IT Officer	5	Pakistan	Research/ SAP development	Vendor	Large	ISO	<1
68.	Software Developer	5	Ghana	Global Software Development	Vendor	Small	Not Sure	Nil
69.	Researcher	5	Ghana	Research	Vendor	Large	ISO	8
70.	Consultant	55	USA	Global Software Development	Client	Small	CMMILevel-5 (Optimizing)	20
71.	Professor	14	Pakistan	Research	Vendor	Large	Not Sure	Nil
72.	Researcher	15	Pakistan	Collocated Software Development/ Global Software Development/ Research	Vendor	Small	Not Sure	4
73.	Researcher	5	Pakistan	Research	Vendor	Large	Not Sure	Nil
74.	Lecturer	11	Pakistan	Research	Vendor	Small	Not Sure	Nil
75.	FOUNDER of Bangalore Software Process Improvement Network (BSPIN)	27	India	Global Software Development	Vendor	Medium	ISO	3

(continued on next page)

S.No	Job title	Experience	Country	Primary business function	Scope of the company	Size	Adopted SPI standards/models	SPI in operation (Years)
76.	Web developer	2	Pakistan	Collocated Software Development	Vendor	Small	Not Sure	0
77.	Professor	8	Spain	Research	Client	Medium	Research Centre	Nil
78.	Manager	17	France	Global Software Development	Client	Medium	ISO	10
79.	Research assistant	7	Saudi Arabia	Research	Vendor	Not sure	Not Sure	Nil
80.	Process Consultant	30	USA	Project management support	Client	Medium	working on CMMI-SVC	<2
81.	Researcher	2	Pakistan	Global Software Development/ Research	Vendor	Small	Not Sure	Nil
82.	Lecturer	10	UK	Collocated Software Development	Client	Medium	CMMILevel-2 (Managed)	Nil
83.	SPIIM leader	30	UK	Implementing SPI	Client	Small	CMMILevel-3 (Defined)	20
84.	Software Engineer	14	Brazil	Oil and Gas	Client	Large	ISO	Nil
85.	Professor	25	Denmark	Research	Client	Medium	No process model	Nil
86.	Lecturer	7	South Africa	Research	Client	Large	Not Sure	Nil
87.	Senior VP, Operational Excellence	30	USA	Solutions and Services. Software and Systems engineering and service delivery	Client	Large	CMMILevel-3 (Defined)	20
88.	Web Developer	20	USA	Global Software Development	Client	Small	CMMILevel-1 (Initial)	<1
89.	Product Manager	10	Norway	Collocated Software Development/ Research	Client	Medium	CMMILevel-5 (Optimizing)	5
90.	Software Engineer	4	Pakistan	Global Software Development	Vendor	Medium	CMMILevel-3 (Defined)	2
91.	Configuration Management	15	India	Collocated Software Development	Vendor	Medium	Not Sure	Nil
92.	Project Coordinator / QA Professional	8	UAE	Global Software Development	Client	Larger	ISO	5
93.	Assistant Vice President	21	Germany	Global Software Development	Client	Larger	CMMILevel-5 (Optimizing)	10

Appendix C

See Table 13

Table 13
Selected primary studies using SLR.

Tracking #	Title	Study type	Research method	Year	QA1	QA2	QA3	QA4	QA5	Final score
LT1	"Ullah Khan, S.S., Niazi, M., Ahmad, R.: Critical Success Factors for Offshore Software Development Outsourcing Vendors: An Empirical Study. Product-Focused Software Process Improvement, vol. (6156), pp. 146–160 (2010) "	Conference/ PROFES	Questionnaire Survey	2010	1	1	0	0	1	3
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, vol. 56, pp. 807–820 (2014)"	Journal/IST	Mix (SLR,replication study, grounded theory)	2014	0.5	1	0.5	1	0.5	3.5
LT3	"Herbsleb, J.D., Dennis R.G.: A systematic survey of CMM experience and results. IEEE 18th International Conference on Software Engineering, pp.323–330 (1996)"	Conference/ICSE	Questionnaire Survey	1996	0.5	1	0.5	1	0.5	3.5
LT4	"Rainer, A., Hall, T.: Key success factors for implementing software process improvement: a maturity-based analysis. Journal of systems and software, 62(2), pp.71–84 (2002)"	Journal/JSS	Questionnaire Survey	2002	1	1	0	1	1	4
LT5	"Ramasubbu, N.: Governing Software Process Improvements in Globally Distributed Product Development. IEEE Transactions on Software Engineering, vol. 40, pp. 235–250 (2014)"	Journal/TSE	Action Research	2015	1	1	0	1	1	4

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Table 13 (*continued*)

Tracking #	Title	Study type	Research method	Year	QA1	QA2	QA3	QA4	QA5	Final score
LT6	"El Emam, K., Koru, A. G.: A replicated survey of IT software project failures, IEEE Software, vol. 25, pp. 84–90 (2008)"	Journal/IEEE Software	Questionnaire Survey	2008	0.5	0.5	0.5	1	0.5	2.5
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, vol. 7, pp. 327–338 (2013)"	Journal/IET Software	SLR	2013	1	0.5	0	0.5	1	3
LT8	"Kautz, K., Nielsen, P. A.: Implementing software process improvement: two cases of technology transfer. 33rd Annual Hawaii International Conference on System Sciences, p. 1–10 *(2000)*"	Conference/33rd Annual Hawaii International Conference on System Sciences (HICSS)	Case Study	2000	0.5	0.5	0	1	0.5	2.5
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, vol. 74, pp. 155–172 *(2005)*"	Journal/JSS	Interview (Content Analysis)	2005	1	1	0	1	1	4
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,, 7(5), 283–293 (2013)"	Journal/IET Software	SLR	2013	1	1	0.5	0	1	3.5
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, pp. 196–203 (2003)"	Conference/ Third International Conference On Quality Software (ICQS)	Interview (Content Analysis)	2003	0.5	1	0	1	0.5	3
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, vol. 81, pp. 972–995 (2008)"	Journal/JSS	Interview (Content Analysis)	2008	0.5	1	0	1	0.5	3
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 (2004)"	Journal/ MIS Quarterly (MISQ)	Action Research	2004	0.5	0.5	0	1	0.5	2.5
LT14	"Rainer, A., Hall, T.: A quantitative and qualitative analysis of factors affecting software processes. Journal of systems and software, vol. 66, pp. 7–21 (2003)"	Journal/JSS	Mix (Questionnaire Survey, interview)	2003	1	1	0	1	1	4
LT15	"Dyba, T.: An empirical investigation of the key factors for success in software process improvement. IEEE Transactions on Software Engineering, 31(5), pp.410–424 (2005)"	Journal/TSE	Questionnaire Survey	2005	0.5	1	0.5	1	1	4
LT16	"Niazi, M., Babar, M. A., Verner, J. M.: Software Process Improvement barriers: A cross-cultural comparison. Information and Software Technology, vol. 52, pp. 1204–1216 (2010)"	Journal/IST	Questionnaire Survey	2010	1	0.5	0	1	0.5	3
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, vol. 54, pp. 479–500 (2012)"	Journal/IST	Interview (Grounded Theory)	2012	1	1	0	1	1	4
LT18	"Richardson, I., Casey, V., Burton, J., McCaffery, F.: Global software engineering: A software process approach, Collaborative Software Engineering, Springer Berlin Heidelberg, Germany, pp. 35–56 (2010)"	Book Chapter/ Collaborative Software Engineering	Mix(case study, ction research)	2010	0.5	0.5	0	0.5	1	2.5
LT19	"Sulayman, M., Mendes, E.: Quantitative assessments of key success factors in software process improvement for small and medium web companies. Proceedings of the ACM Symposium on Applied Computing. pp. 2319–2323 (2010)"	Conference/SAC	Questionnaire Survey	2010	0.5	1	0.5	1	0.5	3.5
LT20	"Khan, S. U., Niazi, M., Ahmad, R.: Critical barriers for offshore software development outsourcing vendors: a systematic literature review. Asia-Pacific Software Engineering Conference, pp. 79–86 (2009)"	Conference/ APSEC	SLR	2009	1	0	0	0.5	1	2.5
LT21	"Bayona-Oré, S., Calvo-Manzano, J. A., Cuevas, G., San-Feliu, T.: Critical success factors taxonomy for software process deployment. Software Quality Journal, vol. 22, pp. 21–48, 2014″	Journal/ Software Quality Journal (SQJ)	Mixed Method (Systematic Review, Questionnaire Survey, Case Study)	2014	0.5	1	0.5	1	1	4
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, pp. 83–94 (2014)"	Conference/ICSE	Case Study	2014	0.5	0.5	0	0.5	0.5	2

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Table 13 (*continued*)

Tracking #	Title	Study type	Research method	Year	QA1	QA2	QA3	QA4	QA5	Final score
LT23	"Niazi, M., Wilson, D., Zowghi, D.: Critical success factors for software process improvement implementation: an empirical study, Software Process: Improvement and Practice, vol. 11, pp.193–211 (2006)"	Journal/JSEP	Interview (Content Analysis)	2006	1	1	0	1	1	4
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, pp. 179–189 (2013)"	Book Chapter/ Systems, Software and Services Process Improvement (SSPI)	SLR	2013	0.5	1	0.5	1	0.5	3.5
LT25	"Baddoo, N., Hall, T.: De-Motivators of software process improvement: An analysis of practitioner's views. Journal of Systems and Software, vol. 66, pp. 23–33 (2003)"	Journal/JSS	Questionnaire Survey	2003	1	1	0.5	1	1	4.5
LT26	"Baddoo, N., Hall, T., Wilson, D.: Implementing a people focused SPI programme. 11th European Software Control and Metrics Conference, pp.373–382 (2000)"	Conference/ ESCOM	Mixed Method (focus group discussions, questionnaires, structured interviews and Repertory Grid Technique (RGT))	2000	0.5	1	1	1	0.5	4
LT27	"Niazi, M., Wilson, D., Zowghi, D.: Critical barriers for software process improvement implementation: An empirical study. IASTED Conference on Software Engineering, pp. 389–395 (2004)"	Conference/ IASTED	Interview (Content Analysis)	2004	1	1	0	1	1	4
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, vol. 84, pp. 686–699 (2011)"	Journal/JSS	SLR	2011	1	0	0	0	1	2
LT29	"Moitra, D.: Managing change for (SPI) initiatives: A practical experience-based approach. Software Process Improvement and Practice, pp. 199–207 (1998)"	Journal/JSEP	Case Study	1998	0.5	1	1	1	0.5	4
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, pp. 30–39 (2008)"	Conference/ ACM SIGMIS CPR	Interview (Content Analysis)	2008	1	0.5	0	1	1	3.5
LT31	"Niazi, M., Wilson, D., Zowghi, D., Wong, B.: A model for the implementation of software process improvement: An empirical study. Product-Focused Software Process Improvement, pp. 1–16 (2004)"	Conference/ PROFES	Interview (Content Analysis)	2004	1	1	0	1	1	4
LT32	"Niazi, M.: 'Software process improvement implementation: avoiding critical barriers, CROSSTALK. The Journal of Defense Software Engineering, vol. 22, pp. 24–27 (2009)"	Journal /Defense Software Engineering	Interview (Content Analysis)	2009	1	1	0	1	1	4
LT33	"Shah, H., Harrold, M. J., Sinha, S.: 'Global software testing under deadline pressure: Vendor-side experiences, Information and Software Technology, vol. 56, pp. 6–19 (2014)"	Journal/IST	Mixed Method (Interviews, participant observations)	2014	1	0.5	0	0	1	2.5
LT34	"Ågerfalk, P., Fitzgerald, M., Olsson, H.H., Conchúir, E.O.: Benefits of Global Software Development: The Known and Unknown. Making Globally Distributed Software Development a Success Story, Springer Berlin Heidelberg, Vol.5007, pp. 1–9. (2008)"	Book Chapter/ Making Globally Distributed Software Development a Success Story	Informal Literature Review	2008	0.5	0	0	0	0.5	1
LT35	"A. Taweel, Delaney, B., Arvanitis, T.N., Zhao, L.: Communication, Knowledge and Co-ordination Management in Globally Distributed Software Development: Informed by a scientific Software Engineering Case Study. presented at the Proceedings of theFourth IEEE International Conference on Global Software Engineering, pp.370–375 (2009)"	Conference/ ICGSE	Case Study	2009	0.5	0.5	0	0	0.5	1.5
LT36	"E. Ó. Conchúir, Ågerfalk, J.P., Olsson, H.H., Fitzgerald, B.: Global software development: where are the benefits? Communications of the ACM, vol. 52, pp. 127–131 (2009)"	Journal/ Communications of the ACM	Interview (Content Analysis)	2009	0.5	0	0	0	1	1.5
LT37	"Wiegers, K.: Software process improvement: Ten traps to avoid. *Software Development,* vol. 4, (1996)"	Magazine/ Software Development	Informal Literature Review	1996	0.5	1	0.5	1	0.5	3.5
LT38	"Mohd, N.N.H, Ahmad, R., Hassan, H.N.: Resistance factors in the implementation of software process improvement project. IEEE International Symposium on Information Technology, pp. 1–10 (2008)"	Conference/ ITNG	Questionnaire Survey	2008	0.5	1	0	1	1	3

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Table 13 (*continued*)

Tracking #	Title	Study type	Research method	Year	QA1	QA2	QA3	QA4	QA5	Final score
LT39	"Dutra. E., Santos, G.: Software Process Improvement Implementation Risks: A Qualitative Study Based on Software Development Maturity Models Implementations in Brazil.Product-Focused Software Process Improvement, pp. 43–60 (2015)"	Conference/ PROFES	Mixed (SLR, Interview)	2015	0.5	1	0.5	1	0.5	3.5
LT40	"Mishra, D., Mishra, A.: Software process improvement methodologies for small and medium enterprises. Product-Focused Software Process Improvement, pp. 273–288 (2008)"	Conference/ PROFES	Questionnaire Survey	2008	0.5	0.5	0.5	1	0.5	2.5
LT41	"Niazi, M.: A comparative study of software process improvement implementation success factors. *Journal of Software: Evolution and Process,* 27(9), 700–722 (2015)"	Journal/ JSEP	Mixed (SLR, Informal literature review, snowballing)	2015	1	0	0	1	1	3
LT42	"Niazi, M., Babar, A.M., Katugampola, M.N.: Demotivators of software process improvement: an empirical investigation. *Software Process: Improvement and Practice* 13(3), 249–264 (2008)"	Journal/ JSEP	Questionnaire Survey	2008	1	1	0.5	1	1	4.5
LT43	"Khan, A. A., Basri, S., Dominic, P.D.D., Fazal, E. A.: A Survey based study on Factors effecting Communication in GSD. Research Journal of Applied Sciences, Engineering and Technology, 7 (7), 1309–1317 (2013)"	Journal/ JASET	Questionnaire Survey	2013	1	0.5	0.5	0	1	3
LT44	"Shih, C.C., Huang, S. J.: Exploring the relationship between organizational culture and software process improvement deployment," Information & Management, vol. 47, pp. 271–281 (2010)"	Journal/ Information and Management	Questionnaire Survey	2010	0.5	0.5	0.5	1	0.5	2.5
LT45	"Babar, M. A. Verner, M.J., Nguyen, T.P.: Establishing and maintaining trust in software outsourcing relationships: An empirical investigation. *Journal of Systems and Software,* 80(9), 1438–1449 (2007)"	Journal/ JSEP	Mixed (Case Study, Interview)	2007	0.5	0.5	0.5	0	0.5	2
LT46	"Oza,V.N., Hall, T., Rainer, A., Grey, S.: Trust in software outsourcing relationships: An empirical investigation of Indian software companies. Information and Software Technology, vol. 48, pp. 345–354 (2006)"	Journal/IST	Mixed (Case Study, Interview)	2006	1	0.5	0.5	0	1	3
LT47	"Moe, B.N., Šmite, D.: Understanding a lack of trust in Global Software Teams: a multiple-case study. Software Process: Improvement and Practice, vol. 13, pp. 217–231 (2008)"	Journal/ JSEP	Case Study	2008	1	0.5	0	0	1	2.5
LT48	"Emam, K.E., Smith, B., Fusaro, P.: Success factors and barriers for software process improvement. Better software practice for business benefit: Principles and experience. IEEE Computer Society, (1999)"	Book chapter/ Better software practice for business benefit: Principles and experience	Case Study	1999	0.5	1	0	1	1	3.5
LT49	"Dybå,T.: Enabling software process improvement: an investigation of the importance of organizational issues. *Empirical Software Engineering* , 7(4), pp.387–390 (2002)"	Journal/ EMSE	Case Study	2002	0.5	1	0.5	1	1	4
[LT50]	"Nasir, M.H.N.M., Ahmad, R., Hassan, N.H.: An Empirical Study of Barriers in the Implementation of Software Process Improvement Project in Malaysia. Journal of Applied Sciences, Vo l(8), pp.4362–4368 (2008)"	Journal of Applied Sciences	Questionnaire Survey	2008	0.5	1	0.5	1	1	4
[LT51]	"Ross, M.: Process Improvement - Barriers and Opportunities for Teaching and Training. Proceedings of the International Workshop on Software Process Education, Training and Professionalism, Gothenburg, Sweden, pp.1–6 (2015)"	Conference/ IWSPEPT	Case Study	2015	0.5	0.5	0	0.5	0.5	2
[LT52]	"Lepasaar, M., Varkoi,T., Jaakkola, H.: Models and Success Factors of Process Change. in *Product Focused Software Process Improvement* Springer Berlin Heidelberg, vol. (2188), pp. 68–77 (2001)"	Conference/ PROFES	Case Study	2001	0.5	0	0	1	1	2.5
[LT53]	"Khan U.S., Niazi, M., Ahmad,R.: Critical success factors for offshore software development outsourcing vendors: A systematic literature review. Fourth IEEE International Conference On Global Software Engineering, pp.207–216 (2009)"	Conference/ ICGSE	Questionnaire Survey	2010	1	0	0	0	1	2
[LT54]	"Ilyas, M., Khan, S. U.: Software integration in global software development: Success factors for GSD vendors. in *16th IEEE/ACIS International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing,* pp. 1–6 (2015)"	Conference/ *SNPD*	SLR	2015	1	0	0	0	1	2
[LT55]	"Khan, S. U., Alam, A. U.: Knowledge Sharing Management Model (KSMM) for Software Development Outsourcing Vendors. International Journal of Advances in Science and Technology, vol (4238), pp. 135–144 (2012)"	Journal/IJAST	SLR	2012	1	0.5	0	0	0.5	2

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Table 13 (*continued*)

Tracking #	Title	Study type	Research method	Year	QA1	QA2	QA3	QA4	QA5	Final score
[LT56]	"Alsaade, F., Zaman, N., Hassan, F.N., Abdullah, A.: An Improved Software Development Process for Small and Medium Software Development Enterprises Based on Client's Perspective. Trends in Applied Sciences Research, vol(9), pp.254–261 (2014)"	Journal/ Trends in Applied Sciences Research	Case Study	2014	0	0.5	0	1	0.5	2
[LT57]	"Rafael, P., Audy, LN.J., Evaristo, R.: An empirical study on global software development: Offshore insourcing of IT projects. *Proceedings of the International Workshop on Global Software Development, International Conference on Software Engineering (ICSE 2004)*, Vol(24), (2004)"	Conference/ International Workshop on Global Software Development	Case Study	2004	0.5	0	0	0	1	1.5
[LT58]	"Christiansen, H. M.: Meeting the challenge of communication in offshore software development. in *Software Engineering Approaches for Offshore and Outsourced Development*, ed: Springer, pp. 19–26 (2007)"	Book Chapter/ *Software Engineering Approaches for Offshore and Outsourced Development*	Case Study	2007	0.5	0.5	0	0.5	1	2.5
[LT59]	"Stefanie, B., Hickl, S., Oberweis, A.: Risk Management in Global Software Development Process Planning. *37th EUROMICRO Conference on Software Engineering and Advanced Applications (SEAA),* pp–357–361 (2011)"	Conference/ *EUROMICRO*	Case Study	2011	0.5	0.5	0	0	1	2
[LT60]	"Paasivaara. M., Lassenius, C.: Could global software development benefit from agile methods?. In *International Conference on Global Software Engineering,* pp. 109–113 (2006)"	Conference/ ICGSE	Informal literature review	2006	0.5	0.5	0	0	0.5	1.5
[LT61]	"Herbsleb, J. D., Mockus, A., Finholt, A.T., Grinter, E.R.: An empirical study of global software development: distance and speed. in *Proceedings of the 23rd international conference on software engineering*, pp. 81–90 (2001)"	Conference/ ICSE	Questionnaire Survey	2001	1	0.5	0.5	0	1	3
[LT62]	"Plugge, A., Janssen, M.: Managing change in IT outsourcing arrangements: an offshore service provider perspective on adaptability. *An International Journal of Strategic Outsourcing,* vol (2), pp. 257–274 (2009)"	Journal/ International Journal of Strategic Outsourcing	Mixed Method(Case Study/Informal literature review)	2009	0.5	0.5	0	0	1	2
[LT63]	"Jennex, M. E., Adelakun, O.: Success factors for offshore information system development. *Journal of Information Technology Case and Application Research.* Vol(5), pp. 12–31 (2003)"	Book Chapter/ Information Systems Development	Mixed Method (Questionnaire Survey /Informal literature review)	2003	1	0	0	0	1	2
[LT64]	"Kuhrmann, M., Konopka, C., Nellemann, P., Diebold, P., Münch, J.: Software process improvement: where is the evidence?: initial findings from a systematic mapping study. *Proceedings of the International Conference on Software and System Process*, pp.107–116 (2015)"	Conference/ ICSS	SLR	2015	1	0.5	0	1	1	3.5
[LT65]	"Remus, U., Wiener, M.: Critical success factors for managing offshore software development projects. *Journal of Global Information Technology Management,* vol(12), pp. 6–29 (2009)"	Journal/JGIM	Interview (Grounded theory)	2009	0.5	0	0	0	1	1.5
[LT66]	"Viana, D., Conte, T., Vilela, D., Souza, R. B.C., Santos, G., Prikladnicki, R.: The influence of human aspects on software process improvement: Qualitative research findings and comparison to previous studies. In *16th International Conference on Evaluation & Assessment in Software Engineering (EASE),* pp. 121–125 (2012)"	Conference/ EASE	Interview (Grounded theory)	2012	0.5	0.5	0.5	1	0.5	3
[LT67]	"Anandasivam, G., Mukhopadhyay, T., Krishnan, S.M.: The role of software processes and communication in offshore software development. Communications of the ACM, 45(4), pp.193–200 (2002)"	Journal/ Communication of the ACM	Questionnaire Survey	2002	0.5	0.5	0	0.5	0.5	2
[LT68]	"Krishna, S., Sahay, S., Walsham, G.:Managing cross-cultural issues in global software outsourcing. Communications of the ACM, 47(4), pp. 62–66 (2004)"	Journal/ Communication of the ACM	Case Study	2004	0.5	0	0	0.5	1	2
[LT69]	"Kobitzsch, W., Dieter, R., Raimund L. F.: Outsourcing in India [software development]. Software, IEEE 18(2), pp–78–86 (2001)"	Journal/IEEE Software	Case Study	2001	0.5	0	0	0	1	1.5
[LT70]	"Subhas, C.M., Kumar, V., Kumar, U.: Identifying some important success factors in adopting agile software development practices. Journal of Systems and Software, 82(11), pp–1869–1890 (2009)"	Journal/JSS	Questionnaire Survey	2009	1	0	0	0	1	2
[LT71]	"Santos, G., Montoni, M., Vasconcellos, J., Figueiredo, S., Cabral, R., Cerdeiral C., Katsurayama, E.A., Lupo, P., Zanetti, D., Rocha, R.A.: Implementing software process improvement initiatives in small and medium-size enterprises in Brazil," in *6th International Conference on Quality of Information and Communications Technology,* pp. 187–198 (2007)"	Conference/ *QUATIC*	Case Study	2007	0.5	0.5	0	1	1	3

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Table 13 (*continued*)

Tracking #	Title	Study type	Research method	Year	QA1	QA2	QA3	QA4	QA5	Final score
[LT72]	"Ferreira, M. G., Wazlawick, R. S.: Software Process Improvement: A organizational change that need to be managed and motivated. *International Journal of Computer, Electrical, Automation, Control and Information Engineering,* vol. 6, p. 19 (2011)"	Journal	Questionnaire Survey	2011	1	0.5	0	1	1	3.5
[LT73]	"Prikladnicki, R., Audy, N.L.J., Damian, D., Oliveira, D.C.T.: Distributed Software Development: Practices and challenges in different business strategies of offshoring and onshoring," in *Second IEEE International Conference on Global Software Engineering*, pp. 262–274 (2007)"	Conference/ ICGSE	Case Study	2007	0.5	0.5	0	1	1	3
[LT74]	"Niazi, M., Babar, A.M.: De-motivators of software process improvement: An analysis of vietnamese practitioners' views," in *Product-Focused Software Process Improvement*, ed: Springer, 2007, pp. 118–131. (Vendor, Veitnam) (Springer)"	Conference/ PROFES	Questionnaire Survey	2007	1	1	0.5	1	1	4.5
[LT75]	"Babar, M. A., Niazi, M.: Implementing Software Process Improvement Initiatives: An Analysis of Vietnamese Practitioners' Views, in *IEEE International Conference on Global Software Engineering,* pp. 67–76 (2008)"	Conference/ ICGSE	Questionnaire Survey	2008	1	1	0.5	1	1	4.5
[LT76]	"Bunditwongrat, N., Mathupayas, T., Atcharawan, N.: An empirical framework of key success factors for software process improvement. Proceedings of the European Conference on Information Management & Evaluation, pp–82–90 (2011)"	Conference/ ICIME								
	Questionnaire Survey	2011	1	1	0.5	1	1	4.5		
[LT77]	"Phongpaibul, M., Boehm, B.: Improving quality through software process improvement in Thailand: initial analysis, in *ACM SIGSOFT Software Engineering Notes*, pp. 1–6 (2005)"	Conference/ WoSQ	Interview (Grounded Theory)	2005	0.5	0.5	0	1	1	3
[LT78]	"Mishra, D., Mishra, A.: Software process improvement in SMEs: A comparative view, *Computer Science and Information Systems,* vol. 6, pp. 111–140 (2009)"	Journal/ CSIS	Case Study	2009	0.5	0.5	0	1	0.5	2.5
[LT79]	"Wilson, N.D., Hall, T., Baddoo, N.: A framework for evaluation and prediction of software process improvement success. Journal of systems and software, 59(2), pp.135–142 (2001)"	Journal/JSS	Interview (Grounded Theory)	2001	0.5	0.5	0	1	1	3
[LT80]	"Sommerville, I., Rodden, T.: Human, social and organisational influences on the software process," *Software Process,* vol. 4, pp. 194–199 (1996)"	Journal/JSEP	Case Study	1996	1	0.5	0	1	1	3.5
[LT81]	"Beecham, S., Hall, T., Rainer, A.: Software process improvement problems in twelve software companies: An empirical analysis. Empirical software engineering. 8(1), pp.7–42 (2003)"	Journal/EMSE	Interview (Content Analysis)	2003	0.5	0.5	0.5	1	1	3.5
[LT82]	"Baddoo, N., Hall, T.: Motivators of Software Process Improvement: an analysis of practitioners' views. *Journal of systems and software,* vol. 62, pp. 85–96 (2002)"	Journal/JSS	Interview (Content Analysis)	2002	1	0.5	0	1	1	3.5
[LT83]	"Katumba, B., Knauss, E.: Agile Development in Automotive Software Development: Challenges and Opportunities. in *Product-Focused Software Process Improvement*, ed: Springer, pp. 33–47 (2014)"	Conference/ PROFES	Case Study	2014	0.5	1	0.5	1	1	4
[LT84]	"Niazi, M.: Software Process Improvement: A Road to Success. in *Product-Focused Software Process Improvement*. vol. 4034, Springer Berlin Heidelberg, pp. 395–401 (2006)"	Conference/ PROFES	Informal literature review	2006	1	0	0	1	1	3
[LT85]	"Valtanen, A., Sihvonen, H.M.: Employees' Motivation for SPI: Case Study in a Small Finnish Software Company," in *Software Process Improvement*. vol. 16, Springer Berlin Heidelberg, pp. 152–163 (2008)"	Chapter/ Software Process Improvement	Mixed Method (Interview, Questionnaire Survey)	2008	1	0.5	0	1	1	3.5

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