Understanding Software Process Improvement in Global Software Development: A Theoretical Framework of Human Factors

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ABSTRACT
Presently, most of the software development organizations are adopting the phenomena of Global Software Development (GSD), mainly because of the significant return on investment it produces. However, GSD is a complex phenomenon and there are many challenges associated with it, especially that related to Software Process Improvement (SPI). The aim of this work is to identify humans' related success factors and barriers that could impact the SPI process in GSD organizations and proposed a theoretical framework of the factors in relation to SPI implementation. We have adopted the Systematic Literature Review (SLR) method in order to investigate the success factors and barriers. Using the SLR approach, total ten success factors and eight barriers were identified. The paper also reported the Critical Success Factors (CSFs) and Critical Barriers (CBs) for SPI implementation following the criteria of the factors having a frequency ≥ 50% as critical. Our results reveal that five out of ten factors are critical for SPI program. Moreover, total three barriers were ranked as the most critical barriers. Based on the analysis of the identified factors, we have presented a theoretical framework that has highlighted an association between the identified factors and the implementation of the SPI program in GSD environment.

CCS Concepts
Software and Its engineering → Software creation and management → Software development process management → Software development methods → Capability Maturity Model

Keywords
Software Process Improvement; Systematic Literature Review; Human; Global Software Development

1. INTRODUCTION
Software process improvement (SPI) provides an organization with a commanding means of evaluating their abilities to improve the software development process; accordingly, this practice allows organizations to identify their strengths and weaknesses. Zahran [1] defined SPI as "the discipline of defining, characterizing, improving, and measuring software management, better product innovation, faster cycle times, greater product quality, and reduced development costs simultaneously." Different standards and models for SPI have been developed, each of which assists organizations in optimizing their software processes through evaluation of process efficiency. Khan and Keung [2] mentioned that the failure rate of SP programs is 70%, and one of the ground reasons of this failure is the inadequate attention given to process improvement problems.

Various process improvement models and standards have been developed to assist software organizations effectively manage the software development processes. Capability maturity model integration (CMMI) is one such model consists of structured and methodical practices for process evaluation and improvement [3]. The International Organization for Standardization (ISO) has also developed standards and recommendations for SPI: for example, ISO 9000 is used to assess the quality of established systems in an organization [4], whereas ISO/IEC 15504 is used for process improvement under the Software Process Improvement and Capability Determination (SPICE) [5]. SPICE was developed to test and advertise process improvement standards and models [5]. The ISO/IEC 15504 standard has since evolved into more advance process assessment and improvement standards, i.e., ISO/IEC 330XX [6]. The ISO/IEC 330XX family covers the assessment of processes deployed in an organization, including their maintenance, change management, delivery, and improvement [6]. These models and techniques can assist an organization to develop a quality product, reduce development cost and time, and promote user satisfaction [2, 7, 8, 9].

However, little attention has been paid to developing process improvement models and standards in the context of GSD, which has hence yielded limited success for process improvement efforts [7]. GSD is the plan of action in which the software development is performed beyond the geographical, cultural and temporal boundaries [2]. Ramasubbu [9] reported that, most organizations currently outsource software development activities to attain various benefits, and it is significant that process improvement experts have complete understanding of SPI program. However, process improvement challenges in GSD environment are different and SPI practitioners should explicitly address those challenges [2, 8, 9]. The implementation of SPI activities is considerably more complex in the GSD environment than in collocated development [9]. The literature on SPI has not examined the distributed nature of GSD organizations in sufficient detail [8].

Less attention has been given to successfully execute the process improvement activities in GSD environment, and even few studies have been done to develop models and frameworks in general and factors that are critical for the efficient execution of process improvement programs in particular [2, 7, 8, 9]. There is a pressing need for some techniques and methods that could guide the GSD organizations to assess and implement the process improvement programs [2, 8]. These techniques and methods should have the potential to reduce the time, cost, and failure risk of SPI implementation. In this regard, we propose a model that can assist SPI practitioners to successfully assess, measure, and improve their process improvement activities related to humans. Therefore, we have been motivated to develop a software process improvement implementation and management model (SPIIMM), that could help the SPI practitioners to assess, implement and manage the humans' related aspects of SPI. According to Komiyama [10] "all personnel must be interested in the process, as the success of software projects depends on processes". Organizations were believed to be mostly dependent on human factors as they usually relied on key individuals [10]. Therefore, it is significant for organizations to properly manage the success factors and barriers reported in the domain of human category.

In this paper, we have discussed the primary step to develop the proposed model (SPIIMM). We have reported the success factors and barriers that could have a positive or negative impact on humans' related aspects of the SPI program in GSD environment. These factors will help to develop the factors component of SPIIMM.

Systematic Literature Review (SLR) approach was adopted to have a better understanding of the concern factors for SPI. The SLR approach enabled us to assess and understand the available literature [11] in order to extract the most relevant success factors and barriers of SPI. The reported success factors and barriers will assist the theorist and SPI practitioners to address the key areas of SPI program related to the humans. For this reason, we have developed the following research questions.

RQ1: What are the humans related success factors, as identified in the literature that could have a positive impact on the SPI implementation in GSD?

RQ1.1: What are the most critical humans related success factors identified in the literature?

RQ2: What are the humans' related barriers to SPI implementation in GSD environments are identified in the literature?

RQ2.1: What are the most critical humans related barriers reported in the literature?

RQ3: How to develop a theoretical framework for human factors of SPI?

2. RESEARCH METHODOLOGY

Systematic literature review (SLR) method was selected in order to conduct this research study. An SLR is a secondary study that reviews all primary studies (i.e., those that explore a specific research area), identifying, analyzing, and exploring all evidence related to research questions in an unbiased and iterative way [11]. Kitchenham and Charters [11] classified SLR into three main phases: planning the review, conducting the review and reporting the review.

2.1 Planning the Review

In the first phase of the review, the SLR protocol was developed. SLR protocol provided the complete guideline to develop the research questions, search process, inclusion and exclusion criteria, articles selection, publications quality assessment and data extraction [11].

2.1.1 Research Questions

The research questions developed for this study are discussed in section 1.

2.1.2 Search Process

A comprehensive search process was conducted in order to classify all the available research articles relevant to our questions of interest.

For the search process, the keywords and their alternatives were chosen based on the available literature in the domain of SPI [2, 7, 8, 9, 12, 17]. The major keywords and their alternate words were concatenated with the help of "OR" and "AND" operators that were later used in different databases to identify the relevant primary studies.

The following search strings were developed and used in several databases in order to identify the relevant articles.

("Factors" OR "Aspects" OR "Items" OR "Elements" OR "Drivers" OR "Motivators" OR "Variables" OR "Characteristics" OR "Parameters") AND ("barriers" OR "obstacles" OR "hurdles" OR "difficulties" OR "impediments" OR "hindrance") 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 "software contracting-out" OR "IT outsourcing") 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")

Databases were chosen based on prior research experience, literature background and suggestions provided by other researchers [12]. Total five databases were selected, i.e., IEEE, Scopus, Google Scholar, Science Direct and ISI Web of Science.

2.1.3 Inclusion and Exclusion Criteria

The selected primary studies must be available in English language. Each primary study article must be conference, journal or book chapter. We emphasized on the articles that have discussed process improvement programs in the GSD environment. More focus was on those papers that discussed success factors and barriers along their categories.

We have excluded those papers which have not reported the software process improvement success factors and barriers. Those articles were also excluded that did not provide the detail information regarding the process improvement standards and models. The duplicated articles were also not considered. Additionally, those articles were also excluded that were reported in other languages except English.

2.1.4 Study Quality Assessment

The Quality Assessment (QA) of the selected articles was performed concurrently with the data extraction phase. A checklist was developed to assess the quality of the selected research articles. The guideline provided by [2, 8, 13] was followed in the design of this checklist (Table 1).

The quality assessment checklist consists of five QA questions (Q1-Q5). For each given item (QA1-QA5), the evaluation was done as follows:

- The articles containing answers to the checklist questions were assigned 1 point.
- The articles containing partial answers to the checklist question were assigned 0.5 points.
- The articles not containing any answers to the checklist questions were assigned 0 points.

Table 1: Study Quality Assessment Criteria

QA Questions	Checklist Questions
QA1	"Do the adopted research methods address the research questions?"
QA2	"Does the study discuss any factors of SPI?"
QA3	"Does the study discuss SPI implementation standards and models?"
QA4	"Is the collected data related to SPI?"
QA5	"Are the identified results related to justification of the research questions?"

We have also evaluated the quality of the selected primary studies against each quality assessment question discussed in Table 1. The QA score for each primary study is shown in Table 2.

Table 2: QA score for each selected primary study

ID	QA1	QA2	QA3	QA4	QA5	Final Score
[LT1]	1	1	0	1	1	4
[LT2]	0.5	1	0.5	1	0.5	3.5
[LT3]	0.5	1	0.5	1	1	4
[LT4]	0.5	0.5	0.5	1	0.5	2.5
[LT5]	1	1	0	1	1	4
[LT6]	1	0.5	0	1	0.5	3
[LT7]	1	0.5	0	0.5	1	3
[LT8]	0.5	1	0.5	1	0.5	3.5
[LT9]	1	0.5	0.5	0	1	3
[LT10]	1	0.5	0	1	1	3.5
[LT11]	1	1	0	1	1	4
[LT12]	1	1	0.5	0	1	3.5
[LT13]	1	1	0	0	1	3
[LT14]	0.5	0.5	0	1	0.5	2.5
[LT15]	1	0.5	0	1	0.5	3
[LT16]	0.5	0.5	0	1	0.5	2.5
[LT17]	1	1	0.5	1	1	4.5
[LT18]	0.5	1	0	1	0.5	3
[LT19]	1	1	0	1	1	4

2.2 Planning the Review

2.2.1 Articles Selection

The SLR protocol search strings (Sect. 2.1.2) were applied and a total of 2174 articles extracted from all the selected databases. The tollgate approach proposed by Afzal [14] was used in the articles selection process. Tollgate approach [14] led to a short list of the 22 articles to be considered in the primary studies selection. Tollgate techniques have five phases and the selected digital repositories were exclusively assessed using these phases (Table 3)

- St-1: Explore using the search terms
- St-2: Title and abstract based inclusion/exclusion
- St-3:Introduction and conclusion based inclusion/exclusion
- St-4: Full text based inclusion/exclusion
- St-5: Final selection of the articles to be included in the primary studies selection

After applying the tollgate approach, we have identified total 19 articles that focused on SPI in GSD.

Table 3: Tollgate Approach

SD	St-1	St-2	St-3	St-4	St-5	% of final selected articles (n=19)
WI	25	24	17	11	4	21
IE	461	390	135	76	5	26
AC	560	511	194	117	1	5
SP	146	112	37	25	3	16
ScD	502	673	232	154	4	21
GS	480	430	176	86	2	11
TL	2174	2140	791	469	19	100

SD= "Selected Databases", WI= "Wiley Inter Science", IE= "IEEE Xplore", AC= "ACM Digital Library", SP= "Springer Link", ScD="Science Direct", GS="Google Scholar", TL="Total", n= "total no of selected primary studies"

2.2.2 Data Extraction

We have reported the following data of each selected primary study article in order to address the research questions: paper title and QA score. A complete list of the selected 19 articles is given in the Appendix.

3. REPORTING THE RESULTS

Using SLR approach, we have identified total ten success factors and eight barriers in the domain of human category of SPI. Grounded theory-based coding approach [15] was adopted which provides qualitative and analytical approach in which concepts (success factors and barriers) are labeled and categorized through the close examination of qualitative data. We have used grounded theory-based coding approach [15] to review the selected 19 primary studies, conceptualize the underpinning factors and assign a label (name) to each factor. Similar or related factors are semantically compared and grouped in the human category. Therefore, applying the grounded theory-based coding approach enabled us to identify humans' related category of SPI and classified the identified success factors and barriers across this category.

This section reports the results of the identified factors in relation to each of the research questions.

3.1 RQ1

The following are the identified ten success factors as shown in Figure 1, Table 4 and briefly discussed thereafter. In Table 4, (n=19) is the total number of primary studies selected during the SLR study.

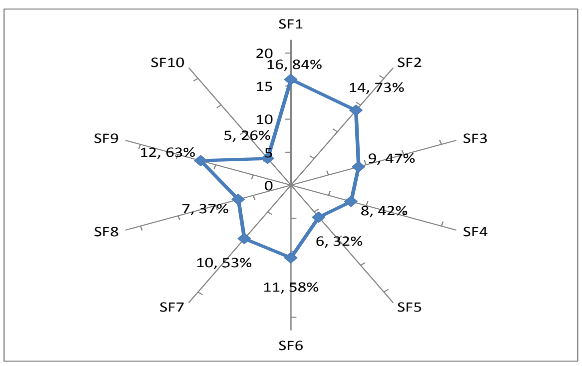

Figure 1: Frequency analysis of the identified success factors

Table 4: Identified Success Factors

S.No	Success Factors	Frequency (n=19)	% of occurrence
SF1	Management Commitment	16	84
SF2	Staff Involvement	14	73
SF3	Strong Relationship	9	47
SF4	Information Sharing	8	42
SF5	SPI Expertise	6	32
SF6	Roles and Responsibilities	11	58
SF7	SPI Leadership	10	53
SF8	SPI Awareness	7	37
SF9	Skilled Human Resources	12	63
SF10	3C's (Communication, coordination and control)	5	26

3.1.1 Management Commitment (SF1)

Most of the SPI literature focused on the importance of organizational management support for SPI [LT1]. The organizational management commitment plays a significant role in order to successfully execute the SPI activities. Sulayman et al [LT2] define management commitment as "the degree to which the higher and lower level management in an organization financially support, realize and involved in SPI activities". Hall et al [LT1] demonstrate the importance of management commitment by conducting an empirical study. In particular, they reported that when the SPI manager who was highly committed to SPI was replaced by someone with a lower commitment, all prior SPI effort was lost. Therefore, based on the above discussion, we have developed the following hypothesis.

H1: Management commitment has a positive relationship with the SPI implementation in GSD.

3.1.2 Staff Involvement (SF2)

Sulayman et al [LT2] define staff involvement as the extent to which organizational staff own, believe, attain and participate in the process improvement activities. Bayona et al [LT3] highlighted that the staff involvement during the process definition of SPI activities is important to make them feel part of the program. Ramasubbu [LT4] reported the results of an industrial empirical study and pointed out that staff involvement in SPI activities reduce the resistance to the deployment of new processes. As a result of the given discussion, the following hypothesis is developed.

H2: Staff Involvement has a positive relationship with the SPI implementation in GSD.

3.1.3 Strong Relationship (SF3)

According to Niazi et al [LT5], "strong relationship is the degree to which the team members can effectively coordinate and communicate to implement the SPI program". Strong relationship is the key element to effectively perform the SPI related activities and tasks [LT6]. Moreover, it leads to better team management, decision making, risk management and staff coordination [LT6]. Niazi et al, [LT5] reported that GSD teams might not be able to accomplish SPI activities within time and budget due to the lack of trust and support among the team members. Higher team management should motivate the team members to participate in SPI related activities in order to build long term positive and trustworthy relationship with different other distributed teams [LT5]. Consequently, we argue that strong relationship is a key factor to successfully implement the SPI program in GSD.

H3: Strong relationship has a positive association with the SPI implementation in GSD.

3.1.4 Information Sharing (SF4)

Sulayman et al [LT2] define information sharing as "the degree to which the distributed team members coordinate and communicate to share the information to involve in process improvement program". Ramasubbu [LT4] reported that proper information sharing among the geographically distributed sites could assist the team members to positively execute the SPI activities. Khan et al [LT7] concluded that team members can properly participate in the process improvement activities based on the information and knowledge sharing, management of information and information partnership [LT7]. Thus, we proposed the following hypothesis.

H4: Information sharing has a positive association with the SPI implementation in GSD.

3.1.5 SPI Expertise (SF5)

Bayona et al [LT3] define SPI expertise as the extent to which individuals can achieve specific SPI goals [LT3]. According to Hall [LT1], the success of SPI implementation programs depends on the expertise of team members. More specifically, if the management staff of SPI program has appropriate process improvement knowledge and awareness, then there is more chance of process improvement success and adoption in the best practice of domain [LT8]. Otherwise, the deployment of the process improvement program may end with the failure and frustration [LT3].

H5: SPI Expertise has a positive relationship with the SPI implementation in GSD.

3.1.6 Roles and Responsibilities (SF6)

Bayona et al [LT3] suggests that the assignment of specific roles and responsibilities to team members assist the SPI implementation process. Roles and responsibilities should be clearly defined; otherwise confusion may occur during the implementation of SPI activities [LT3]. Therefore, we hypothesize that

H6: Roles and Responsibilities have a positive relationship with the SPI implementation in GSD.

3.1.7 SPI Leadership (SF7)

Hall et al [LT1] reported in their empirical study that most of the respondents highlighted the importance of the managers' leadership. They specified that the leadership of SPI team is vital for the successful execution of the SPI program [LT1]. The management should have the ability to direct and encourage team members to achieve the specific goals [LT3]. The success and acceptance of the SPI program mostly depend on the skillful top management individuals. If they have ample knowledge and deep understanding of SPI program, then they could accomplish their concern objectives [LT8]. Lack of SPI leadership could undermine the effectiveness of SPI program and the organization might not be able to actualize the key objectives of the business [LT1]. Hence, we argue that SPI leadership is a core factor for the SPI implementation.

H7: SPI leadership has a positive association with the SPI implementation in GSD.

3.1.8 SPI Awareness (SF8)

Sulayman et al [LT2] explained SPI awareness as the degree to which the top management takes the initiatives of SPI certification and provides team members with the training opportunities. Deployment of SPI program is the practice of implementation of new processes in an organization [LT5]. It is important to motivate the team members to conduct and participate in the awareness sessions relating to the implementation of process improvement programs. Therefore, we have developed the following hypothesis.

H8: SPI Awareness has a positive association with the SPI implementation in GSD.

3.1.9 Skilled Human Resources (SF9)

The results reveal that success factor ‘SF8: skilled human resources’ can play a significant role in SPI implementation program. Various researchers have discussed the significance of skilled humans for SPI activities. Bayona et al, [LT8] emphasized on the deployment of the qualified workers having professional certification and experience in the field of computer science, management and other related fields. They consider the skilled staff as the backbone of the GSD industry. Consequently, we hypothesize that:

H9: Skilled Human Resources have a positive association with the SPI implementation in GSD.

3.1.10 3C’s (Communication, coordination and control) (SF10)

Khan et al, [LT9] define 3C’s as the process of knowledge transmission between the distributed team members and the mode of transfer they adopt to enhance this interaction. Effective communication channels are claimed to assist process improvement. Coordination refers to the contribution of different people working together on a task for a specific goal [LT9]. Control refers to “the process of adhering to goals, policies, standards or quality levels” [LT9]. The Control manages the basic structures needed for SPI implementation i.e. on time, in budget and desired quality software development. Control and coordination are correlated with each other and both of them depend on communication [LT10]. Therefore, for successful implementation of SPI activities, it’s significant to properly manage the 3C’s issues.

H10: 3C’s (Communication, coordination and control) have a positive association with the SPI implementation in GSD.

3.2 RQ1.1

According to Niazi [LT11], the critical factors are presenting the key areas where the organizational management must focus to achieve the specific business goals. Niazi [LT11] and Khan et al. [LT12] shed light that limited attention given to those key areas can undermine the business performance. Critical factors may differ from person to person as it depends on the position of individual’s hold in an organization. Critical success factors (CSFs) depend on the geographical regions of the managers and may change with the passage of time [LT11].

In this research study, we have used the following criteria in order to conclude the criticality of the identified 10 success factors:

If a factor has frequency ≥50% of the selected primary studies, then the factor is considered as a critical factor. The same criteria have been used by other researchers in different other domains [LT11, LT7].

By using the above criteria, the identified CSFs are: SF1: Management commitment (84%), SF2: staff involvement (73%), SF6: roles and responsibilities (58%), SF7: SPI leadership (53%) and SF9: skilled human resources (63%). The identified CSFs are labelled as the most critical for SPI because their frequency ≥50% of all the other success factors.

3.3 RQ2

To address RQ2, Table 5 and Figure 2 presents the list of the identified barriers along their frequencies and percentage of occurrence in the selected primary studies (n=19).

Table 5: Identified Barriers

S. No	Success Factors	Frequency (n=19)	% of occurrence
BA1	Inexperienced staff	15	79
BA2	Staff turnover	13	68
BA3	Cultural differences	9	47
BA4	Time pressure	13	68
BA5	Lack of process improvement knowledge	8	42
BA6	Lack of training	5	26
BA7	Lack of trust	7	37
BA8	Lack of communication	8	42

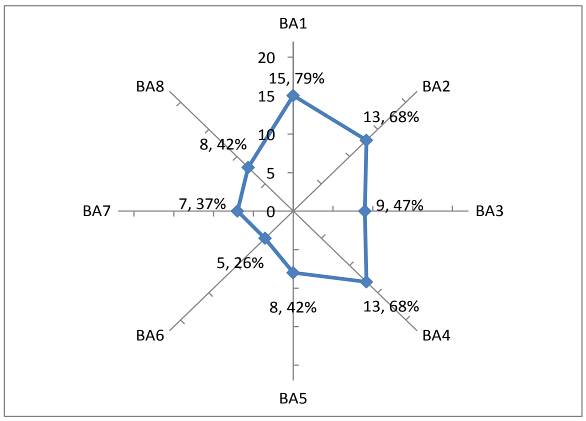

Figure 2: Frequency analysis of the identified barriers

In this section, we have thoroughly discussed the relationship between the independent variables (identified barriers) and dependent variable (humans related SPI Implementation in GSD).

3.3.1 Inexperienced Staff (BA1)

The results presented in Table 5 revealed that (79%) of the selected primary studies indicated BA1 (inexperienced staff) as a barrier to process improvement activities. Hall et al. [LT1] discussed the results of empirical study and reported the challenges of SPI activities, including the lack of knowledge regarding the process improvement program. Niazi et al. [LT6] reported in their empirical study that those organizations which have successfully addressed the process improvement challenges had skillful and experienced SPI team members. We have proposed the following hypothesis based on the above discussion.

H11: Inexperienced staff negatively impacts the process improvement activities in GSD.

3.3.2 Staff Turnover (BA2)

BA2 (staff turnover) was cited as a critical barrier by (68%) of the primary studies. Staff turnover indicates the percentage of the individuals who leave the organization or replaced by new staff [LT12]. Rainer and Hall [LT19] mentioned that the frequent staff turnover could significantly increase the cost of the process improvement program. Staff turnover is related to the direct cost of employing new staff members as well the loss of skillful and experienced individuals [LT19]. Hall et al. [LT1] conducted empirical study with 45 focus groups and they suggested that boosting the motivation levels of staff members could decrease the staff turnover.

H112: Frequent staff turnover could negatively impact the process improvement activities in GSD.

3.3.3 Cultural Differences (BA3)

BA3 (cultural differences) was mentioned in the (47%) of the reported primary studies. In distributed environment, the team members might be culturally and geographically distinct [LT9]. It is significant to successfully overcome the cultural challenges faced by the team members. For instance, it is possible that the distributed team members may not be able to communicate with each other using their native languages [LT9]. Furthermore, cultural difference may cause misunderstanding, which can bring confusion among the team members [LT9]. Therefore, we hypnotized that:

H13: Cultural differences have negative association with SPI programs in GSD.

3.3.4 Time Pressure (BA4)

The results given in Table 5 shows that (68%) of the articles considered BA4 (time pressure) as the critical barrier of SPI implementation. Niazi et al. [LT6] highlighted that time pressure was one of the critical challenges for organizations who initiated the process improvement program. Due to time pressure, the practitioners might make quick decisions in order to stay on schedule, but those decisions may not be in the favor of SPI program [LT1, LT6]. Empirical study conducted by Hall et al. [LT1] reported that majority of the practitioners considered time pressure as the demotivation factor for software process improvement. Based on the given discussion, we have developed the following hypothesis.

H14: Time pressure could negatively affect the process improvement programs in GSD.

3.3.5 Lack of Process Improvement Knowledge (BA5)

BA5 (lack of process improvement knowledge) was reported by (42%) of the selected primary studies. The lack of adequate process improvement knowledge and expertise could be a serious threat for the SPI programs [LT16]. Bayona et al. [LT8] focused on the experience and expertise of SPI practitioners for process improvement programs. They suggested that process improvement practitioners should have complete knowledge and understanding of SPI activities. Niazi et al. [LT6] highlighted that lack of process improvement knowledge could undermine the entire SPI program. Based on the above discussion, the following hypothesis is developed.

H15: Lack of SPI knowledge could be a serious challenge for SPI activities in GSD.

3.3.6 Lack of Training (BA6)

BA5 (lack of training) was cited in (26%) of the selected primary studies as the barrier to process improvement. The process improvement program could not be effective if the GSD organizations did not provide proper training to SPI practitioners [LT17]. Due to lack of training, the process improvement team members might not able to assess the real need of process improvement change [LT17]. It is significant for the SPI practitioners to have strong understanding of process improvement standards, models and techniques such as CMM, CMMI and ISO/IEC 330XX [LT17].

H16: Lack of proper training decrease the success rate of SPI implementation in GSD.

3.3.7 Lack of Trust (BA7)

It is challenging to develop trust and confidence between the SPI practitioners working in GSD environment [LT9, LT17]. It is shown in Table 5 that (37%) of the selected primary studies considered lack of trust as the barriers for SPI. Promoting team building activities could strengthen the inter-team communication that could increase the trust level of team members [LT9].

H17: Lack of trust has negative relationship with SPI programs in GSD.

3.3.8 Lack of Communication (BA8)

The SLR results given in Table 5 indicate that BA8 (lack of communication) is cited by (42%) of the primary studies. The geographically distributed nature of GSD organizations makes communication a major issue for SPI practitioners [LT9]. Lack of communication could decrease the level of trust and frequent feedback. Weak communication could create misunderstanding, lack of coordination and of lack of control over SPI activities [LT9].

H18: Lack of communication has negative relationship with SPI programs in GSD.

3.4 RQ2.1

We have followed the criteria discussed in section 3.2 in order to categorize the critical barriers (CBs). Three barriers were ranked as CBs by using the criteria of barriers having frequency >50% of the selected primary studies. The identified CBs are: BA1: inexperienced staff (79%), BA2: staff turnover (68%) and BA4: time pressure (68%). The CBs are presenting some of the crucial areas of process improvement program where organization need much focus in order to successfully execute the SPI activities [LT17].

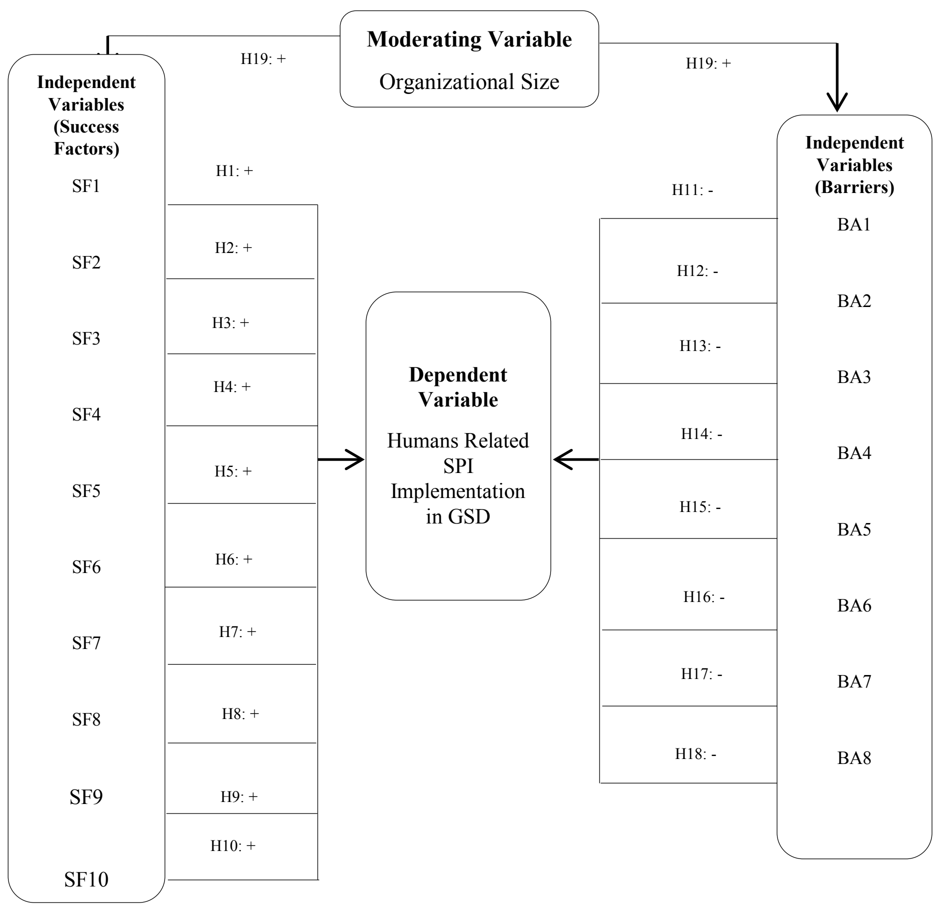

Figure 3: Proposed Theoretical Framework

3.5 RQ3

The theoretical research framework of the reported success factors and barriers is presented in Figure3. The framework is based on the identified success factors, barriers and their relationship with the SPI implementation as discussed in sections 3.1 and 3.3. The framework consists of 18 independent variables (i.e. the reported success factors, barriers) and single dependent variable (i.e. humans' related SPI implementation in GSD). We have also identified one moderating variable (i.e. organizational size). It has been discussed in software engineering studies that small, medium and large size organizations have various operational differences.

Majority of the large size organizations adopts formal standards and models, while small and medium focus on informal processes [11]. Small and medium size organizations have concerns about the budget need to acquire and sustain the formal processes [8]. In this study, we have investigated that whether small, medium and large organizations implement process improvement practices differently [12]. It is important to investigate the significance of organizational size in the context of SPI implementation.

The following hypothesis has been developed to investigate the relationship of organizational size and the SPI success.

H19: The reported success factors and barriers influence the SPI implementation activities for a large organization to a greater extent than that of small and medium organization.

It is shown in Figure 3, that each success factor has a positive relationship with the dependent variable and identified barriers have negative association. The framework is presenting a relational view of the independent, moderating and dependent variables. The relationship of the variables is presented based on the proposed hypotheses.

4. THREATS TO VALIDITY

During the SLR process, most of the data were extracted by the first author of the article. However, we tried to alleviate this threat by observing any unclear problems and discussed them together, still there exists a higher risk that a single researcher could be biased and continually extract the wrong data. However, the co-authors were involved to randomly check different steps in the SLR.

One possible threat to internal validity is that for any selected SLR article, the reported factors might not have assuredly described their primary causes. It might possible that in some articles there may have been a trend to report specific types of factors. Most of the selected articles reported findings of empirical studies, experience reports and case studies which might be subject to the publication bias.

In addition, most of the authors of the selected 19 primary studies are from academia, which might lack a deep knowledge about the current trends of SPI programs in the industry. In order to mitigate this threat, we planned to perform an industrial empirical study to assess the validity of the identified success factors and barriers.

5. CONCLUSIONS AND FUTURE WORK

Presently majority of the software development firms are adopting the phenomena of global software development. The fast growing nature of GSD motivated us to identify humans related success factors that can positively affect the SPI program. We have followed SLR approach and 19 research articles related to humans oriented SPI and GSD were selected. We have identified a total of ten success factors and eight barriers from the selected research articles. In the identified ten success factors, total five factors were categorized as the most critical factors. Furthermore, three barriers were ranked as the most critical barriers. The identified critical success factors and critical barriers can act as a guide for the SPI practitioners to effectively implement the SPI activities in the domain of GSD. The critical factors are presenting the key areas which have much more impact on process improvement implementation as compared to the other identified factors. We have developed the theoretical framework of the identified success factors, barriers and the SPI implementation based on their relationship discussed in the literature. We believe that the findings of this research work can possibly result into tackling the problems associated with the humans related process improvement activities, which is a key to the success and progression of GSD organizations.

The following points highlight the future directions of this study.

- Empirically validate the identified factors in the context of humans related software process improvement.
- Investigate the best practices to address the identified success factors and barriers.
- Conduct industrial empirical study with the SPI practitioners to identify additional success factors, barriers and their practices.
- Empirically assess the theoretical framework of this study in order to test the hypotheses.

The concluding aim of this study is to develop a model that could address the humans' related aspects of software process improvement in GSD. This model will assist the GSD organizations to assess and measure their process improvement readiness prior to SPI implementation.

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APPENDIX

Selected primary studies using SLR

ID	Title
[LT1]	"Hall, T., Rainer, A., Baddoo, N.: Implementing software process improvement: an empirical study. Software Process Improvement and Practice 7(1): 3-15 (2002)"
[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)"
[LT3]	"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)"
[LT4]	"Ramasubbu, N.: Governing Software Process Improvements in Globally Distributed Product Development. IEEE Transactions on Software Engineering, vol. 40, pp. 235-250 (2014)"
[LT5]	"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)"
[LT6]	"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)"
[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)"
[LT8]	"Bayona, S., Calvo-Manzano, J. A., San Feliu, T.: 'Review of Critical Success Factors Related to People in Software Process Improvement' in Systems, Software and Services Process Improvement'(Springer Berlin Heidelberg, Germany, 2013) pp. 179-189"
[LT9]	"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)"

[LT10]	“Espinosa. C., Edrein, I., Rodríguez-Jacobo, L., Fernández-Zepeda. A. J.: A framework for evaluation and control of the factors that influence the software process improvement in small organizations. Journal of software: Evolution and Process, Vol (25) 4, 393-406, (2013)”
[LT11]	“Niazi, M., Wilson, D., Zowghi, D.: Critical success factors for software process improvement implementation: an empirical study. Software Process: Improvement and Practice, Vol. 11 (2). pp 193-211, (2006)”
[LT12]	“Khan, A.A., Keung, J.: Systematic Review of success factors and barriers for Software Process Improvement in Global Software Development. IET Software, ISSN 1751-8814 (2016)”
[LT13]	“Khan, U. S., Niazi, M., Ahmad, R.: Critical Success Factors for Offshore Software Development Outsourcing Vendors: An Empirical Study. Product-Focused Software Process Improvement, pp. 146-160 (2010) “
[LT14]	“Ngwenyama O., Nielsen, P. A.: ‘Competing values in software process improvement: an assumption analysis of CMM from an organizational culture perspective, IEEE Transactions on Engineering Management, vol. 50, pp. 100-112, (2003)”
[LT15]	“Stelzer, D., Mellis. W.: Success factors of organizational change in software process improvement, Software Process: Improvement and Practice Vol. 4 (4), 227-250, (1998)”
[LT16]	“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)”
[LT17]	“Khan, A. A., Keung, J., Niazi, M., Hussain, S., Ahmad, A. Systematic Literature Review and Empirical investigation of Barriers for Software Process Improvement in Global Software Development: Client-Vendor Perspective, Information and Software Technology, (March, 2017), doi: 10.1016/j.infsof.2017.03.006”
[LT18]	“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)”
[LT19]	“Rainer, A., Hall, T.: Key success factors for implementing software process improvement: a maturity-based analysis. Journal of systems and software, Vol. 62(2), pp.71-84 (2002)”

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