



A Systematic Review of Lean Implementation Frameworks and Roadmaps: Lessons Learned the Way Forward

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A Systematic Review of Lean Implementation Frameworks and Roadmaps: Lessons Learned and the Way Forward

Abstract

Purpose: The purpose of this study is to carry out a comprehensive systematic review of Lean implementation frameworks and roadmaps developed over the past decade and report the key findings along with the limitations and the way forward.

Methodology: A systematic review methodology proposed by Tranfield (2003) was followed to identify the relevant works on the research topic. Articles were searched using a set of inclusion criteria in various databases including Google Scholar, Web of Science and Science Direct over a period of thirty years.

Findings: The high failure rate of Lean system implementation, reaching a range between 70 -90% in almost all industries, is a matter of concern. This failure rate is still high even though numerous frameworks and roadmap models exist to streamline Lean implementation. There is no standard framework or roadmap identified in the literature and many organisations are implementing lean in their unique ways. However it would be desirable to develop a practical and systematic roadmap on Lean looking into the cultural and leadership dimensions rather than focusing on a set of tools. Moreover, most frameworks and roadmaps lack the sustianance aspects of Lean implementation.

Limitation: This research only identifies the fundamental gaps with the existing frameworks and roadmaps on lean implementation. The next phase of the research is to develop a roadmap and validate it with a number of organisations in different cultural contexts and leadership styles.

Originality: The authors argue that this is one of the most comprehensive systematic review on lean frameworks and roadmaps ever produced in the literature to date.

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3 **Keywords:** Lean implementation, systematic literature review, Lean future research agenda
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8 **Introduction**

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12 In recent decades, organisations, whether in manufacturing or services, have faced intensified
13 global competition, exacting customer demands, economic challenges, and financial crises
14 (Halkos et al., 2021). In this fiercely competitive landscape, Lean management has emerged
15 as a prominent strategy for driving continuous improvement. Lean management is a powerful
16 methodology aimed at reducing the cost of poor quality, improving financial performance,
17 and satisfying customers (Antony et al., 2020). Notable organisations, including Motorola,
18 General Electric, and Ford Motor Company, have successfully adopted Lean principles,
19 showcasing its effectiveness (Liker et al., 2011).
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24 However, not all organisations have reaped the benefits of Lean management (Demirkesen &
25 Bayhan, 2020), despite its proven potential for significant returns (Chavez et al., 2015).
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30 Implementing Lean is often described as a complex and challenging process (AlManei et al.,
31 2020; McDermott et al., 2022) with a lack of comprehensive implementation guides (Basu et
32 al., 2020). Furthermore, studies have shown that a significant number of Lean initiatives have
33 not achieved the expected results. For example, Baker (2022) reported that less than 10% of
34 organisations that started Lean achieved a high level of leanness. Moreover, the Lean
35 implementation methodology is primarily designed for large companies, and small and
36 medium companies still struggle (AlManei et al., 2017).
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42 Each organisation has unique requirements and challenges, necessitating tailored approaches
43 to avoid failure. Several systematic reviews studied the Lean implementation frameworks and
44 roadmaps with different objectives and focus. Anand and Kodali (2010) used a comparative
45 analysis to identify existing frameworks that suffered from various shortcomings and
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3 attempted to develop one to overcome these weaknesses. However, the framework did not
4 describe the prerequisites or requirements, which tool organisations should use in each phase
5 of Lean system implementation. Sundar et al. (2014) identified that the frameworks focused
6 only on a few aspects of Lean and developed a roadmap that included a step-by-step
7 approach with several Lean elements. Jasti and Kodali (2016) performed a critical review to
8 identify the inconsistencies in the Lean implementation framework and identified that Lean
9 implementation was developed and verified only in developed countries. They devised a
10 framework with 11 pillars and 102 elements to address these inconsistencies. Rafique et al.
11 (2019) focused on how technology and RFID could help implement Lean management. All
12 the reviews suffered from the same shortcoming: none of them performed a comparative
13 analysis of the different roadmaps, no indication of the organisation characteristics were
14 recorded, and failed to incorporate organisation description in their developed framework
15 while organisation characteristic has been termed as key (Markus et al. 2000). Mostafa et al.
16 (2013) pointed out that little research focuses on the sequences of implementing a Lean
17 system. These research gaps were recently summarised by Vallejo et al. (2020), who
18 highlighted five main limitations in Lean management implementation: (i) the absence of
19 clear guidelines in the early stages of implementation, (ii) lack of curricula, (iii) insufficient
20 understanding of the usage of tools and techniques, (iv) scarcity of an adequate roadmap, and
21 (v) more robust Lean programs are necessary to facilitate learning in organisations.
22 These studies highlight a significant gap in the literature concerning understanding the
23 suitability of the various Lean management implementation approaches developed to date.
24 The search identified that no studies focused on the differences and similarities of Lean
25 implementation approaches with respect to the chronological sequence of steps involved and
26 considered the organisational specificities.

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58 This research aims to narrow the gap in knowledge by studying the different approaches to
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3 answer the research questions through a systematic review, as it is a method that searches,
4 appraises, and collates all relevant evidence to provide a complete interpretation of research
5 results (Garza-Reyes, 2015; Zawacki-Richter et al., 2020). The following research questions
6 help answer the objective.
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- 11 • What are the different sequences of Lean implementation?
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- 13 • What are the similarities and differences between the different Lean implementation
14 approaches?
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- 16 • What prerequisite, tools, barriers and critical success factors (CSF) apply to the
17 different approaches, and how have they been mitigated and leveraged, respectively?
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- 19 • Have the context specific (organisation, industry, sector) requirements being been
20 taken into account, to enable effective lean implementation?
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29 Through these research questions, this study contributes to operations management,
30 particularly in the realm of Lean practices. It serves to shed light on the distinct purposes of
31 various Lean implementation approaches, explore their compatibility with different industry
32 and organisational types, and identify areas where a more resilient Lean system
33 implementation is needed. Furthermore, this research aims to offer practical insights for
34 organisations embarking on Lean implementation journeys. The findings enable them to
35 select the appropriate framework and roadmap more applicable to them based on the
36 similarities between their organisation and the ones referenced.
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49 **Methodology**

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51 A systematic review methodology explored the essential components for developing an
52 effective Lean system implementation framework and roadmap. A literature review is “a
53 systematic, explicit, comprehensive and reproducible method for the identification,
54 evaluation, and synthesis of completed and recorded work produced by researchers, scholars,
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and practitioners” (Paul et al., 2020, p.101717). The research employed the systematic review procedures structured by Tranfield et al. (2003), as illustrated in Figure 1.

<INSERT FIGURE 1 APPROXIMATELY HERE>

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Planning the review

The first step was to gather adequate literature connected to Lean implementation methods. The study limited the time range for the literature search to between 1991 and 2020. The year 1991 is after the publication of the book, 'The Machine That Changed the World' (Womack et al., 1990), where the authors coined the term Lean manufacturing. The search engines Google Scholar, Web of Science, and reputable publishers such as Taylor and Francis and Elsevier were used to locate relevant journal articles for this study, following guidance from previous similar studies such as Siegel et al. (2019). The search strings used to retrieve potential articles for review were: 'lean framework,' 'lean roadmap,' and 'lean methodology'. The researchers selected the keywords as this research would focus on the implementation approach for Lean management. Including and exclusion criteria were used to retrieve research papers relevant to the study, as listed in Figure 2.

<INSERT FIGURE 2 APPROXIMATELY HERE>

Conducting the review

Step two relate to the process of retrieving and selecting relevant literature materials. The literature screening started after establishing the review protocol. The study obtained and screened the first set of articles. This approach also searched any relevant articles they referred to in the first set. Therefore, the study adopted a snowball sampling procedure. The same search strings were used on the different search databases, leading to the same articles' appearance. The systematic approach was crucial to ensure a complete and thorough exploration of the literature. The study considered the search complete when the results started to become redundant. The search process identified an initial total of 126 articles. The

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3 abstract of each article was analysed. The criteria helped reduce the number of reviews to 37
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5 articles, which developed a Lean management implementation approach.
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10 *Analysis of Reviews*

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12 The third step of the systematic review process deals with the actual analysis of the studies
13 identified in step 2. The analysis identified numerous elements as critical for effective Lean
14 system implementation from previous research. However, none of the reviews has
15 systematically compared the developed roadmaps and frameworks. Among the essential
16 themes identified in the literature that impacted Lean implementation, the following aspects
17 were identified for deeper investigation in this review: (i) barriers, (ii) critical success factors,
18 (iii) essential conditions for successful implementation, (iv) different types of implementation
19 approaches that have been developed, (v) implementation sequences with the similarities and
20 differences, (vi) Lean tools used during the implementation, and (vii) customisation of the
21 Lean framework for the specific industries. Content analysis was performed across the
22 selected reviews to identify and extract information related to these. Figure 3 illustrates how
23 this study applied the themes to the literature review process.
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47 The selected focus aims to analyse and quantify the meaning and relationship between the
48 different themes to bridge existing research gaps. The different codes or categories were
49 identified from the literature review using the deductive approach for retrieving data. The
50 study recorded the frequency of each code and revised the codes as new elements, as
51 illustrated in Figure 4.
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Findings reporting

- The fourth and final step is about the reporting of the findings. The systematic review of the literature highlighted the major difficulties in an organisation's ability to adopt an adequate step-by-step approach for Lean systems and select the appropriate Lean tools for achieving process excellence (Dirk, 2013). The content analysis performed was essential to record why numerous initiatives were unsuccessful. The report of findings was structured based on the research questions, namely: what are the different sequences of Lean implementation? what are the similarities and differences between the different Lean implementation approaches? what barriers and critical success factors (CSF) apply to the different approaches and how have they been mitigated and leveraged, respectively? have the context specific (organisation, industry,sector) requirements been taken into account, to enable effective lean implementation?

Findings and discussion

What are the different sequences of Lean implementation?

An implementation approach in the form of a roadmap or framework is critical to enable the proper sequencing of actions for transforming an organisation from a 'non-Lean' system to a 'Lean' one. Flow charts, diagrams, and graphical representations are different ways to portray Lean management implementation sequences. The different approaches identified and termed in this research to illustrate the implementation sequences were (A) single-phase flow chart, (B) multi-phase flow chart, and (C) diagram construct as illustrated in Table 1. The selected reviews used conceptual and case study-based for the development of frameworks, whereas a

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3 roadmap was used exclusively for case study-based development. A complete set of sequence
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5 for successful lean implementation was identified to encompass stages like (0) assessment of
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7 need and readiness, (1) conceptual design, (2) implementation design, (3) implementation
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9 with evaluation, (4) transformation completion, and (5) sustainment planning. Interestingly,
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11 while there were variations in the number of milestones and the details, each approach
12
13 maintained similar sequences. This finding aligns with the belief that organisations should
14
15 not follow identical implementation sequences (Anvari et al., 2011). The analysis identified
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17 no specific preference for using a specific approach, as shown in Figure 5. A main short
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19 coming identified was the absence of Crucial milestones, such as 0, 1, and 5 in majority of
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21 the the reviews, despite their significance in ensuring a successful implementation. Other
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23 critical gaps identified were the insufficient analysis of the purpose of different Lean
24
25 implementation sequences, their prerequisites, and how to leverage CSFs to counteract and
26
27 mitigate barriers or when is a milestone considered as achieved. For Lean systems to function
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29 correctly, they must be implemented in the form of stages or “building blocks” with specific
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31 foundation prerequisites to be met prior to the deployment of subsequent stages to avoid
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33 jeopardising the implementation and to ensure the reaping of maximum benefits (Mostafa et
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35 al., 2013).
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42 Another essential gap identified was inadequate processes and importance given for the
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44 evaluation of an organisation’s readiness to embark on the Lean.. Milestone 0, where an
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46 organisation screens itself to evaluate its readiness to embark on the Lean journey, was
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48 present in only two reviews (Anvari et al., 2011; Crabill, 2000) whilst it should be a critical
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50 and compulsory milestone. Equally under research are organisational change management
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52 processes and sustainability frameworks for Lean sustenance. The literature often overlooked
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54 human resource management despite people being at the centre of Lean. Only five reviews
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56 included a sustenance plan.
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21 *Single-phase flow chart lean implementation type*
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24 The analysis found that 16% of the reviews explained the transition from traditional to Lean
25 production through single-phase flow charts. The sequence are different for each review
26 which primarily provided meand to resolve a problem. Table 2 illustrates a single-phase
27 flowchart from Prasad et al. (2020). The single-phase flowchart is simple to follow to resolve
28 a problem but lacks the depth and explicit approach for successful Lean management
29 implementation and sustenance. The reviews do not share the organisation's description.
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44 *Multiphase flow chart Lean implementation type*
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47 The analysis found that 27% of the reviews used the multiphase flow chart to explain the
48 transition to a Lean manufacturing system. The flow chart consists of several main phases
49 (Mostafa et al., 2013) or stages (Vallejo et al., 2020) or milestones (Setianto & Haddud,
50 2016), as would be termed in this review. The milestones consist of several other steps called
51 components or sub-elements. Organisations is recognised as lean when it has achieve all
52 components of all the milestones. A total of 18 different milestones were identified, with each
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3 review having a minimum of three different milestones and a maximum of eight. Table 3
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5 illustrates the six main milestones identified.
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14 *Components of Lean system implementation milestones*

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16 Comparative analysis revealed that specific milestones have similar components. For
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18 example, ‘building an expert Lean team’ was found in the ‘conceptual’ section for all reviews
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20 that included this milestone. On the other hand, not all components occurred in all reviews;
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22 ‘customer definition’ occurred only in the ‘implementation’ milestone of Bhamu (2016).
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24 Moreover, some components happened at different milestones for different implementations.
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26 For example, ‘employee role and responsibilities organisation’ and ‘training’ occurred in the
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28 ‘implementation’ milestone for Mostafa et al. (2013), whereas it appeared in the
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30 ‘implementation design’ milestone for Bhamu (2016).
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38 *Milestone 0 - Assessment of need and readiness phase.* This milestone is an initial
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40 investigation exercise to examine the current state of the organisation and identify if it has the
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42 necessary conditions for Lean implementation to be effective and successful. This milestone
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44 is considered phase 0, as an organisation cannot implement Lean management principles
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46 without the initial investigation for Lean readiness. Table 4 explains the three basic
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48 requirements (catalysts) for Lean to be initiated successfully. Lean implementation is
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50 desirable only if these catalysts exist in an organisation; otherwise, starting Lean would be
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52 full of hurdles, and failure is the probable outcome.
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6 Analysis of the reviews revealed that only Anvari et al. (2011) included an initial
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8 investigation or a pre-validation milestone prior to the conceptualisation and design
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10 milestone. All other reviews directly have the 'conceptual and design' phase, without a
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12 dedicated milestone to analyse if the organisation was ready. The literature identified
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14 management commitment and Lean knowledge as the main barriers to Lean implementation
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16 in general and this study. However, surprisingly, the initial investigation was not mandatory
17
18 or crucial for most reviews. This finding is a significant gap identified in the Lean
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20 implementation models.
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26 *Milestone 1 – Conceptual design.* This milestone focuses on the thinking and design activities
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28 for strategic planning. Required resources are identified and grouped, and Basic lean
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30 knowledge is transferred to selected organisation members. This study found that 70% of the
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32 multiphase Lean implementation studies have 'conceptual design' as the first milestone. The
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34 conceptual phase included 18 components identified within the literature, with each review
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36 having a minimum of 3 and a maximum of 10 components. This finding indicated that,
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38 despite the same milestone, each review's inclusive components differed. The most common
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40 components of the 'conceptual design' milestone identified are (i) Lean knowledge training,
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42 (ii) building up of Lean team implementation (change agents), (iii) securing senior
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44 management commitment, (iv) defining the Lean implementation assessment metrics, and (v)
45
46 recognising the need for change. The least common components of the conceptual design
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48 milestone identified are (i) establishing the change management plan, (ii) getting the supplier
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50 and the customer involved, (iii) establishing a feedback channel, and (iv) gap assessment and
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52 strategic planning. Some components happened uniquely in some reviews, such as the
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3 'monitoring and controlling mechanism' (Mostafa et al., 2013) and the 'change management
4 plan' (Vallejo et al., 2020), as indicated in Figure 6.
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14 *Milestone 2 - Implementation Design.* This milestone erects the designed Lean
15 implementation detailed in the previous milestone. The focus of this milestone is to identify
16 and analyse the organisation's various wastes and problems and establish a plan of action.
17 This study identified 17 different components. Each review had a minimum of three and a
18 maximum of nine components. The value stream map and Lean transformation plan are the
19 most cited components, while questionnaires for assessment and culture management plan
20 were each cited by one review only, Mostafa (2013) and Lean Advancement (2000). Lean
21 transformation plan happens in the 'conceptual design' milestone, and the future VSM map
22 occurs in the 'implementation' milestone for Vallejo et al. (2020) compared to other reviews
23 where they occur in 'implementation design'. One major shortcoming was the absence of
24 description on (i) how to erect the design, (ii) who should form part of the team, (iii) what
25 information to communicate, (iv) how the organisation would ensure that the design is
26 effective to achieve successful Lean management implementation.
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47 *Milestone 3 - Implementation with adequate evaluation.* Implementation with adequate
48 evaluation is the execution phase. This milestone deploys the 'design' plan and executes the
49 'implementation design' for an organisation to transition from a traditional system to a lean
50 one (Mostafa et al., 2013). This milestone is the only milestone in all the reviews with slight
51 differences in the approach and terminology. For example, 'implement the flow' in Karim
52 (2013) and 'action phase' in Maqbool (2019) is equivalent to the implementation milestone.
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3 This study identified seven different components. The different Lean system deployment
4 methods identified in the reviews are the implementation in a particular section of the
5 organisation, commonly termed a pilot study, versus simultaneous implementation across the
6 entire organisation. Mostafa et al. (2013) recommend carrying out the Lean pilot project to
7 conduct trials and create a prototype for the organisation. The criteria for choosing a pilot
8 project also differs between reviews. Womack and Jones (2003) recommended starting with
9 the most troubled subunit of the organisation, while Vallejo et al. (2020) suggested using the
10 most impactful project that would provide the best effort to deliver value ratio, alignment
11 with business objectives and potential financial results. Important steps, which are monitoring
12 and controlling, were present in only three of the 12 reviews, which are Mostafa (2013),
13 Bhamu (2016), and Vallejo et al. (2020). Tollgates or checkpoints are critical to assess the
14 completeness of a milestone before moving to the next for success (Crabill et al., 2000).
15 Vallejo et al. (2020) used the DMAIC tollgate to ensure adequate implementation. Only
16 Mostafa et al. (2013) included the reorganisation of resources in their 'implementation'
17 milestone, while one of the main barriers to Lean is the fear of employees embracing the
18 change due to the ambiguity of roles. Almanei et al. (2018) highlighted the lack of
19 consideration for the complexity of human factors. The transition from traditional mass
20 production to Lean production requires a behavioural shift in the organisation, including
21 training on the new work method and explaining the shift of responsibilities.
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49 *Milestone 4 - Transformation completion.* The final phase for most reviews is completing
50 Lean transformation milestones. It includes the extension of Lean to the whole organisation
51 for organisations that have opted for a pilot approach and establishment and formalising the
52 new work method. Organisations implement the required controls for value to flow across the
53 different units (Crabill et al., 2000). A total of 15 different components were identified, with
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3 a minimum of one to a maximum of eight different components for each review. The most
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5 cited components were (i) communication of the Lean benefit achieved, (ii) plan for
6
7 continuous improvement, (iii) standardisation of work practices, and (iv) monitoring and
8
9 controlling mechanism. While monitoring and controlling have been mentioned, the literature
10
11 does not describe the control method, what to control, who should control, and the feedback
12
13 mechanism for ensuring actions. Therefore, this is a limitation in the reviews. The least cited
14
15 component cited were (i) team development, (ii) institution of kaizen events, (iii) integration
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17 with organisation business plan, (iv) pursuit of perfection, (v) change of supply chain method
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19 of work including the philosophies, (vi) removal of system barriers, and (vii) documentation
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21 of lesson learned, which was cited only by one review (Siegel et al., 2019). According to the
22
23 literature, lessons learned capture and review are significant for the subsequent stage
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25 effectiveness (Mostafa et al., 2013) and can be both from inside and outside of the
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27 organisation. Lean management has been developed and perfected over the years with Gemba
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29 implementation and benchmarking. This finding makes documentation a very critical aspect
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31 for ensuring the success of organisations that aim to be Lean.
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40 *Milestone 5 - Sustenance plan.* Sustaining is the most critical part of any implementation
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42 framework. (Tiwari et al., 2020). Without appropriate periodic improvement mechanisms,
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44 processes tend to deteriorate over time (Snee, 2010). Different mechanisms include (i) regular
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46 training, (ii) a reward and recognition system, and (iii) periodic audit. Only five reviews
47
48 included a mechanism for sustaining Lean in their model (Vallejo et al., 2020; Almanei,
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50 2008; Bhamu, 2016; Tiwari, 2020). Only the review of Vallejo et al. (2020) included both the
51
52 ‘complete transformation’ and ‘sustenance plan’ milestones. Other reviews have the
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54 ‘sustenance’ or ‘complete implementation’ milestone. This finding also explains the high rate
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56 of failure to sustain Lean systems over time as reported by (i) George (2002), who
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3 highlighted that more than 70% of companies could not sustain Lean improvements over
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5 time, (ii) Chay et al. (2015) who commented that it would be unlikely that an organisation
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7 could sustain their early success by only following the implementation plan, and (iii) Bhasin
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9 (2012) who cited lack of sustenance plan as the main reason for the low success of Lean
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11 management. Moreover, this study found that in some organisations, employees attempt to
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13 return to their pre-Lean methods (Scherrer-Rathje et al., 2009), as shown in Table 6.
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24 *Diagram construct Lean implementation type*

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26 Another method of Lean implementation has been through diagrams and constructs. The
27
28 different Lean construct types identified in the reviews are pyramidal shape (Berlec et al.,
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30 2017), roadmap shape (Tiamaz & Souissi, 2019), wheel shape (Silverio et al., 2020), Venn
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32 diagram (Hodge et al., 2011), house shape (Jasti & Kodali, 2016), and schematic diagrams
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34 (Nordin et al., 2012), as illustrated in Table 6. The different implementations focus on distinct
35
36 themes and have various styles for illustration. Unlike the multiphase flow chart, the Lean
37
38 implementation elements in the diagram construct type differ considerably. The construct
39
40 does not have steps or milestones. However, it consists of essential dimensions and their
41
42 relation to each other, identified to be more explicit in describing the necessary elements for
43
44 Lean management implementation, as illustrated in Table 7. The various models of diagram
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46 construction differ in their elements but possess similarities, as described next.
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3 *Foundations for Lean* - Anand (2010) described it as the universal prerequisite which should
4 be present in any organisation for the successful initiation of Lean, as illustrated in Table 8.
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6 They cannot be taught or forced but should be developed and nurtured. Good leadership,
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8 management commitment, culture, and human aspect form part of the prerequisite.
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19 *Pillars* - Pillars refer to the essential principles of Lean manufacturing. Examples of these
20 found in the reviews are (i) small lot production, (ii) zero defect, (iii) customer focus, (iv)
21 supplier relationship, and (v) visual management, as highlighted in Table 9. Pillars were not
22 apparent in the multiphase flow chart. The inclusion of pillars demonstrates the importance of
23 these principles for an organisation to implement Lean management successfully.
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38 *Implementation levels/sequences* - Ahlstrom (1998) reported the importance of the sequences
39 for Lean implementation. Different levels and sequences are described through the pictorial
40 view and demonstrate the prerequisite of each step.
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47 *Decision level* - Decision makers for Lean implementation are described with the relation
48 type amongst each stakeholder. This description is essential to avoid conflicts and ambiguity.
49
50 Only Anand and Kodali (2010) described the decision level and the key stakeholders.
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56 <INSERT TABLE 10 APPROXIMATELY HERE>
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3 *What are the similarities and differences between the different Lean implementation*
4 *approaches?*
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8 There are both commonalities and distinctions among different Lean implementation
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10 approaches. While Lean methodologies generally share principles like waste reduction and
11
12 continuous improvement, the tools, techniques, and strategies vary. Similarities identified are:
13
14 the use of lean tools like 5s, VSM and kanban for improvement; availability of change agent
15
16 to support the transition; framework and roadmap being of singular type with no option of
17
18 customisation to be applicable to other organisation requirement. The difference were mainly
19
20 in the method of implementation: The single-phase implementation instructed steps to be
21
22 followed while the multi-phase implementation prescribed several milestones with
23
24 components to be executed within a particular milestone and the diagram construct emphasized
25
26 on criterias that an organisation need to acquire for successful implementation. Additionally
27
28 the comparative analysis revealed that no two Lean implementations had the same
29
30 milestones, indicating the uniqueness of each approach.
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37
38 What prerequisite, tools, barriers and critical success factors (CSF) apply to the different
39
40 approaches, and how have they been mitigated and leveraged, respectively?
41

42 *Prerequisite*
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45 While the focus has been on effectively implementing Lean and the sequences to pursue it,
46
47 the literature has often overlooked the prerequisites for ensuring a smooth and sustainable
48
49 implementation. Only 8 of the 37 reviews discussed the requirement before initiating Lean.
50
51 50% of the reviews were from multiphase flowcharts and diagram constructs with similar
52
53 prerequisites. The main pre-requirements retrieved from the eight reviews are (i) a sense of
54
55 urgency, (ii) management commitment, (iii) stability in processes, (iv) participative culture,
56
57 (v) a disciplined method of work, (vi) current system evaluation, (vii) strategic approach, and
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2
3 (viii) alignment of Lean with the vision and objectives of an organisation, as illustrated in
4
5 Figure 7. The leading causes of Lean failure reported were due to the incomplete
6
7 understanding of Lean (Mostafa et al., 2013), mistakes during implementation (Anvari et al.,
8
9 2011), lack of management commitment and cultural barriers (Rafique et al., 2017).
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14 <INSERT FIGURE 7 APPROXIMATELY HERE>
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19 *Critical success factors*

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21 This study identified 36 CSF from the reviews. The most cited were management
22
23 commitment and the availability of an expert team. Single-phase flow charts did not explore
24
25 the full CSF spectrum, whereas multiphase diagram constructs cited a vast number of CSF.
26
27 Culture-related issues, which are undeniably critical for successful Lean management
28
29 implementation are not among the common factors in the different approaches. The right
30
31 culture is a prerequisite for success, supported by Shah et al. (2007) and Liker (2012), who
32
33 stated that before focusing on the Lean techniques, it is imperative to achieve a conducive
34
35 culture. Another CSF that was least cited was starting a pilot project, and when cited, the
36
37 project selection methods differed. Mostafa (2013) proposed selecting the most troublesome
38
39 subunit of the organisation, while Vallejo et al. (2020) proposed selecting the project that
40
41 rendered higher value versus less effort, as shown in Figure 8.
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49 <INSERT FIGURE 8 APPROXIMATELY HERE>
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54 *Barriers*

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56 This study identified 28 barriers from the reviewed articles, out of which the main ones were
57
58 (i) incomplete understanding of Lean, (ii) organisational culture issues and (iii) lack of
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3 management commitment. Like the CSF, the single-phase flow chart approach did not
4
5 explore supply chain-related barriers, but the diagram construct cited the highest number of
6
7 barriers. One significant gap identified in all the approaches was the absence of specific
8
9 actions to counteract the effect of barriers. Only Crabill et al. (2000) and Vallejo et al. (2020)
10
11 described the level of knowledge required, how to acquire the same, the communication plan,
12
13 and the necessary tollgates to ensure smooth and successful implementation, as illustrated in
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17 Figure 9.

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21 <INSERT FIGURE 9 APPROXIMATELY HERE>
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23 24 *Lean Tools and techniques*

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26 A significant gap identified in the literature pertains to the selection and utilisation of Lean
27
28 tools. This study reveals a lack of comprehensive guidance for the selection and application
29
30 of Lean tools, resulting in instances of misapplications of Lean manufacturing tools and
31
32 techniques. These misapplications manifest in three primary forms: (i) the inappropriate use
33
34 of a tool to address a specific problem, (ii) the reliance on a single tool as a universal solution
35
36 for all issues, and (iii) the indiscriminate application of multiple tools to address a single
37
38 problem (Pavnaskar et al., 2003). Anvari et al. (2011) emphasize that the insufficient
39
40 knowledge of Lean among its adopters is a major factor contributing to the improper
41
42 selection of Lean tools and strategies, which, in turn, can lead to Lean implementation
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44 failures.
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49 Furthermore, the study also observed the strategies employed by researchers in crafting Lean
50
51 implementation roadmaps and frameworks. It was noted that the predominant approach
52
53 involved an exclusive reliance on traditional Lean methodologies, neglecting the potential
54
55 benefits of integrating alternative operational excellence frameworks to bolster the
56
57 implementation process. Notably, reviews conducted by Rafique et al. (2017) and Vallejo et
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3 al. (2020) exhibited the advantages of amalgamating emerging dimensions like technology
4 and sustainability with Lean practices. This forward-thinking approach is seen as essential
5 since depending solely on conventional techniques may not suffice to ensure the resilience
6 and effectiveness of Lean implementation (Antony et al., 2020).
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14 **Have the context-specific (organisation, industry, sector) requirements been taken into**
15 **account, to enable effective lean implementation?**
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21 While some Lean approaches were generic and stated to be applicable across various
22 industries and organisations, there is a growing trend toward customising Lean
23 methodologies to specific contexts. This customisation aims to enhance the alignment
24 between Lean practices and the unique challenges and opportunities within an organisation.
25 However, the majority of studies did not incorporate this customisation in their
26 implementation guide. No data was identified on the sectors characteristic and how lean
27 frameworks were developed to permit organisation face and overcome the challenges. Failure
28 of incorporation and documentation of organisational characteristic in the implementation
29 guide renders it impossible for an organisation to select the appropriate framework and
30 roadmap. Equally absent from the reviews were descriptions of organisational characteristics
31 upon which the frameworks or roadmaps were built. Attributes such as organisation size,
32 industry, culture, and current state significantly influence the effectiveness of Lean
33 implementation approaches. Notably, organisations should not attempt to replicate a Lean
34 framework from different industries or current states, as the processes' variables differ
35 (Lewis, 2000; Wan and Chen,2006; and Sundar et al. 2014). As stated by Bhasin (2012), a
36 lean roadmap is not a recipe for organisations to strictly follow, as every implementation will
37 be unique, with companies having their own culture, policies and system; any replication
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3 would be a pitfall. Furthermore, it was identified that no previous reviews mentioned the lack
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5 of organisation description while it is of critical importance.
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10 **Conclusions and Future Research Opportunities**

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12 The identified gaps render the implementation sequence developed non-practical as they do
13
14 not possess the level of detail that companies need for implementation. This finding points to
15
16 the shortcomings in the different Lean implementation approaches and sheds light on the
17
18 reasons for the high percentage of failure attempting to implement the Lean system. There is
19
20 a shortage of Lean implementation models that provide a gradual and chronological
21
22 application for an organisation to pursue successful Lean implementation. This review details
23
24 the barriers, CSFs, differences, similarities, and milestones. The reason for choosing a
25
26 particular milestone for a specific approach, the differences, how to overcome barriers, and
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28 other essential aspects remain unanswered.
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36 Despite the vast research areas in the lean field, the gaps identified in this study demonstrate
37
38 that critical areas still require in-depth research to highlight the Lean philosophy and concept
39
40 and render the conceptual frameworks more accessible to practitioners. Further studies are
41
42 required to enable the demystification of Lean implementation processes to be accessible to
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44 managers and engineers. The following section discusses the Future research areas that could
45
46 provide rich information to help narrow the research gap.
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51 ***Ways Forward for Research and Lean management***

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53 In-depth research is required to permit organisations to select roadmaps suitable to their
54
55 specific characteristics. Future research should aim to answer knowledge gaps such as (i)
56
57 what organisation characteristics are predominant in the selection of a particular Lean
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3 implementation approach and (ii) how an organisation's weaknesses and strengths influence
4 the selection of a detailed roadmap with adequate actions initiation for the organisation to be
5 and remain Lean.
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12 The Lean implementation sequences and prerequisites include exploratory studies to analyse
13 which milestones suit a particular organisation, the requirements for implementing a
14 milestone effectively, the chronological order of implementation, and how to measure
15 efficacy and completion of the process.
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24 Concerning readiness for Lean implementation, a formal approach for readiness evaluation
25 with an adequate plan for bridging the gap to render organisations ready to embark on a lean
26 journey is critically required. The following questions remain unanswered: which are
27 essential for Lean implementation success, are: How should an organisation identify if lean is
28 the appropriate methodology for pursuing excellence, and how should it reorganise itself for a
29 smooth initiation of the lean journey?
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40 Despite being a fundamental pillar of Lean management, Lean tools have been quite
41 inexistent in the reviews. Therefore, an adequate descriptive guide is essential for effectively
42 selecting tools. The tool's application should be tested and proven. It is also necessary to
43 communicate clear guidelines on the prerequisite, application scope and other essential
44 requirements to ensure the use of Lean tools is successful and reap the target benefits.
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54 Lean alone does not provide the agility that the current world requires, and seeking the
55 support of other improvement methodologies has proved beneficial. Future studies on how
56 Lean can system leverage other operational excellence approaches to render a higher success
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3 rate is a worthy research area. A few improvement methodologies identified are green Lean,
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5 Lean Six Sigma, Lean-industry 4.0, and Lean operational excellence.
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10 Equally important is an adequate plan for sustaining the Lean implementation efforts to
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12 ensure that no drifting back to previous practices happens, and this has been non-existent in
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14 the reviews.
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19 It is also essential to address the change agent team structure. Critical questions that still
20
21 require answers include: What field of expertise and competencies should the Lean team
22
23 possess, does the organisation or industry type impact the team structure, what are their
24
25 responsibilities, and what level of authority should they possess? What is a supportive
26
27 organisational culture, and how does an organisation develop them?
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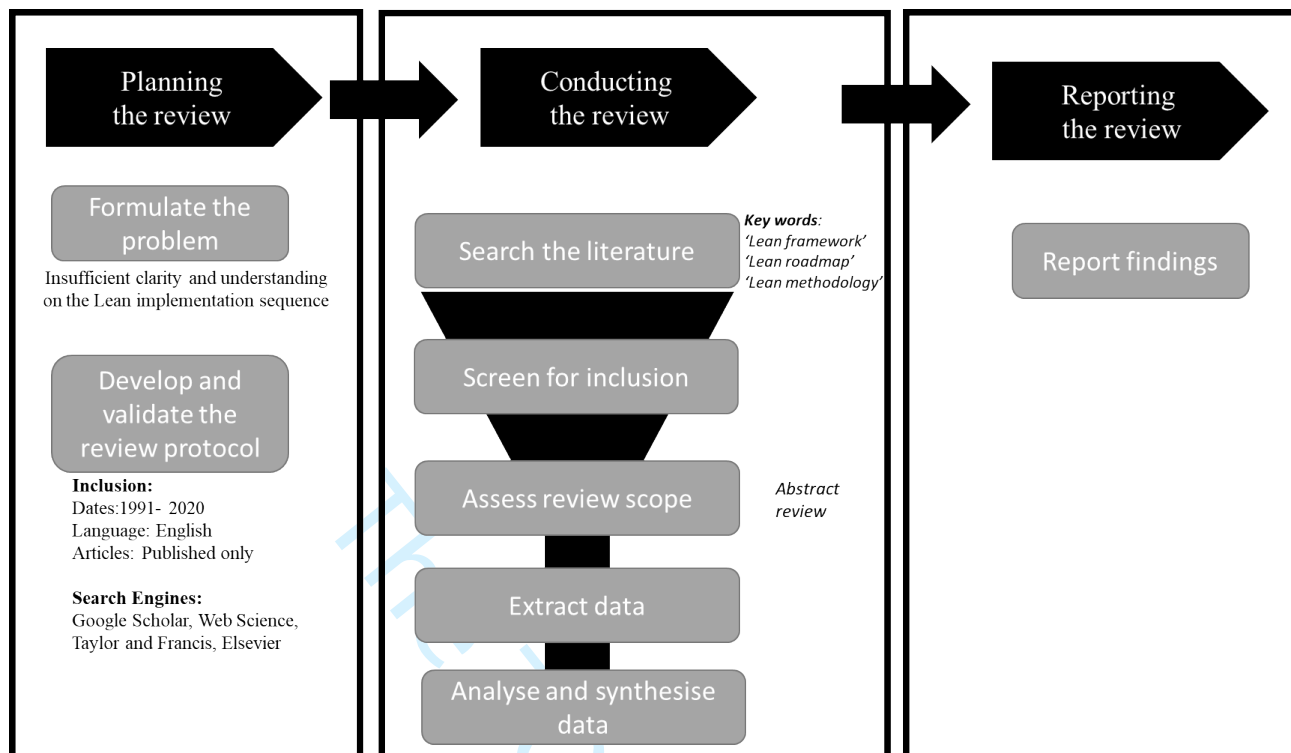


Figure 1. Steps of systematic literature review methodology

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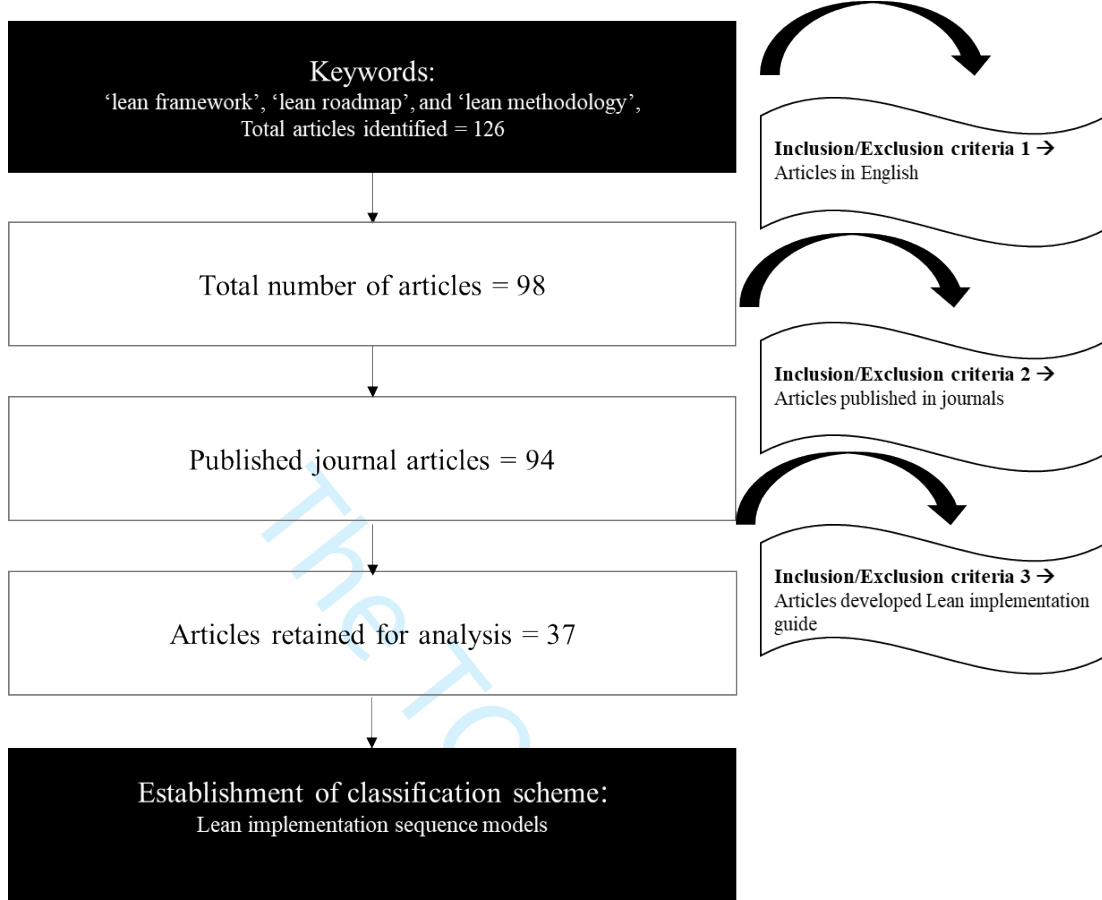


Figure 2. Steps for literature review screening

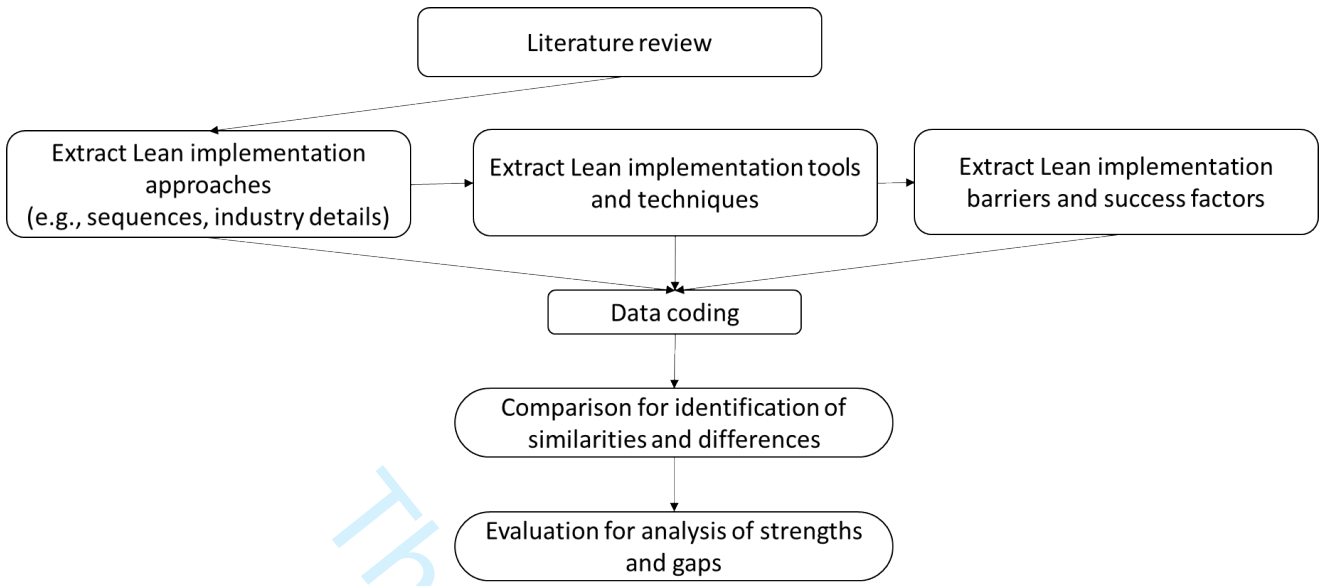


Figure 3. Type of data extraction from literature review

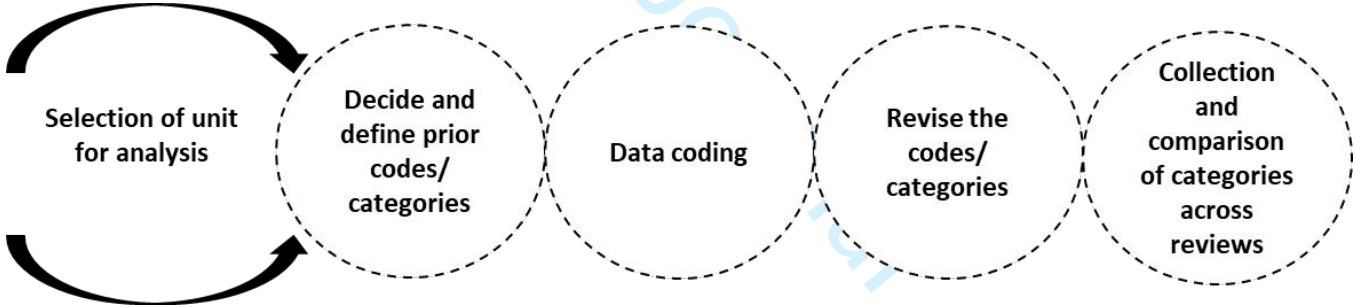


Figure 4. Content analysis process

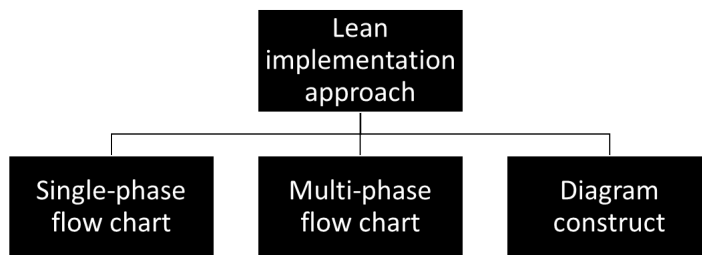


Figure 5. Lean implementation approach

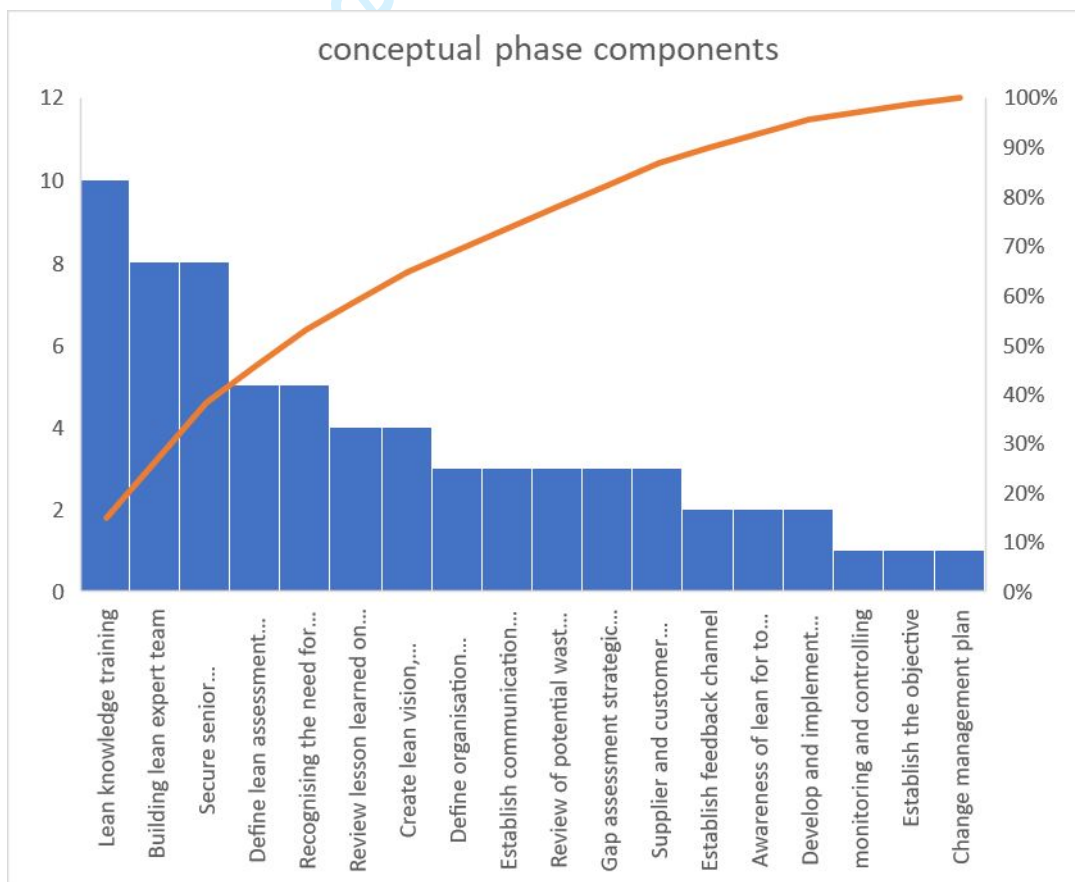


Figure 6. Conceptual phase components

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Figure 7. Prerequisite for successful Lean implementation

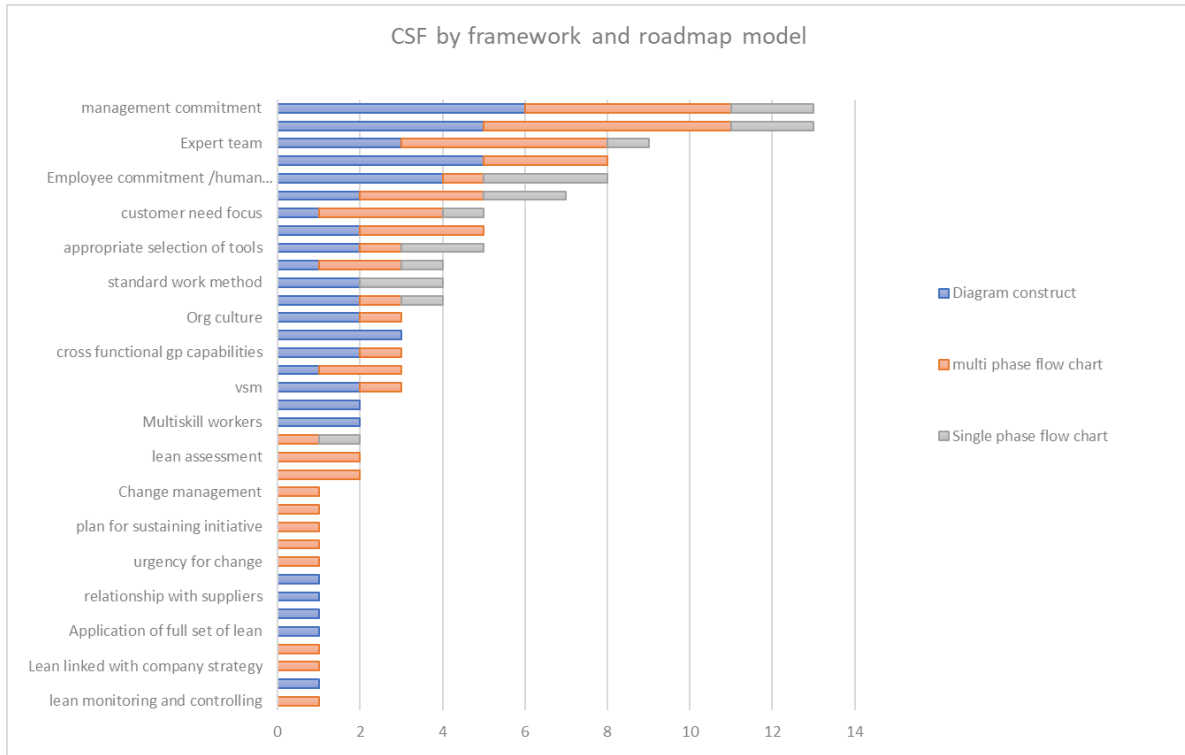


Figure 8. Critical success factors for Lean implementation

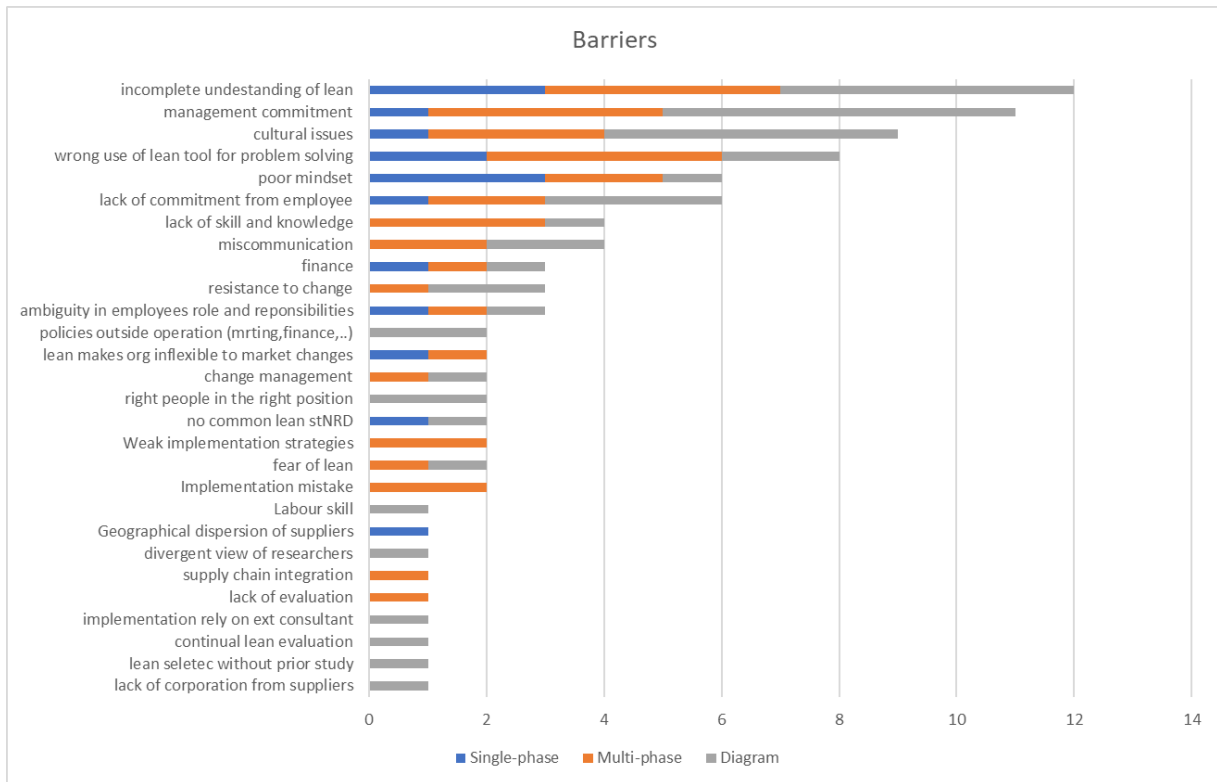


Figure 9. Barriers to Lean implementation

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Table 1. Different Lean implementation approaches

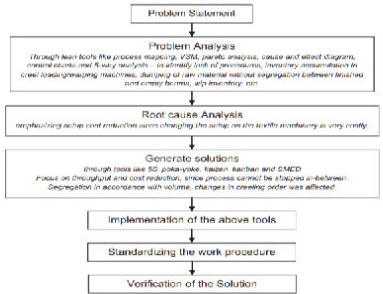
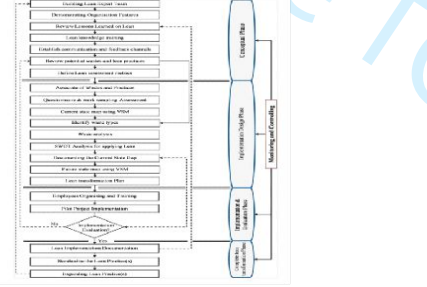

Lean implementation method	Pictorial view of method
<p>Single phase flow chart Consist of several milestones or steps which do not comprises of subcomponents</p>	 <p>Prasad, 2020</p>
<p>Multi-phase flow chart Consists of different milestones which depicts a major phase in the lean system implementation, and of which are inclusive several components that must be worked upon to complete a specific milestone.</p>	 <p>Mostafa, 2013</p>
<p>Diagram construct Consist of lean system implementation milestones organised in a pictorial view, demonstrating the components relationship with each other</p>	 <p>Kodali, 2010</p>

Table 2. Single-phase flowchart milestones

No.	Milestones – flow chart steps
(i)	Problem statement
(ii)	Problem analysis
(iii)	Root cause analysis
(iv)	Solution generation
(v)	Implementation of lean tools
(vi)	Standardisation of work procedure
(vii)	Verification of the solution

Table 3. Lean implementation main milestones

Milestone	Phase common term	Description of milestone	Reference
0	Assessment of need and readiness	An assessment of need and readiness of organisation to implementation of lean systems	Anvari, 2011
1	Conceptual phase	The lean implementation 'kick off', where the personnel for lean implementation are selected and trained Enhancement of mind-set and lean knowledge are expected	Mostafa, 2013
2	Implementation design	Design and preparation of the lean initiative (pre-implementation)	Mostafa, 2013
3	Implementation	Implementation with adequate evaluation	Vallejo, 2020
4	Complete the implementation	Extension to the whole organisation	Bhamu, 2016
5	Sustenance and continuous improvement	Sustenance and continuous implementation (post implementation)	Vallejo, 2020

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Table 4. Lean implementation readiness check

Milestone	Phase common term	Description of milestone
1	Urgency for change	Is there any crisis?
2	Management commitment	Is there a level of management commitment?
3	Change agent	Is there lean tool knowledge in terms of capability or resources to apply tools and techniques?

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Table 6. Multiphase flow chart Lean implementation approach

		Journal	Lean advancement initiative, 2000	Anvari, 2011	Jaaron, 2011	Mostafa, 2013	Karim, 2013	Bhamu, 2016	Almanei, 2018	Rafique, 2019	Maqbool, 2019	Vallejo, 2020	Tiwari, 2020
		SN no	12	2	22	1	10	18	17	3	27	7	31
		No. of elements	24	19	6	26	14	13	13	13	11	19	13
Conceptualisation	Building Lean expert team	8	>	1	1	1	1			1	1		1
	Define organisation features	3		1		1	1						
	Review lessons learned on Lean	4				1				1	1	>	
	Lean knowledge training	10	1	1		1	1	1	1	1	1	1	1
	Establish communication plan	3				1		1	1				
	Establish feedback channel	2		>		1							
	Review of potential waste and Lean practices	3		1		1		1					
	Define Lean assessment metrics/performance indicators	5	>	>		1	1						1
	Monitoring and controlling	1				1							
	Gap assessment strategic planning	3		1								1	1
	Establish the objective	1		1									
	Supplier and customer involved	3	1	1				1					
	Recognising the need for change	5	1	1	1				1			1	
	Secure senior management commitment	8	1		1		1	1	1	1		1	1
	Awareness of Lean for top management	2						1				1	
	Create lean vision, objectives, and goals	4	1						1		1	1	
	Change management plan	1										1	
	Develop and implement recognition and reward system	2							1			1	
	18		7	10	3	9	5	7	5	4	4	10	4
Implementation design	Associate waste and practices	2				1	1						
	Questionnaire and work sampling assessment	1				1							
	Current VSM mapping	9	1	1	1	1	1		1	1	1		1

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Communication of benefit of Lean (selling the benefit)	4		1					1			<	1
Pursue perfection	0											
Plan for continuous improvement	4			1				1	1			1
Document lessons learned	1										1	
Expand to suppliers and customers	1										1	
Integrate with organisation business plan	1										1	
Team development	1	1										
Remove system barriers	1	1										
Institute kaizen events	1	1										
15		8	5	1	4	0	0	4	1	0	4	3

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Table 7. Lean implementation - diagram model

Diagram model	Implemented	Conceptual	Grand Total
House shape		1	1
Pyramid shape	1	2	3
Roadmap shape	1		1
Schematic shape	2	7	9
Venn diagram shape	1		1
Wheel shape		1	1
Grand Total	5	11	16

Table 8. Lean implementation foundation

Review	Foundation	Leadership	Commitment	Culture	Human Aspect	Readiness for Change	Discipline
Anand, 2010	4	1	1	1	1		
Basu, 2019	3	1		1	1		
Hodge, 2010	0						
Jasti, 2016	2		1		1		
Nordin, 2012	1					1	
Nordin, 2017	1					1	
Shepherd, 2020	0						
Susilaawati, 2013	0						
Wong, 2011	2				1		1

Table 9. Lean implementation pillars

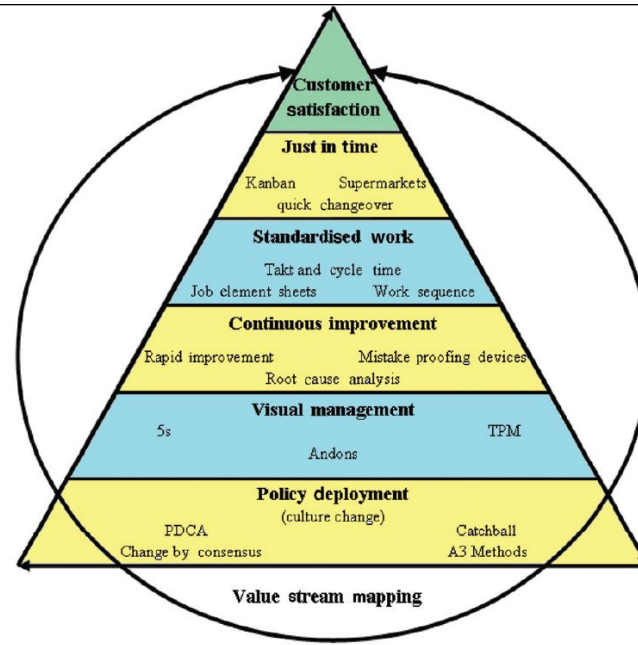
Review	Anand, 2010	Nordin, 2012	Shepherd, 2020	Nordin, 2017	Jasti, 2016	Susilaawati, 2013	Wong, 2011	Hodge, 2010	Basu, 2019
Pillars	8	3	4	4	7	3	5	6	10
Continuous improvement	1				1			1	1
Customer focus	1				1	1		1	1
Design business model			1						
Effective communication		1		1					1
Elimination of waste	1				1				1
Expert team/change agent		1		1					
Just-in-time					1		1	1	
Market opportunities			1						
Order based production	1								
Respect to humanity	1								
Reward system				1					
RND							1		1
Standardization					1			1	1
Supplier relationship	1					1	1		1
System controls		1							
Total productive maintenance					1				
Total quality management					1		1	1	1
Training			1	1		1			1
Viable products			1						
Visual management	1							1	1
Zero defects	1						1		

Table 10. Different models of diagram construct for Lean implementation

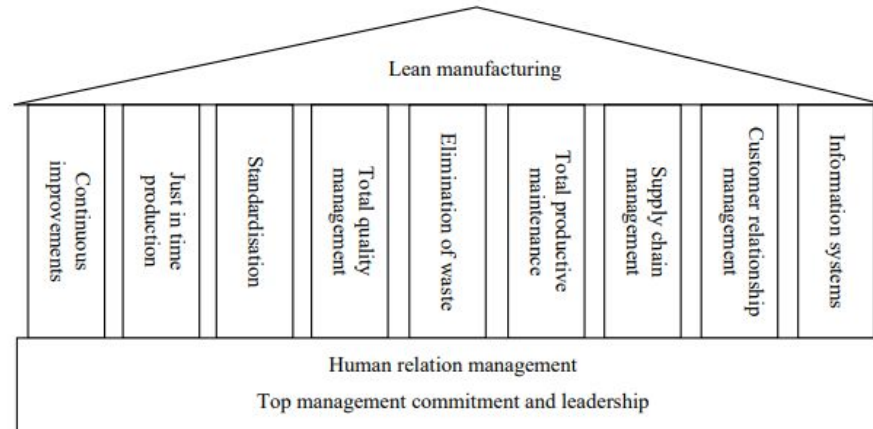
Author	Pictorial view of framework or roadmap
Anand, 2010	

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Hodge, 2011



Jasti, 2016

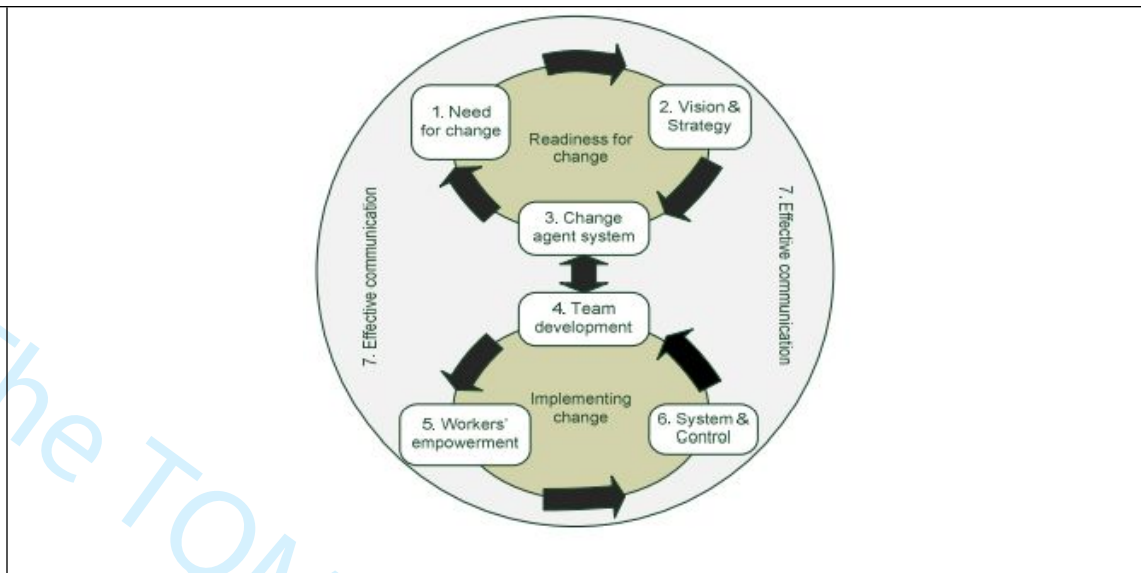


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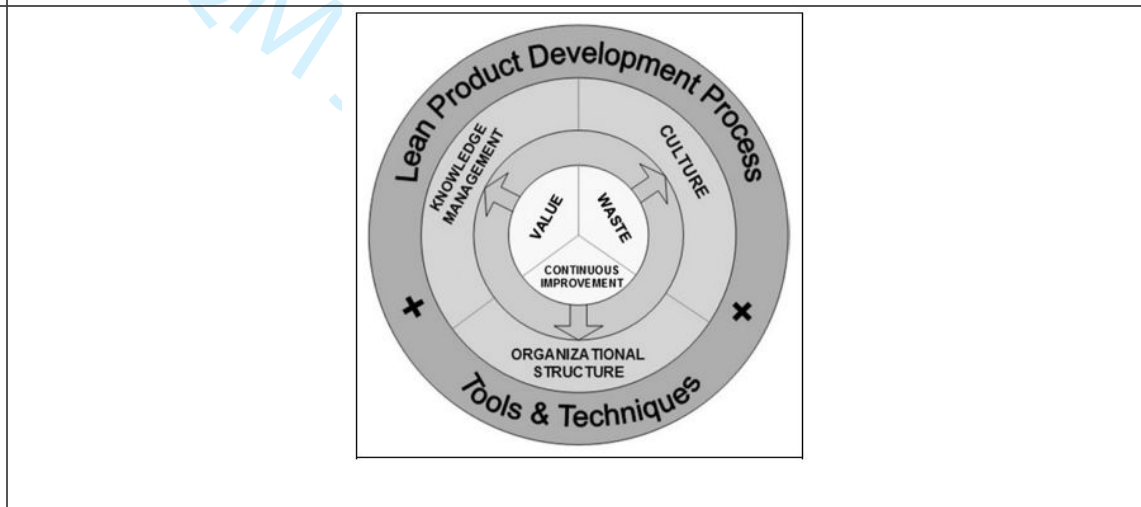
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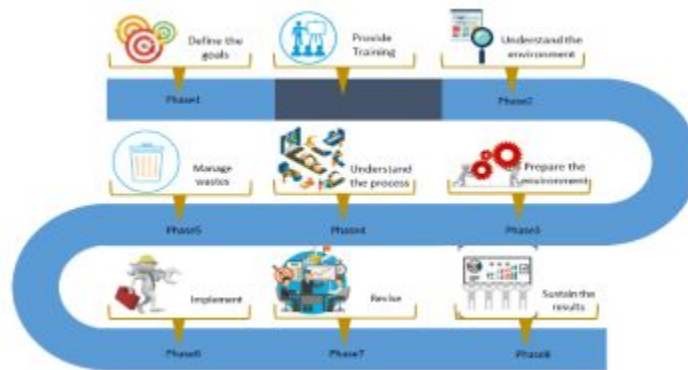
Nordin, 2017



Silverio, 2020



Tiamaz, 2019



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Reviewer(s)' Comments to Author:

Reviewer: 1

Recommendation: Minor Revision

Comments:

I congratulate the authors for this interesting research paper. I have the following suggestions.

Comment 1. Introduction section is too long, please reduce it so that readers interest is maintained.

Response : The authors agree with the above comment and addressed it on page 2 – 4 highlighted in blue font. This section has been reduced from 1,045 words to 784 words – decreased by 261 words

Comment 2. The findings section should be rearranged as per the research questions which is elucidated in the introduction. At present, the section is long and readers find it difficult to understand how the research questions given in the introduction section is answered.

e.g.

What are the different sequences of Lean implementation?

Findings about it....

What are the similarities and differences between the different Lean implementation approaches?

Findings about it....

How do the different attributes of organisations and sectors impact the approaches?

Findings about it....

.....

How does an organisation select the appropriate framework and roadmap?

Findings about it....

Response : The authors are grateful to reviewers for making the above comment and addressed the finding section to permit locating the findings related to the research question as per below:

1. What are the different sequences of Lean implementation?

Addressed on pg 8

2. What are the similarities and differences between the different Lean implementation approaches?

Addressed on pg 18

3. What prerequisite, barriers and critical success factors (CSF) apply to the different approaches, and how have they been mitigated and leveraged, respectively?

Addressed on pg 18

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4. Have the context specific (organisation, industry,sector) requirements being been taken into account, to enable effective lean implementation?

Addressed on pg 21

There was no findings on the organisation characteristic to help selection of the right roadmap which is still a research gap

Therefore the below three objectives have been rephrased as the new one for better clarity.

- How do the different attributes of organisations and sectors impact the approaches?
- To what extent have approaches been tailor-made to meet the needs of specific organisations and industries?
- How does an organisation select the appropriate framework and roadmap?

Been rephrased as

Have the context specific (organisation, industry, sector) requirements been taken into account, to enable effective lean implementation?

Additional Questions:

1. Originality: Does the paper contain new and significant information adequate to justify publication?: The purpose of this research is to carry out a comprehensive systematic review of Lean implementation frameworks and roadmaps. This is a good study and adds to the body of literature on Lean especially in terms of frameworks
2. Relationship to Literature: Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any significant work ignored?: This is a SLR and relevant literature in this area is reviewed
3. Methodology: Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed appropriate?: The research methodology is conducted based on methodology Transfield 2003, and is robust and sound
4. Results: Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together the other elements of the paper?: The results are thematically analyzed and well presented
5. Implications for research, practice and/or society: Does the paper identify clearly any implications for research, practice and/or society? Does the paper bridge the gap between theory and practice? How can the research be used in practice (economic and commercial impact), in teaching, to influence public policy, in research (contributing to the body of knowledge)? What is the impact upon society (influencing public attitudes, affecting quality of life)? Are these implications consistent with the findings and conclusions of the paper?: This study being a SLR on Lean implementation frameworks and roadmaps, will help the academia and industry to implement Lean management.

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6. Quality of Communication: Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc.: Good

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