Lean Management in Health Care: Protocol for a Scoping Review Assessing the Quantitative Literature

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Abstract

Background

Lean management (Lean) is a set of operating philosophies and methods aimed at maximizing value for patients by reducing different forms of waste. It emphasizes consideration for patient’s need, employee engagement and continuous improvement. In the past, research on the use of Lean management has been limited. However, there is a growing body of literature on the topic.

Methods

This protocol outlines the steps necessary to conduct a high quality scoping review on the use of Lean management in healthcare. The review will catalogue and synthesize the existing empirical research on the use of Lean in healthcare. We have developed a comprehensive search strategy covering a range of databases. We will screen all search hits and include all empirical studies that have a pre-intervention and post-intervention measure, regardless of study design. All data will be extracted by two review authors. Extraction results will be compared and disagreements will be addressed when necessary. Results will be presented in narrative form as well as in tables and figures when appropriate.

Discussion

Using the methods outlined in this protocol we will attempt to address the following questions: what are the effects of Lean management in healthcare on patient, professional and systems level outcomes? What are the most frequently reported types of Lean management activities? Which healthcare settings, countries, or locations are common to Lean implementation? What are the most frequently applied Lean management approaches? And, are any activities, contexts or subgroups associated with trends in patient, professional or systems outcomes?

Conclusion

The synthesis described in this protocol will act as a first step in the assessment of the use of Lean management in Healthcare. It will provide a broad overview of the use of Lean in healthcare and a general idea of the associated direction of effects with regards to patient, professional and systems outcomes.
Introduction

Healthcare systems are facing mounting challenges as an aging society brings increased demand for care [1, 2]. Further, findings suggest healthcare systems suffer from an abundance of preventable errors resulting in significant human and financial costs [3, 4]. The need to address these issues is complicated by financial conditions for health care systems which are stagnating and in some cases are even worsening [1].

In response healthcare providers are required to improve outcomes while simultaneously achieving greater efficiencies [5, 6]. To meet these goals many organizations have turned to industrial improvement approaches [7]. One prominent improvement method is the Lean Management System (Lean), which has been estimated to be adopted in some form by 53% of US hospitals [8]. Similarly, a recent Canadian survey suggested that 73% of health regions report Lean as part of their provincial strategy [9]. Lean management promises enhanced quality, capacity and safety while containing costs [7].

Background

Lean management, originally termed the Toyota Production System (TPS) [10] was developed in the auto industry by Taiichi Ohno [11]. The original aim was to ensure defect free manufacturing, while minimizing waste and addressing the needs of the customer [11]. Since that time Lean has been applied to various industries and is most commonly described as “an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability” [12].

When adopted into healthcare, numerous components of Lean have been emphasized with common foci being the development of a culture of continuous improvement [1, 13-16], empowerment of employees [14, 15, 17], the reduction of waste [1, 13, 14] and improving the value received by patients [1, 15, 18]. Concentrating on these values is expected to result in decreased cost [1, 15, 18]; increased safety [1, 17, 18], and improved quality of care [1, 17, 18]. In order to achieve these goals a number of common activities are used in Lean management systems. A description of common activities can be found in appendix 1.

Justification for scoping review

Although Lean has been widely applied in health care systems in Canada, the United States and the United Kingdom [6-9, 19], little has been done to synthesize the available evidence on the use of Lean in healthcare. Further, reviews have either been narrowly focused (e.g. focused only on Lean in surgery or the emergency department) [20] or identified a limited number of studies (i.e. < 35) [21, 22]. The latter shortcoming is of special concern as work to date by our review team suggests a comprehensive review is likely to include over 100 studies. The lack of synthesis, combined with the fact that the costs of both implementation and failure are high due to the “high-touch, high-maintenance” [23, 24] nature of Lean, necessitates a rigorous synthesis of the available literature. This scoping review protocol outlines a preliminary step in the synthesis of the quantitative literature on the use of Lean management in healthcare.

Methods and Analysis
We completed the initial steps in conducting a systematic review on the use of Lean management in healthcare by developing a sensitive search strategy and producing a systematic review protocol [25]. After we began the screening process for the review it became apparent that conducting a systematic review based on the protocol would not be feasible as we estimated the review would contain between 100 and 150 studies. Based on abstracts of identified articles it is suspected that the majority of these studies will utilize relatively weak designs (e.g. simple pre-post comparisons).

As such we concluded the best course of action is to conduct two reviews: 1) a Cochrane EPOC systematic review and 2) a more inclusive scoping review. The scoping review is necessary as only a small portion of the identified studies are likely to meet the strict Cochrane EPOC study design criteria which include only randomized controlled trials (RCTs), cluster randomized controlled trials (cRCTs), non-randomized controlled trials (NRCTs), controlled before-after studies (CBAs), and interrupted time series studies (ITS) [26]. The protocol for the Cochrane EPOC systematic review will be submitted for publication in the Cochrane Library. The scoping review protocol presented in this manuscript outlines the steps in conducting a scoping review on the use of Lean management in healthcare.

The scoping review will synthesize all the comparative quantitative studies identified by our search strategy. To conduct the review we will utilize the five step methodology outlined by Arksey and O’Malley [27] and further developed by Levac et al. [28]. This process requires review authors to 1) identify the research question, 2) identify eligible studies, 3) select relevant studies, 4) extract data and 5) synthesize this data.

**Stage 1: Identifying the research question**

The objective of this scoping review is to provide a high level assessment of the outcomes associated with the use of Lean management in healthcare. In addition, the review will summarize the activities used to implement Lean, the context in which it is implemented, the subgroups of Lean implemented and how these factors interact with the outcomes of interest. As such the research questions will be:

- What are the effects of Lean management in healthcare on patient, professional and systems level outcomes?
- What are the most frequently reported types of Lean activities (e.g. 5S events, RPIWs, Value Stream Mapping)?
- Which healthcare settings (e.g. emergency department, laboratory, pharmacy), countries, or locations (urban or rural) are common to Lean implementation?
- What are the most frequently applied Lean approaches (e.g. Lean Six Sigma, Productive Ward)?
- Are any activities, contexts or subgroups associated with trends in patient professional or systems outcomes?

**Stage 2: Identifying eligible studies**

A sensitive search strategy, developed for a systematic review, has been run, without date or language limits, in MEDLINE, Embase, CINAHL, and Cochrane Library. Focussed search strategies were developed and run in Scopus, Web of Science, and Business Source (Ebsco). Grey literature searches of the Agency for Healthcare Research and Quality and Institute for Healthcare Improvement have been conducted. We have reviewed reference lists of related publications such as systematic and literature reviews, editorials and commentaries on Lean focussed articles. We anticipate a large number of studies will
meet our sc
oping review inclusion criteria so we will not contact authors requesting additional study data. The MEDLINE search strategy is presented in appendix 2.

**Stage 3: Study selection**

Studies will be screened by pairs of trained review authors using the criteria outlined in the following paragraphs. Disagreements will be discussed and if a consensus is not reached studies will be referred to a third author for a final decision. An overview of our inclusion criteria following the population, intervention, comparison, outcomes (PICO) method can be found in table 1.

<table>
<thead>
<tr>
<th>PICO</th>
<th>In</th>
<th>Ex</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Population</strong></td>
<td>All healthcare systems, including hospital care, primary care, community or home care and rehabilitation</td>
<td>Drug manufacturing, drug discovery, medical device manufacturing, medical device delivery, teaching (e.g. techniques for teaching nursing), software development, animal research</td>
</tr>
<tr>
<td></td>
<td>All employees of the healthcare system (e.g. CEOs, health professionals, administrative staff and support staff), patients and their families, management, lean experts and key stakeholders</td>
<td></td>
</tr>
<tr>
<td><strong>Intervention</strong></td>
<td>Lean Intervention meeting our operational definition which requires:</td>
<td>Interventions using Lean activities which do not meet our inclusion criteria</td>
</tr>
<tr>
<td></td>
<td>• A commitment to Lean philosophy including</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o A commitment to Lean principles</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o A commitment to continuous improvement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The use of at least one Lean activity (assessment activity or improvement activity)</td>
<td></td>
</tr>
<tr>
<td><strong>Comparison</strong></td>
<td>Pre Lean processes</td>
<td>Simulation Studies</td>
</tr>
<tr>
<td><strong>Outcome</strong></td>
<td>Patient, professional and systems level outcomes which include a pre and post intervention measure</td>
<td>Studies which only report a measure of change</td>
</tr>
</tbody>
</table>

The inclusion criteria outlined in the above figure utilizes the operational definition of Lean management developed for the systematic review. This definition was developed based on the first 500 studies screened when developing the search strategy. This operational definition requires that all included
studies focus on interventions which: 1) occurred in an organization or subunit of an organization (e.g., department or ward) which has made a commitment to Lean philosophy (including a commitment to both Lean principles and continuous improvement); and 2) utilized at least one Lean assessment activity or Lean improvement activity where:

**Lean Philosophy** is a set of core ideas that make up Lean. This is made up of two components: a commitment to Lean principles and a commitment to continuous improvement.

**Lean principles** refer to an overarching set of principles aimed at transforming workplace culture [29]. These include a focus on: eliminating waste [1, 18, 30]; improving the flow of patients, providers and supplies [1, 11, 14]; and ensuring all processes add value to customers [31]. Further, Lean principles suggest that problems are identified and addressed by front line staff members as it is believed that the people doing the work are best suited to create solutions [14, 17, 29].

**Commitment to continuous improvement** refers to the acknowledgement that Lean doesn’t occur as a single intervention but instead requires a commitment to continually improving the workplace [14, 18, 30].

**Lean Activities** are a set of management practices, tools, or techniques that can be directly observed [12] and are prescribed to improve the workplace. There are two types of Lean activities: assessment activities and improvement activities.

**Lean assessment activities** work as analytic tools to identify waste and areas of possible improvement. These activities allow team members to see problems and identify opportunities to reduce waste and make improvements, but do not prescribe specific solutions. Lean assessment activities include VSM; spaghetti diagrams; RPIWs; Gemba walks; and root cause analysis.

**Lean improvement activities** suggest specific ways to reduce waste and improve the workplace and set up new working practices [1]. These include actions and concepts such as: 5S events; Levelled production; DVM (including Kanban supply management); Standard Work; and Stop the Line techniques.

We will include all studies which meet this definition of Lean management and include the following types of participants:

- All sectors of the health care system, including hospital care, primary care and rehabilitation
- All employees of the healthcare system such as CEOs, health professionals, administrative staff and support staff
- Patients and their families
- Management, Lean experts and key stakeholders

The review will not include any studies focused on the following areas:

- Drug manufacturing
- Drug discovery
- Medical device manufacturing
- Medical device delivery
- Teaching (e.g. techniques for teaching nursing)
- Software development
Finally, we will require that all studies include at least one pre-intervention and one post-intervention measure (i.e. studies which only report a difference measure will not be included). An overview of the inclusion criteria is presented in table 1.

Stage 4: Data extraction

Data will be extracted by two reviewers; disagreements of interpretation or categorization will be resolved by discussion and if a consensus is not reached the decision will be made by a third reviewer. Data extraction will be piloted on five studies by two authors prior to deployment to the full author team. The form will be deployed as an Excel workbook and will contain drop down menus to standardize data extraction.

We will extract data regarding all patient, professional and systems level outcomes. For the purpose of the review patient outcomes are operationalized as outcomes which directly measure the patient’s health or satisfaction after they leave the system. Professional outcomes are operationalized as outcomes which describe how the healthcare professional/staff perceive their work or how they perform tasks but do no measure how efficiently this is done. Finally, systems outcomes are operationalized as outcomes which describe the ability of the system to perform actions using the fewest resources possible. These may influence patients’ experiences but they do not describe the health or satisfaction of the patient following the patient’s visit. This category therefore does not include direct measures of health (e.g. mortality rate) and/or proxy measures of health (e.g. re-admission rate, infection rate). For each of these outcomes we will extract data regarding the direction of changes (favourable/detrimental/no change) and whether the outcome was statistically significant at the $p < 0.05$ level of significance.

In addition, we will extract information regarding the Lean activities used in implementation, characteristics of the organization in which Lean was implemented (including healthcare setting, and location), whether a subgroup of Lean management was used (e.g. Lean Six Sigma or Productive Ward) and the types of healthcare workers, Lean experts and patients involved in the study. The complete list of data extraction fields can be found in appendix 3.

Stage 5: Data synthesis

We will provide a synthesis of our findings based on data extracted. We will provide tables or graphs when the information may be more easily understood using visual representations. All quantitative synthesis will only include count data such as the number of favourable outcomes or the numbers of Lean activities used. This high level synthesis of published data will allow us to describe trends in the outcomes associated with the use of Lean management, characteristics of Lean implementation and organizations which implement Lean as well as any interactions between outcomes and implementation or organizational factors. Further, this analysis should assist in identifying gaps in the available literature and guiding future research.
Ethics

As this research will include only secondary analysis it does not require ethics approval.

Conclusion

The synthesis of the available literature described in this protocol will act as a first step in the assessment of the use of Lean management in Healthcare. The review will provide a broad overview of the use of Lean management in healthcare and provide a general idea of the direction of effects associated with Lean with regards to patient, professional and systems outcomes. Further, the review will describe the most common Lean activities and contexts for implementation.
Works Cited

1. Poksinska B: The current state of Lean implementation in health care: literature review. 


   Academy Press; 2000.

4. Forster A, Clark H, Menard A, Dupuis N: Adverse events among medical patients after discharge 

   323(7322):1192.


   quality & safety* 2014.

8. Hospitals see benefits of Lean and Six Sigma

9. Current state of Lean in Canadian health care
   [http://www.conferenceboard.ca/temp/0b15a8fa-9caa-4562-a50a-3dcb2de235dc/6443_currentstateoflean_cashc_(pub3437)-br.pdf]


    Quality with Lean. Chicago, IL: Health Administration Press; 2008.


    Medicine* 2011, 57(3):265-278.

    Productivity Press; 2010.


17. Casey JT, Brinton TS, Gonzalez CM: Utilization of lean management principles in the 


    qualitative content analysis of the importance of existing quality improvement capacity in the 
    implementation of Releasing Time to Care: the Productive Ward in Saskatchewan, Canada. 
    *BMC health services research* 2014, 14:642.

    systematic review. *Surg* 2015, 13(2):91-100.

21. Vest JR, Gamm LD: A critical review of the research literature on Six Sigma, Lean and StuderGroup's 
    Hardwiring Excellence in the United States: the need to demonstrate and


26. *What study designs should be included in an EPOC review? EPOC Resources for review authors* [http://epoc.cochrane.org/sites/epoc.cochrane.org/files/uploads/05%20What%20study%20designs%20should%20be%20included%20in%20an%20EPOC%20review%202013%2008%2012_2.pdf](http://epoc.cochrane.org/sites/epoc.cochrane.org/files/uploads/05%20What%20study%20designs%20should%20be%20included%20in%20an%20EPOC%20review%202013%2008%2012_2.pdf)


33. Saskatchewan Healthcare Management System Ressources: Glossary Terms [https://www.saskatoonhealthregion.ca/about/SHCMS/Pages/Resources.aspx](https://www.saskatoonhealthregion.ca/about/SHCMS/Pages/Resources.aspx)

34. *A Brief Introduction to A3 Thinking* [http://a3thinking.com/](http://a3thinking.com/)

## Appendix 1: Common Lean activities

<table>
<thead>
<tr>
<th>Lean tool/technique</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value Stream Mapping</td>
<td>A Value Stream Map in healthcare is a visual tool plotting all processes required to deliver a healthcare service. It facilitates enhanced understanding of the flow of patients, supplies or information through a healthcare process [32].</td>
</tr>
<tr>
<td>RPIW</td>
<td>RPIW stands for Rapid Process Improvement Workshop. An RPIW is generally a week-long event where teams of patients and their families, staff and clinicians focus on one problem, identify the root cause, create solutions and implement sustainable changes [33].</td>
</tr>
<tr>
<td>5S events</td>
<td>5S stands for ‘Sort, Sweep, Simplify, Standardize, Sustain/Self-Discipline’, and represents a set of concepts that ensure a clean and well organized work place [32].</td>
</tr>
<tr>
<td>A3 Problem Solving</td>
<td>A3 Problem Solving refers to a standardized method of addressing problems utilizing an A3 report, which is a standardized form of planning and report writing. The content follows the Plan-Do-Study-Act (PDSA) cycle [34].</td>
</tr>
<tr>
<td>Gemba walk</td>
<td>Gemba is a Japanese term which means ‘the work place’. It simply refers to the ‘work floor’ or unit where the necessary patient care is provided [33]. A Gemba walk refers to the act of a manager or CEO spending time on the hospital floor and speaking to frontline staff who understand the organization's problems and shortcomings [11].</td>
</tr>
<tr>
<td>Stop the Line techniques</td>
<td>Stop the Line techniques come from manufacturing (specifically the assembly line) and here refer to the act of enabling all healthcare professionals to immediately stop the line (a process of care) when a defect or error is realized. This prevents errors from being passed on and makes the cause of errors more salient [35].</td>
</tr>
<tr>
<td>Levelled production</td>
<td>Levelled production in healthcare refers to the elimination of unnecessary variation (unevenness) to avoid bottlenecks and backups which can lead to patient wait times and wasted time for healthcare professionals [11]. Levelled production requires a rigorous study of organizational processes, and scheduling patients and clients according to actual or forecasted demand [11].</td>
</tr>
<tr>
<td>DVM</td>
<td>DVM (Daily Visual Management) is a system aimed at improving communication and ensuring information is available when needed. This is done by displaying objectives, metrics and progress transparently and using measures (e.g., staff injuries, patient falls) to manage change [32]. DVM is closely linked to the wider strategic management system or policy deployment system of an organization [11].</td>
</tr>
<tr>
<td>Standard Work</td>
<td>Standard Work in healthcare details the steps in a course of treatment or care in a multi-disciplinary care plan. It prescribes a uniform way to achieve a desired service or patient outcome based on the best available evidence. Standard Work serves as the basis for any kind of work improvement [32].</td>
</tr>
</tbody>
</table>
Appendix 2: MEDLINE Search strategy

1. ((total quality or quality assurance or quality improvement) adj3 lean).ti,ab. (23)
2. (think lean or lean thinking).ti,ab. (83)
3. (lean adj3 (workflow? or efficiency or efficient$)).ti,ab. (92)
4. (lean and (approach or business model? or care or collaborat$ or design$ or enterpri?e or healthcare or health care or implementation? or industry or initiative? or intervention$ or leader$ or management or methodolog$ or method? or organi?ation$ or plan or planning or philosophy or practice or practices or principles or principle or process improvement? or production or program? or programme or programmes or quality or redesign$ or reengineer$ or restructur$ or reorgani$ or safety or sigma or strategy or strategies or thinking or tool or tools or workshop$)).ti. (509)
5. (organ?ation$ adj5 lean).ab. (39)
6. (lean adj2 (approach or business model? or care or collaborat$ or design$ or enterpri?e or healthcare or health care or implementation? or industry or initiative? or intervention$ or leader$ or management or methodolog$ or plan or planning or philosophy or practice or practices or principles or principle or process improvement? or production or program? or programme or programmes or quality or redesign$ or reengineer$ or restructur$ or safety or sigma or strategy or strategies or thinking or tool or tools or workshop$)).ab. (568)
7. (lean and (admitting or clinic or clinics or emergency department? or emergency medicine or emergency room? or emergency service? or family practice? or general practice? or healthcare or health care or hospital? or hospitali?ed or inpatient? or intensive care or ICU or "length of stay or nursing" or oncology or outpatient? or patient care or pharmacist? or pharmacy or practitioner? or physician? or readmission? or surgeon? or surgery or surgical or trauma center? or trauma centre? or trauma service? or trauma care or ward or wards)).ti. (221)
8. (lean adj4 (admitting or clinic or clinics or emergency department? or emergency medicine or emergency room? or emergency service? or family practice? or general practice? or healthcare or health care or hospital? or hospitali?ed or inpatient? or intensive care or ICU or "length of stay or nursing" or oncology or outpatient? or patient care or pharmacist? or pharmacy or practitioner? or physician? or readmission? or surgeon? or surgery or surgical or trauma center? or trauma centre? or trauma service? or trauma care or ward or wards)).ab. (176)
9. (((PDSA or PDCA or TQIS) adj3 (cycle or process or processes or intervention or quality or lean or improv$)) or ("plan do study" or "plan do check")).ti,ab. (418)
10. (Lean and waste).ti. or (lean adj3 waste).ab. (18)
11. ((wait$ time? or reduc$ wait$) and lean).ti. or ((wait$ time? or reduc$ wait$) adj4 lean).ab. (6)
12. (lean and (overcrowd$ or patient$ flow? or wait time$)).ti,ab. (53)
13. (lean technique? or lean manufacturing).ti,ab. (55)
14. (lean basics or lean training).ti,ab. [added Feb 20] (3)
15. ((lean adj7 5s) or (5s adj3 (event? or method? or methodolog$ or model? or process or processes or safety or waste or quality))).ti,ab. (102)
16. ((a3 adj3 (healthcare or health care or problem solving or quality improv$ or workflow? or method? or methodology or process or processes)) or A3 thinking or (a3 adj3 lean))).ti,ab. (65)
17. toyota.ti,ab. (182)
18. (gemba or Kaizen or kanban).ti,ab. (64)
19. (innovation? adj2 collaborat$).ti,ab. (95)
20. (PROCESS MAP? or process mapping).ti,ab. (213)
21. (mistake proofing or value-stream map? or incident learning).ti,ab. (43)
22. Pareto diagram?.ti,ab. (18)
23. ((shewhart or shewart or deming) adj3 (cycle or method$)).ti,ab. (90)
24. process failure-mode-and-effects-analysis.ti,ab. (2)
25. (breakthrough adj3 (series or project or collaborative?)).ti,ab. (148)
26. rapid process improvement?.ti,ab. (8)
27. (rapid cycle adj3 (improvement or quality or process or processes)).ti,ab. (76)
28. quality improvement? tool?.ti,ab. (225)
29. (six sigma or 6 sigma).ti,ab. (398)
30. or/1-29 [Set 1] (2964)
31. (bibliography or biography or editorial or lectures or news or newspaper article).pt. (737304)
32. animals/ not (animals/ and humans/) (3909440)
33. 30 not (or/31-32) [Set 1] (2687)
34. remove duplicates from 33 (2660)
Appendix 3: Data extraction fields

Excel Book 1: Study Information

**Study ID:** Last Name of the first author followed by publication year (required) (use “anonymous” if author is not available) (add a letter starting at "a" and continue alphabetically if multiple articles require the same study ID)

**Author:** Names of all authors (Last name, initials) (N/A if not available)

**Year of Publication:** Year the study was published (N/A if unavailable)

**Title:** Title of the article from which data is being extracted (N/A if not available)

**Journal:** Name of the journal in which the study was published (no abbreviations) (N/A if not available)

**Intervention Number:** Some studies will include multiple unique interventions (e.g. VSM and DVM implemented in “hospital a” and 5S implemented in “hospital b”). If this is the case please list each intervention separately on a different row using numbers starting at 1 (i.e. data for the intervention occurring in “hospital a” will be listed on row 12 and marked as intervention “1” and data for the intervention occurring in “hospital b” will be listed on row 13 and marked as intervention “2”). If only 1 intervention list as intervention number 1.

**Inclusion:** No data needs to be entered, this column is just split up the form

**Healthcare Setting (Y/N):** Did the study take place in a healthcare setting (Yes, No, Unclear)

**Setting (Specify):** Specify the setting in which the study took place (e.g. hospital, clinic, research facility) (N/A if not present)

**Setting Subunit (Specify):** Specify the subunit of the setting (e.g. laboratory, OR, ED, Radiology, Pharmacy) if study did not occur in a hospital this may be the same as the setting (N/A if not present)

**Commitment to continuous improvement:** Did the organization show a commitment to continuous quality improvement (refers to the acknowledgement that Lean doesn’t occur as a single intervention but instead requires a dedication to continually improving the workplace) (Yes, No, Unclear)

**Lean Principles:** Did the organization subunit of the organization show a dedication to Lean principles (overarching set of principles aimed at transforming workplace culture[29]. These include a focus on: eliminating waste; improving the flow of patients, providers and supplies; and ensuring all processes add value to customer. Further, Lean principles suggest that problems are identified and addressed by front line staff members as it is believed that the people doing the work are best suited to create solutions.) (Yes, No, Unclear)

**Lean Philosophy:** Requires that both of the above were answered “Yes” (Yes, No, Unclear)

**Lean Assessment Activity (Y/N):** Did the organization utilize at least one Lean assessment activity (e.g. VSM, RPIW, Gemba Walk, A3) (Yes, No, Unclear)
Lean Assessment Activity (List): List Lean assessment activities (alphabetically, numbers first (e.g. 5S), N/A if not present)

Lean Improvement Activity: Did the organization utilize at least one Lean improvement activity (e.g. 5S, DVM, Standard Work) (Yes, No, Unclear)

Lean Improvement Activity (List): List Lean improvement activities (alphabetically, numbers first (e.g. 5S), N/A if not present)

Comparison: Was a comparison made (requires both a pre-Lean measure and a post-Lean measure) (Yes, No, Unclear)

Inclusion: Does the study meet our inclusion criteria? (If “no” do not continue data extraction). This requires that articles include 1) a dedication to Lean Philosophies 2) the use of a Lean Assessment Activity or Lean Improvement Activity, 3) that a comparison was made and 4) that the study occurred in a healthcare setting (Yes, No, Unclear)

Intervention: No data needs to be entered, this column is just split up the form

Study Design: What type of study design was used (RCT, Controlled Clinical Trial, Pragmatic Controlled Trial; Controlled Before-After-Study (CBA); Cross-sectional Study; Interrupted Time Series; Observational Study; Cohort Study; Pre-post comparison; Follow-up Study; Longitudinal Study; Prospective Study; Retrospective Study; Case control Study; Case Series; Case Study (no control)).

Cochrane EPOC Design: Did the design meet the Cochrane EPOC criteria (RCT, NRCT, CBA, ITS). A description of Cochrane EPOC designs can be found in appendix 1. (Yes, No, Unclear)

Six Sigma: Was Six Sigma used in the study (Six Sigma can be identified by the fact that it often focuses on statistical analyses of variance and uses define, measure, analyze, improve, control (DMAIC) techniques to make improvements) (Yes, No, Unclear)

Productive Ward: Productive Ward will be specifically named if used (essentially a nurse focused variant of Lean) (Yes, No, Unclear)

Country: What country did the study take place in (if multiple list alphabetically with countries separated by commas) (N/A if not present)

Urban or Rural: Did the study take place in an urban or rural location (N/A if not present)

Pre-Intervention Length (Weeks): How long was the pre-intervention observation period (measured in weeks [4 weeks/month, 52 weeks/year]), if only months are mentioned assume the intervention began on the first day of the month and ended on the final day of the month (N/A if not present)

Washout Period Length (Weeks): How long was the washout period (measured in weeks [4 weeks/month, 52 weeks/year]) if only months are mentioned assume the intervention began on the first day of the month and ended on the final day of the month (N/A if not present)
**Post-Intervention Length (Weeks):** How long was the pre-intervention observation period (measured in weeks [4 weeks/month, 52 weeks/year]) if only months are mentioned assume the intervention began on the first day of the month and ended on the final day of the month (N/A if not present)

**Healthcare Workers Involved:** List all the types of healthcare workers involved (e.g. nurses, physicians, pharmacists, radiologists, etc.) (list in alphabetical order) (do not list numbers) (N/A if not present)

**Additional Personnel Involved (Specify):** List all the types of additional personnel involved (e.g. Sensai, CQI group, community members, etc.) (list in alphabetical order) (do not list numbers) (N/A if not present)
Excel Book 2: Outcome Information

Study ID: Last Name of the first author followed by publication year (required) (use “anonymous” if author is not available) (add a letter starting at "a" and continue alphabetically if multiple articles require the same study ID)

Intervention Number: Some studies will include multiple unique interventions (e.g. VSM and DVM implemented in “hospital a” and 5S implemented in “hospital b”). Please use the intervention number that corresponds to data entered in Excel Book 1: Study Information

Outcome Name: The name of the outcome of interest

Outcome Type (Patient, Professional, and System): Is the outcome a patient outcome, professional outcome or systems outcome? (Unclear if uncertain about categorization)

- **Patient Outcomes**: These outcomes directly measure the patient’s health or satisfaction after they leave the system. Examples include:
  - Mortality rate
  - Re-admission rate
  - Patient satisfaction
  - Measures of health related quality of life
  - Patient falls

- **Professional Outcomes**: These measures look at how the healthcare professional/staff perceive their work or how they perform tasks but do no measure how efficiently this is done. Examples include:
  - Employee satisfaction
  - Employee teamwork
  - Time spent with patient (as a proportion of total time)
  - Employee engagement
  - Adherence to guidelines

- **Systems (Efficiency) Outcomes**: The ability of the system to perform actions using the fewest resources possible. These may influence patients’ experiences but they do not describe the health or satisfaction of the patient following the patient’s visit. This category therefore does not include direct measures of health (e.g. mortality rate) and or proxy measures of health (e.g. re-admission rate, infection rate). Examples include:
  - Admission time
  - Collection time
  - Turn-around time
  - Turn-over time
  - Triage time
  - Time to see physician
  - Examination time
  - Dispensing time
  - Scheduling time
- Near miss events
- Wait times
- Staff overtime
- Cost of providing services
- Steps taken
- Process steps
- Patients LWBS

**Control Group:** Is there a control group present (Yes, No, Unclear)

**Statistical Testing:** Was a statistical test performed (e.g. t-test, ANOVA, chi-squared) (Yes, No, Unclear)

**Direction of Change** (Favourable/Detrimental/No Change)

**Statistical Significance of Change:** (p<0.05, p>0.05, not reported)