

# A STUDY OF THE BENEFITS OF LEAN CONSTRUCTION DURING THE PANDEMIC: THE CASE OF PERU

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## ABSTRACT

Lean Construction (LC) has been implemented worldwide in different construction projects, and the Covid-19 pandemic has been no exception. However, more research needs to be compiled on the benefits of LC during this period, considering the high variability and uncertainty generated. Therefore, this article evaluates the benefits of implementing LC during the pandemic stage. In the first stage, a literature review was conducted using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), where the main benefits of implementing Lean Construction during the pandemic are identified. In the second stage, the benefits were validated through interviews with professionals in different Peruvian construction projects. The main benefits were: improved planning, easier identification of constraints, and improved project communication. The following study will help construction industry professionals consider LC implementation's benefits in future scenarios with high variability.

## KEYWORDS

Lean Construction, Covid, pandemic, benefits, Peru

## INTRODUCTION

The construction sector is one of the sectors that promote higher economic growth worldwide. However, it faces several problems, such as low productivity (Barbosa et al., 2017) and; a fragmented chain (Hossain & Nadeem, 2019); it is also a dangerous industry, where personnel are exposed to numerous safety risks, resulting in deaths or serious injuries (Lee et al., 2014). These problems have been heightened in the wake of the COVID-19 pandemic, where the construction sector faced various impacts such as reduced productivity, delayed project delivery, cost overruns (Ahmed et al., 2022), labor shortages (Husein et al., 2021), among others.

Many of the problems described above have been solved through the application of LC; several authors have recorded benefits such as reduced variability (Alarcón et al., 2008), mitigation of cost overruns and delay in project delivery (Gómez-Cabrera et al., 2020). So also during the pandemic, LC has been implemented, achieving benefits such as improved planning (De la Torre et al., 2021), improved workplace safety, reduction in the number of contagions (Verán & Brioso, 2021), maintaining social distance between workers (Santos et al., 2022).

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Despite the benefits shown during the pandemic, little research has compiled the benefits obtained from LC. Therefore, the main objective of this study is to identify the main benefits of implementing LC in the Peruvian construction industry during Covid-19. The construction sector in developing countries was hardest hit by Covid-19 (Al-Mhdawi et al., 2023). In Peru, the construction sector was one of the sectors most affected by the onset of the Covid-19 pandemic since the Peruvian government declared a state of emergency in the country, paralyzing all activities in the construction sector (Instituto Peruano de Economía, 2020), which caused the construction sector to suffer a reduction in GDP of -30% per year (Madera et al., 2022). In addition, the Peruvian government proposed a series of guidelines for the spread of Covid-19, such as evaluating the outbreak (control of body temperature and pulse oximetry, and identification of symptoms), installing information panels, maintaining a distance of 1.5 meters, providing hygiene products, ensuring the use of masks, using personal protective equipment, and daily cleaning and disinfection of the entire construction site and equipment (MINSA, 2020), which affected the construction work (Verán-Leigh & Brioso, 2021).

The article begins with a literature review identifying the main benefits associated with LC during the pandemic. After that, six Peruvian professionals were interviewed to compile the benefits they obtained with the implementation of LC and validate them with respect to the benefits obtained from the literature review.

## **BACKGROUND**

### **COVID IMPACTS IN CONSTRUCTION PROJECTS**

The Covid 19 pandemic has affected the whole world, especially in the construction sector (Rani et al., 2022), so several studies have been conducted to understand the impact in different parts of the world. For example, Al-Mhdawi et al. (2021) studied the impacts in Iraq, where the significant impacts were supply chain disruptions, labor restrictions, and legislative changes. In South Asia, research was conducted in India, where, according to Rani et al., 2022, the three main impacts were labor shortages, supply chain disruptions, and decreased productivity in Construction. In Latin America, studies have also been recorded; for example, according to Araya and Sierra, 2021, based on data from 40 interviewees, in Chile, impacts on productivity, technical performance of workers, and present and future financial solvency were obtained, such impacts were the ones that caused the most effects on the stakeholders who addressed the construction project. These impacts are mentioned following the impacts found in the United States; according to Alsharif et al. (2021), among the impacts found are reductions in efficiency and productivity rates, material delivery delays and material shortages, and the suspension or slowdown of construction projects. Finally, in the case of Peru, according to Fernandez et al. (2021), the impact was evidenced by a significant increase in labor costs.

### **LEAN CONSTRUCTION BENEFITS**

Lean Construction has been implemented in different countries, such as, for example, Egypt, where Shaqour (2022) mentioned that the main benefits are improved process control, improved planning, reduced project execution time, and improved safety. Similarly, Sarhan et al. (2017) evaluate the benefits in Saudi Arabia. He identifies similar benefits to Shaqour's (2022) study, such as reduction of construction time and process improvement, and mentions that quality improvement is the main benefit of the Saudi Arabian industry. Finally, in the case of Peru, Erazo-Rondinel and Huamán-Orosco (2021); identified the main benefits of improving on-site planning; identifying waste and minimizing it; and reducing construction time.

## **RESEARCH METHOD**

The following research follows two stages; in the first stage, a literature review is conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

methodology. In the second stage, a qualitative study is conducted through 06 interviews with professionals about their experience implementing Lean Construction during the pandemic. Each of the stages is described below (Figure 1).

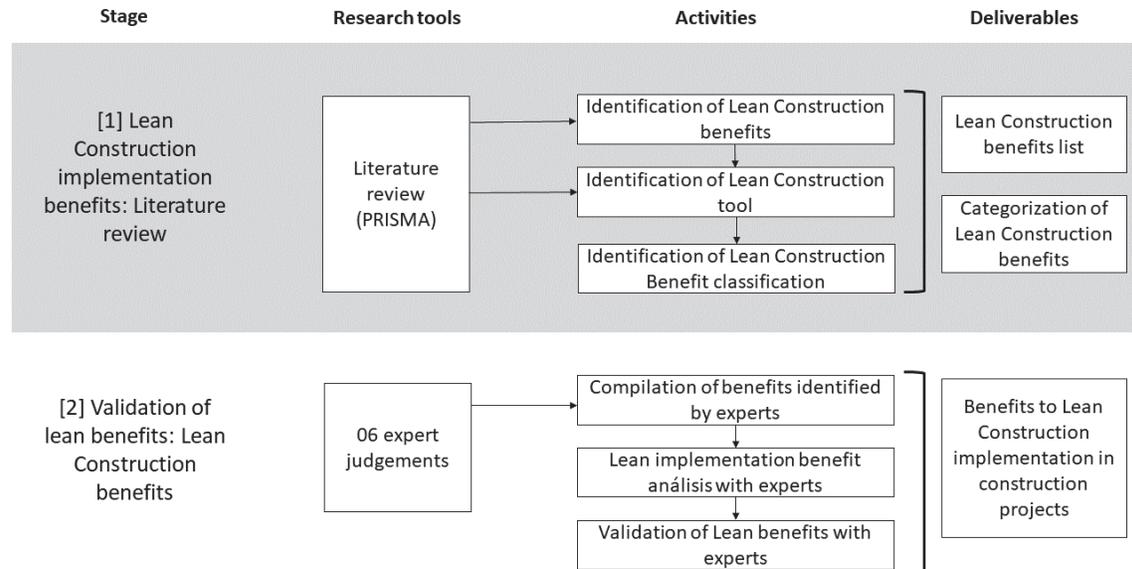


Figure 1: Diagram with the main stages of the investigation.

### FIRST STAGE: PRISMA REVIEW

A systematic literature review was performed to identify, select, and include the articles to be evaluated in this study, following each step of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology (Mamani et al., 2022). PRISMA has been used in studies associated with Lean (Besser et al., 2017; Souza et al., 2021).

For the literature review, a search of publications related to Lean Construction and Covid was conducted using Scopus and the IGLC database. Scopus is one of the databases with a vast domain in construction research compared to other databases (Galaz-Delgado et al., 2021). In addition, the IGLC database was used, which hosts most publications on the application of Lean Construction worldwide (Daniel et al., 2015). In the first stage, the search was performed using keywords, as shown below. For the SCOPUS database, they were I ("lean construction" AND "covid"), II ("lean construction" AND "pandemic"), and III ("lean construction" AND "coronavirus") and for the IGLC database, they were a) coronavirus, b) covid and c) pandemic.

A filter of publications ranging from 2020 to 2023 was applied, which had 85 articles and included four by collecting snowballs that could contribute to the study/evaluation of the benefits of Lean Construction, having a total of 89 articles. For the next eligibility phase, 48 duplicate publications were eliminated from the reviewed articles after having combinations I, II, and III. Next, relevant articles were filtered for evaluation, considering that they refer to the benefits, impact, or applications of lean tools during the Covid-19 pandemic. In total, 22 articles were excluded through a title and abstract review, leaving a total of 19 articles, which were filtered again through a complete review, thus excluding six articles that did not meet the criteria to be considered in this study, leaving a total of 13 articles that were considered for this research. The above steps are described in Figure 2.

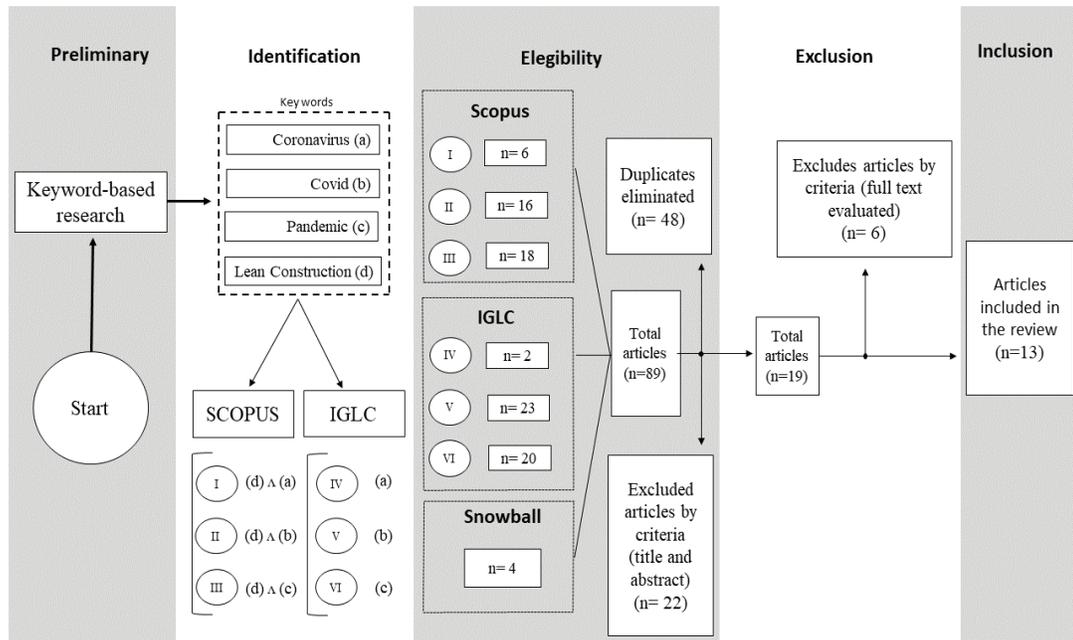


Figure 2: PRISMA flow diagram for the systematic review.

After the literature review, we will continue with the second stage corresponding to the research's qualitative approach.

## SECOND STAGE: QUALITATIVE STUDY

The qualitative approach has been previously used with topics related to Lean Construction, for example, to identify the significant impacts and difficulties of LPS in Brazilian companies (Viana et al., 2010), to identify tools and facilitators for lean adoption (Bashir et al. 2013 and Marhani et al. 2018). That is why the following study, like those mentioned, is based on a qualitative analysis of the benefits of Lean Construction during the pandemic context.

For this stage, 6 participants were selected from various construction projects in Peru who applied Lean during the pandemic; below is a description of the profile of the interviewees and the type of project in which they participated (Table 1). The interviewees were asked to have at least five years of experience implementing the Lean philosophy. The interviews were conducted by telephone and video calls and lasted 20 to 30 minutes with each interviewee. The interview was divided into two stages: a first stage where the interviewee's information was collected, such as years of experience, experience in implementing Lean Construction, and types of projects in which he/she has participated. In the second stage, the benefits obtained in the literature were validated. The experts were asked if they had observed the benefit, and they were asked to give examples. Concerning the limitations, the study includes using a convenience sample and a small sample size because six professionals were interviewed. In addition, the benefits obtained will vary according to the region where they were applied since government measures about COVID vary.

Table 1: Profile of interviewees

Number	Years of experience	Years of exp. With LC	Current role	Projects participated in
Interviewee 1	7 years	7 years	Risk leader	Infrastructure, Urban development, mining, plants, the aviation sector
Interviewee 2	12 years	12 years	Manager	High-rise buildings and retail projects
Interviewee 3	15 years	7 years	Operations Manager	High-rise buildings
Interviewee 4	7 years	7 years	Technical Office Engineer	High-rise buildings and sports infrastructure
Interviewee 5	17 years	12 years	Superintendent	High-rise buildings
Interviewee 6	5 years	5 years	Fire Water Subcontractor	High-rise buildings

## RESULTS AND DISCUSSION

### RESULTS OF LITERATURE REVIEW

#### Main Lean Benefits

Another result of the literature review was the identification of benefits. Thus, 11 main benefits were identified from the 13 articles mentioned. The benefits are arranged in Table N°2. Among the benefits, the following were identified: Improved planning ("B1"), Facilitation of constraint identification ("B2"), Improved productivity in the COVID stage ("B3"), Alternatives for activity sequencing ("B4"), Improved decision making in the project ("B5"), Maintaining social distancing ("B6"), Improving safety at the work site ("B7"), Reducing the number of contagions ("B8"), Transparency with project information ("B9"), Improving communication in the project ("B10"), Continuous improvement of the project ("B11").

From Table N°2, we can notice that the main benefit obtained by the authors is the improvement of planning through the reduction of variability (9 results) because most authors have implemented LPS. The second benefit identified is the timely identification of constraints (6 results) because the Covid-19 context is a context of high uncertainty, and the team, using lean tools, can better protect its planning. Another benefit obtained is the improvement of productivity (with five results). In this case, the authors have mentioned that the use of LC helps mitigate the effects of the pandemic on the project's productivity. In addition, other results obtained have reduced the number of contagions and improved safety at the work site because they are mainly related to better project planning and adequate distribution of the crews.

Table 2: Lean benefits in relation to the selected articles.

Autor	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	Total
McHugh et al.2021	x	x	x	x	x	x	x	x				8
Espinoza et al.2021					x							1
Verán & Briosó.2021	x	x		x				x				4
Santos et al.2022		x		x		x						3
Chaize et al.2022					x				x	x		3
Sosa & De La Torre.2021					x				x	x		3
De La Torre et al.2021	x	x	x									3
Le & Nguyen.2022	x											1
Jiang et al.2022	x		x				x					3
Parameswaran & Ranadewa.2021	x		x								x	3
Salazar et al.202	x	x										2
Retamal et al.2021	x	x				x						3
Simeão & Ferreira.2022	x		x	x							x	4
Total	9	6	5	4	4	3	2	2	2	2	2	

## RESULTS OF INTERVIEWS IN PERUVIAN CONSTRUCTION PROJECTS

Likewise, the benefits obtained by the interviewees are related to the list of benefits obtained in the literature review, which we can evidence in Table N°3 that the most frequent benefit by the interviewees at the time of using Lean Construction was benefit B1(Improvement of planning) taking into account that each of the interviewees applied in the six construction projects the LPS tool for example, interviewee 01 mentioned [*"Level 4 schedules were developed to support the master schedule and it was beneficial to consider the restrictions we had with the Covid problem"*]. Regarding the relation of items obtained from the literature review, benefit B1 has a frequency of 9 answers, a similar frequency also happens with B2 (Facilitation of constraint identification) being the second most demanded, with a total of 6 answers.

In contrast to the literature review, benefit B3 (Improved productivity) and benefit B6 (Maintaining social distance) was not very common among the interviewees, as they indicated [*"Due to social distance some activities saw their productivity reduced"*] and [*"They only followed legal norms"*], and in comparison with the items obtained from the literature review, they had a total of 5 and 3 mentions in favor, respectively.

We highlight benefit B4 (Alternatives for the sequencing of activities) by the six mentions by the interviewees. With B4, the time has been optimized by flexibly changing schedules, having an objective as a goal, and concerning B5 (Improvement of decision making in the project), had a total of 4 according to the answers of the interviewees, for example, according to interviewee 01 [*"It helped in the integrated meetings that were made with the field people"*]. Likewise, in the literature review, both benefits B4, and B5 obtained a total of 4 mentions, which evidences a small variation in the frequency given in B4.

Table 3: Benefits identified by interviewees.

Code	E1	E2	E3	E4	E5	E6
B1	X	X	X	X	X	X
B2	X	X	X	X	X	X
B3						
B4	X	X	X		X	X
B5	X	X			X	
B6		X		X		
B7		X	X		X	
B8		X				
B9	X	X	X	X		X
B10	X	X	X	X		X
B11	X	X		X		X

Of the benefits related to workers' safety, benefit B7 (Improvement of safety in the workplace) and B8 (Reduction in the number of contagions), B7 has a higher frequency than the literary review, also according to interviewees 02, 03, and 05, they mention that [*"The companies implemented order and cleanliness, through the 5S tool"*]. On the other hand, benefit B8 has a better frequency in the literature review and interviews since it is complicated to establish a relationship between lean tools and reducing the number of contagions. However, one of the respondents mentions that [*"Thanks to planning and proper distribution of subcontractors, in 8 months only one member of his team was infected by Covid-19"*]. Therefore, both benefits compared to the article got two mentions.

We see that also the benefits B9 (Transparency with the project information), B10 (Improvement of the communication in the project), and B11 (Continuous improvement of the project) have a high degree of percentage accepted by the interviewees, taking into account that in B9, the Spaghetti diagram was used, for the subject of the approaches, optimizing displacements and that they are the correct ones, in B10, the communication channels were improved to make them more effective. Finally, in B11, the PPC (Percentage of Plan Completed) and CNC (Causes of Non-Compliance) metrics together with a historical database, according to the interviewees mentioned that the above [*"serves to make decisions and corrective options, since it allows you to have more practical and dynamic visual tools"*]. Therefore, in this opportunity, B9, B10, and B11 obtained two mentions of each benefit compared to the article.

## CONCLUSIONS

The following research seeks to identify the main benefits of implementing Lean Construction through a literature review and interviews with Peruvian construction professionals. The main benefit obtained was the improvement of planning, associated with identifying constraints and generating alternative plans, all related to the Last Planner System. The second benefit identified was the improvement in the identification of constraints, improved communication, and improved transparency, mainly because the interviewees have been implementing the Last Planner System and promoting weekly meetings. The least observed benefit is the reduction in the number of contagions. The interviewees mentioned that this could not be determined and could be an effect of good lean planning.

Another important conclusion is that the interviewees quickly identified the benefits associated with Lean Construction because they have been implementing LC for over five years,

which generates an understanding of the tools and principles. These results could change if professionals with little experience with LC are interviewed.

The authors recommend conducting qualitative studies in other countries since each country implemented different measures concerning Covid-19 and to determine if there could be any relationship between the measures and the benefits of LC.

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