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Effect of Covid-19 Pandemic in Construction Labor Productivity: A Quantitative and Qualitative Data Analysis

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Abstract This research aims to identify and analyze the various factors affecting construction labor productivity covering the period from December 9, 2020 - January 31, 2021, a year after it was declared Covid-19 a pandemic. Due to the pandemic effect, the local government units in four selected study areas imposed intermittent Enhance Community Quarantine on all places to control the Coronavirus spread in compliance with the health department protocol. Fifty-five questionnaires returned out of 63 distributed are tabulated according to each group-related factor. The correlation analysis resulted in the highest coefficient value of 0.89 between the CTDEO and contractor groups. Meaning, most respondents have the same perception of the factors affecting construction's low labor productivity. Besides, results depicted that the absence of health workers on the construction site ranked 1st in the health & safety provision factor group with an RII of 0.97, followed by no safety engineers on the construction project sites with an RII of 0.93. From all the seven groups of factors, the health and safety group-related factors ranked 1st with an RII of 0.81, next, the schedule compression group with an RII of 0.78. Hypothesis testing asserted that working six days per week was one of the significant factors affecting labor productivity on the contractor's side, suggested by more than 50% of the respondents. The workforce group-related factors with an RII of 0.77 demonstrated a slight difference with the schedule compression group-related factors. Thus, the Covid-19 pandemic has a significant effect on the essential factors affecting construction's low labor productivity.

Keywords: *construction labor productivity, correlation analysis, Covid-19 pandemic, health & safety provisions, hypothesis testing*

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1. Introduction

A road is considered the prime mover for all the economic sectors and the human populace among all transportation modes. It is unanimously accepted that the need for an efficient infrastructure for economic and social growth is multilateral linkages human activities [1]. Literature reviews indicated the road construction labor cost comprises 12% - 30% of the total budget costs, and it has become a significant issue in the construction industry [2,3]. Project engineers, site engineers, and supervisors could not clearly understand how to achieve good productivity that rests on the labor component, specifically during the Covid-19 pandemic.

Hence, understanding these factors may help the construction project professionals who work on the initial phase of construction planning to deliver the project plan as per the approved contract efficiently or to regain from their losses. This research's primary goal is to provide essential information about the effect of the Covid-19 pandemic on the labor productivity in the construction industries' project management team, which would likely enable success in the construction project site.

The study's findings may help put the fundamentals of influence on labor productivity in road construction projects to manage productivity, despite the Covid-19 pandemic's effect. Most of the road construction projects implemented by the Department of Public Works and Highways at the District Engineering levels, Philippines, suffered issues from health and safety, schedule compression issues, workforce, and materials and equipment-related issues, including lack of empowerment for the laborers, labor productivity losses [4].

Labor productivity is the most critical for any construction company in any country [5]. Optimized productivity is a vital requirement of any construction project. An assessment of labor-oriented works is essential to construction projects [6], and labor productivity depends on many factors. A study conducted by [7] found the causes of Trinidad and Tobago's low productivity,

such as lack of skilled labor supervision is one of the essential factors impeding labor productivity, with a shortage of experienced workers as a distant second, lack of construction project management experience, delay of payment of wages to labor, and poor communication, and bad weather conditions. It was stated in other literature reviews that price increase and decreased profit margins were among other factors influencing productivity. In response to these issues, contractors should implement technical procedures to improve construction labor productivity. Likewise, [9,10] stated that it is challenging to improve productivity without improved work methods. Productivity is the most important goal. It provides cost-saving opportunities [11] to schedule construction's financial successes [12] accurately.

This study may provide information to help construction managers to make palliative measures to cope with the productivity losses during and after the pandemic period. Understanding the influential factors affecting labor productivity could improve the project's productivity and identify the required resources to properly execute the activities according to the required duration adherence with the approved contract.

The construction industries worldwide showing similar practices, but most are varied in the actual implementation of road projects. An example is the construction methods and techniques applied, the understanding and perception of laborers, the construction project's management strategy, the laborers' culture, and the like.

Hence, this research aimed to investigate the following objectives: (1) to identify the different essential factors affecting construction labor productivity; (2) to rank, correlate and analyze the significant factors causing significant low labor productivity due to Covid-19 Pandemic.

2. Research Methodology

The survey and data collection were conducted from December 9, 2020 - January 31, 2021, a year after declaring Covid-19 a pandemic. A questionnaire format was developed for the analysis of likely influencing factors in the initial research. The questionnaire's purpose is to answer the following: identifying the respondent's role, and then a breakdown of potential influencing factors to agree strongly or disagree and an analysis and evaluation of the factors causing low construction productivity due to the effect of Covid-19 pandemic. Additionally, the secondary data was compiled by using literature as a reference. All measures have an ordinal scale. The questionnaires are developed and tested prior to distribution to the target respondents in the study area.

2.2.1. Study Area and Population of the Study

Four places are chosen for the study: Tuguegarao city, Ilagan city, Tumauini town, and Delfin Albano in Region 02. It is approximately 238.2 km from Manila via the R-8 and AH-26 to the boundary between Region 02 and Region 03. Tuguegarao city is the seat of the various agencies' administration. It is located in the northern Philippines and is about 480 kilometers away from Manila, the country's capital [3].

This research included project managers, project engineers, site engineers, and supervisors of Cagayan Third District Engineering Office (CTDEO), Isabela First District Engineering Office (IFDEO), and contractors directly involved in the road constructions implementation.

2.2.2. Sampling and Sample Size Determination

Probability sampling was utilized to ensure the reliability of the representation of the population. All DPWH District Engineering Offices in Region 02 are mandated to implement national infrastructure projects such as rigid and asphalt pavements, flood control, and public buildings projects. At present, there are multiple highway concreting works, large-related flood control projects, and pavement repair initiatives undertaken by the two pre-selected district engineering offices. The three participating organizations in the project's implementation: Cagayan Third District Engineering Office (CTDEO), Isabela First District Engineering Office (IFDEO), and the Contractors. There were approximately sixteen contractors within the study area directly involved in road construction projects, and 27 projects were pre-selected. The minimum number of projects was obtained using the following equation to estimate a 94% confidence level [13,14]:

$$n = n'/\left[1+\left(n'/N\right)\right] \quad (1)$$

Where: n = total number of population

n' = sample size from an infinite population, $n' = S^2/V^2$

N = sample size from a finite population

S^2= represents variance of the elements in the population; and,

V= standard error of the sampling population. (Usually, S=0.5, and V=0.06)

Therefore, $n' = S^2/V^2 = (0.5)^2/(0.06)^2 = 69.44$

From the above equation, for N=27; substituting values

So, n = 69.44/[1+(69.44/27)] = 19.44 say 20 projects.

To achieve the 94% confidence level in this research, it was computed to send the questionnaires to 20 projects. On the other hand, the number of respondents was assigned to those ongoing 20 road projects based on the organization's corresponding group. There were 63 respondents purposively targeted and distributed, as shown in Table 1.

Table 1. A sample size of respondents and its distribution

Organization	No. of Organization	No. of Projects	No. of Project Managers	No. of Project Engineers	No. of Resident Engineers	No. of Foreman
District Offices	2	20	2	3	4	4
Contractors	16		4	6	8	32
Total	18		6	9	12	36
In percent (out of 63)			9.52%	14.28%	19.05%	57.15%
Total No. of Respondents			63			

2.2.3. Validity Test Measure, Consistency, Reliability, and Correlation Technique

According to [15], an experiment using measurement must be accurate, and the most critical factor is that the data collection and analysis are reliable. Additional researchers can also express the same ideas and conclusions through raw data. In other words, this is the quality in which data can be replicated [15]. Cronbach's Alpha (α) was developed as a 0 to 1 to measure the internal consistency. This measurement methodology was created in the context of previous questions designed to measure a particular definition measure the same concept or structure are linked to the objects' interconnection. Internal consistency accounts for the alpha reliability factor [16,17].

$$\propto = \frac{I}{I-1}\left(1-\frac{\sum_{i=1}^{I}\sigma_I^2}{\sigma_X^2}\right) \quad (2)$$

Where: I = Number of Items; σ_I^2 = variant items; σ_X^2 = total score variant.

Higher Cronbach's Alpha indicates a high internal agreement in build X^2. The higher the coefficient, the greater the internal consistency is of items [16]. From [18], provided the following rules of thumb: ≥ 0.9 (Excellent), ≥ 0.8 (Good), ≥ 0.7 (Acceptable), ≥ 0.6 (Questionable), ≥ 0.5 (Poor), and ≤ 0.5 (Unacceptable) [3]. The increasing Alpha's value depends on the number of objects on the scale [19]. Cronbach's Alpha is the most commonly used measure of dependability. Before further analysis, the data reliability coefficient was examined. The findings thus hold true.

The correlation coefficient was obtained from the different factors that give a direction and strength of the relationship between -1 < *Rho* < 1. The correlation matrix's interpretation was made according to the standard correlation reference table, where the correlation coefficient is represented by the absolute value of *Rho* (rs). The range of values and their respective interpretations are presented in Table 2 [20]. The independent explanatory variables showed less correlation coefficient (*Rho* < 0.5) with other parameters sorted out from the correlation matrix.

Table 2. Standard correlation table

No	*Rho* (rs)	Relationship Strength
1	0.00-0.19	Very Weak
2	0.20-0.39	Weak
3	0.4-0.59	Moderate
4	0.6-0.79	Strong
5	0.8-1.0	Very Strong

Source: [20].

As stated in the previous section, Cronbach's Alpha is the average correlation between items and measures internal consistency more than an instrument's reliability. Cronbach's Alpha is based on strict assumptions (for example, unidimensional, and uncorrelated errors). On the other hand, the Joreskog *Rho* is a composite reliability coefficient used in the Pearson correlation. It means *Rho* overcomes some limitations of the Alpha.

$$Rho(\rho cal) = 1-\frac{6\times\left(\sum di^2\right)}{N\times\left(N^2-1\right)} \quad (3)$$

2.2.4. Relative Importance Index (RII)

Variables were employed to measure productivity and used to rank the different factors. The index has several attributes: 1, 2, 3, 4, and 5 to quantify their importance. Table 3 shows the scale with corresponding ordinal, adjectival rating, and description.

Table 3. A rating scale for factors influencing laborer's productivity

Ordinal number	Description
1	Strongly disagree
2	Don't agree
3	Neutral
4	Agree
5	Strongly agree

To determine which factors are essential, the practicality and frequency of factors based on the Likert scale define the relative importance index (RII) using the given formula below [19].

$$RII = \frac{\left(5n^5+4n^4+3n^3+2n^2+n\right)}{5\left(n^5+n^4+n^3+n^2+n\right)} \quad (4)$$

Where: RII = represents Relative Importance Index
n^5, n^4, n^3, n^2 & n= represents number of indicators of answer.

Computation with the Relative Importance Index (RII) provides a value between 0.2 and 1.0. The 0.2 value represents the lowest strength, and the 1.0 value the highest strength value. The data obtained from questionnaire surveys and desk studies are qualitatively and quantitatively analyzed, evaluated, and interpreted.

2.2.5. Hypotheses Testing

The use of hypothesis testing helped this data analysis and interpretation. The proportions are often made in the context of the probability (*p)* of success for a binomial distribution [21].

$$Z = \frac{\text{Sample Proportion} - \text{Null hypothesized proportion}}{\text{standard deviation of Sample Proportion.}} \quad (5)$$

The rejection area & interpretation: For Ha: p ≠ po; reject Ho if T is greater than $Z_{0.025}$= 1.96 or less than −1.96. It is performed using equation (5). The test results are shown in Table 6. All of the T values greater than 1.96 are essential to the study area's construction efficiency analysis. Testing of Ho: p = 0.50 vs. Ha: $p \neq 0.50$, the percentage of respondents who believe that p affects low labor productivity is close to significant [3].

3. Results and Discussions

3.1. Questionnaires Distributed and Collected

There were 63 questionnaires distributed, and 55 returned with valid information while the other 8 questionnaires did not provide answers, which are

therefore excluded from the study. Table 4 shows the statistical data of questionnaires distributed and collected.

Table 4. Statistical data of questionnaires distributed and collected

Description	No.	Percentage of Total (%)
Total questionnaires distributed	63	100.00%
Total questionnaires collected	55	87.30%
Invalid data	8	12.70%
Used for study	55	87.30%

3.2. Job Title

Table 5 provided the following information: All questionnaires were distributed, following the questionnaire's format and instructions.

Table 5. Job Title of the Respondents and number of questionnaires collected and retuned

Job Title of the Respondents	Number of Respondents
Project Managers	4
Project Engineers	7
Resident Engineers	10
Foremen	34
Total number of respondents with questionnaire collected, thoroughly answered	55

3.3. Degree of Agreement between Stratified Respondents

In this research, the Cronbach's α value measured the degree of agreement between engineers and laborers and indicated Cronbach's α of 0.973, which means excellent agreement. While engineers and supervisors, the Cronbach's α = 0.914, likewise, engineers and managers, Cronbach's α = 0.861. On the other hand, the degree agreement between skilled labor and supervisor, the Cronbach's α = 0.908, and the degree agreement between skilled laborers and managers, Cronbach's α = 0.843, degree agreement between supervisor and managers, Cronbach's α = 0.925. From these results, the reliability and correlation test indicated that the degree of agreement between all respondents is very good. It means the reliability of data is high.

3.4. Degree of Agreement between Road Construction Projects

The value of Cronbach's α indicated ≥ 0.8, which is Good. The result ensures the reliability of each project response. Cronbach's α equals 0.847 for all projects, which means Good reliability of all response data in the study. A correlation is a measure of a monotonic association between two variables. A monotonic relationship between two variables is when either the value of 1 variable increases. The other variable value also increases; or the value of 1 variable increases, the other variable value decreases [22,23,24]. The correlation between the road projects was measured using the Pearson Correlation method. Most of the factor's correlation is in a good range, while few are within the acceptable range. So, the response of respondents from different projects regarding the major factors is significantly similar.

3.5. Significant Factors Affecting Construction Labor Productivity and Efficiency

The significant factors affecting road construction projects' labor efficiency were grouped and categorized according to their similarity. The following factors influence road construction: Construction productivity factors for road projects were calculated to be equal to a staggering 53 factors. Seven categories or groups with sub-related factors, such as (1) Supervision-related factor, (2) (Health & safety-related factors, (3) Workforce-related factor, (4) Schedule compression-related factor, (5) Material & equipment-related factors, (6) Motivation-related factors and (7) Management team-related factors were assessed. Each group is examined in detail below:

3.5.1. Supervision-related Factors

The supervisor's changing instruction order ranked 1st in the supervision group, with an RII value of 0.83, and 10th among all 53 influencing factors affecting low labor productivity, as shown in Table 13. The inspection delay ranked at 2nd and 15th in all factors. Intermediate, poor, or no supervision ranked 3rd with 0.71. On the other hand, supervisor absenteeism was the last factor in this group and the last ranking factor. It is insignificant because it did not affect labor productivity.

Table 6. Ranking of supervision- related factors

Supervision-related factors	Relative Importance Index (RII)	Ranked
Changing instruction order	0.83	1st
Inspection delay	0.78	2nd
Poor or no supervision methods	0.71	3rd
Changing of foreman	0.70	4th
Redo of works	0.69	5th
Unskilled supervisors	0.66	6th
Supervisors' absenteeism	0.43	7th

3.5.2. Health and Safety-related Factors

Table 7 indicated health and safety group rankings. No health worker in the construction site ranked 1st with an RII of 0.97, also ranked 1st among all 53 related factors. This was due to the laxity of the rules and regulations, including the Covid-19 or health department protocols. In every unit or agency, checking laborers' health conditions must be the standard practice based on the world order before their work hours.

Another result, no safety engineer was assigned to the construction project sites and ranked 2nd with an RII of 0.93, next by a lack of labor safety standard practice with an RII of 0.88. Since the Convid-19 pandemic started, the local authorities implemented some protocols to manage and monitor the health and safety problems by imposing intermittent Enhanced Community Quarantine for at least 14 days with individuals affected by the Coronavirus. Improper observance of Covid-19 protocols was ranked 5th. This factor depicted that there was a significant inter-relationship with no health workers in the construction sites. All of these related factors on health and safety indicated a strong influence affecting low labor productivity.

Table 7. Ranking of health and safety-related factors

Health and safety-related factors	Relative Importance Index (RII)	Ranked
No health workers on the construction site	0.97	1st
No safety engineer in the construction on site	0.93	2nd
Lack of laborer's safety practice & standard	0.88	3rd
Unsafe working conditions	0.86	4th
Ignore safety precaution	0.84	5th
Improper observance of Covid-19 protocol	0.83	6th
Awareness of Covid-19 protocol	0.81	7th
Accident awareness	0.77	8th
Inadequate safety plan	0.72	9th
Inadequate lightings	0.70	10th
Lack of health & safety provisions	0.65	11th

3.5.3. Workforce-related Factors

Table 8 shows the workers' absenteeism has been a productivity-determining force for the workforce, ranked 2nd in the factor-related group, with an RII of 0.85, ranked 8th among all factors identified. In comparison, labor empowerment such as training was ranked 1st with an RII of 0.89, significantly affecting productivity. The laborers' poor health ranked last with an RII of 0.60 in this workforce-related factor and ranked 28th from all factors. For 40-year-plus year-olds, the rise in age was 7th with an RII of 0.67 and 23rd among all 53 factors.

Table 8. Ranking of Workforce-related factors

Workforce related-factors	Relative Importance Index (RII)	Ranked
Lack of empowerment (training/ seminar)	0.89	1st
Absenteeism of laborers due to health issues	0.85	2nd
Low laborers morals/ commitment	0.81	3rd
Poor relations among workers	0.80	4th
Lack of skill & experience of the Workers	0.79	5th
High workforce turnover	0.72	6th
Increase of laborers' age (above 40 years)	0.67	7th
Poor health of the workers	0.60	8th

3.5.4. Schedule Compression-related Factors

Shifting of work ranked 1st in the schedule compression factor with an RII of 0.91 and ranked 3rd among all 53 identified factors affecting construction low labor productivity. Working 6 days per week ranked 2nd in the schedule compression group. Shifting of work or reassignment of work was ranked 1st with an RII of 0.91 in the schedule compression factor and 3rd among all 53 influencing factors affecting low labor productivity. Poor work planning ranked 3rd with an RII of 0.85 and 8th among all factors. The frequency of Working overtime ranked 4th in the schedule compression factor and 11th among all factors in this study. To cope with the construction schedules to finish the activity on time, the contractor required the laborers to do overtime, including Saturdays.

Overcrowding and overlapping work were the last in this group of factors, and 2nd to the last among them. This was insignificant as an influencing factor to the low labor productivity because the employer limited laborers in a week due to the Covid-19 pandemic.

Table 9. Ranking of schedule compression-related factors

Schedule compression-related factors	Relative Importance Index (RII)	Ranked
Shifting of work or reassignment of work	0.91	1st
Working 6 days/ week	0.87	2nd
Poor work planning	0.85	3rd
Frequency of working overtime	0.82	4th
Overcrowding (overlapping)	0.45	5th

3.5.5. Material and Equipment Resource-related Factors

Table 10 shows that poor equipment and tools factors are ranked 1st with an RII of 0.86, and lack of equipment and tools also ranked 2nd with an RII of 0.83. The formerly ranked 7th, while the latter ranked 10th among all 53 factors affecting low labor productivity. The result justified as equipment on the site, including transit mixer, dump trucks, road roller machine, bulldozer, and water truck. The construction stage depends on this heavy equipment. Any breakdown of the equipment will lead to material-handling problems, including slowdown or suspension of activities.

Hence, the availability of heavy equipment is considered essential for construction operations. [20,21] proved that heavy equipment and tools were the main factors that negatively affect low labor productivity in road projects. Shortages of Materials ranked 3rd, affecting low labor productivity with an RII of 0.79. In contrast, the materials' poor arrangement ranked the last in the material and equipment resource factors and ranked 31st among all identified factors.

Although, in this research, the shortage of materials ranked 3rd, and the materials and equipment-related factors ranked 4th among the seven groups of factors affecting labor productivity, there was a strong influence on the low labor productivity in road construction projects. This result is related to the limited delivery of construction materials due to intermittent imposition of Enhance Community Quarantine (ECQ) for at least 14 days in compliance with the health department protocol.

Table 10. Ranking of materials and equipment related-factors

Material and equipment-related factors	Relative Importance Index (RII)	Ranked
Poor condition of equipment & tools	0.86	1st
Lack of equipment and tools	0.83	2nd
Material shortages	0.79	3rd
Low quality of raw material	0.67	4th
Improper material's storage location	0.61	5th
Poor arrangement of materials	0.54	6th

3.5.6. Motivation Related Factor

Low salary or underpaid laborers ranked 1st in the motivation group, with an RII value of 0.75, and the 17th among all 53 influencing factors affecting labor

productivity as indicated in Table 11. The contractors were the most affected due to Covid-19, as evidence for their declining operations. Lack of labor recognition ranked 2nd in this group and 18th among all the factors. The least among the motivation factors was no security of tenure in their job. Meaning the laborers are paid on a daily basis.

Table 11. Ranking of motivation-related factors

Motivation-related factors	Relative Importance Index (RII)	Ranked
Low salary or underpaid	0.75	1st
Lack of labor recognition	0.72	2nd
Lack of place for eating & resting	0.68	3rd
Little or no financial rewards	0.63	4th
Late payment of salary	0.57	5th
Poor condition of a bunkhouse	0.55	6th
No security of tenure	0.54	7th

3.5.7. Management Team-related Factors

Table 12 indicated the ranking factors for the management team factor. Poor relations between labor supervisors was ranked 1st in the management team-related factors, with a relative importance index of 0.85, and was 8th among all 53 factors affecting labor productivity, as indicated in Table 13. Lack of labor surveillance ranked 2nd in the management team-related group factors, with an RII of 0.81 and 12th among all actors affecting construction labor productivity. Simultaneously, the poor communication & coordination related-factors were ranked 3rd with an RII of 0.79 and 14th among all factors affecting low labor productivity in this study.

Table 12. Ranking of management team-related factors

Management team-related factors	Relative Importance Index (RII)	Ranked
Poor relations between labor supervisor	0.85	1st
Lack of labor surveillance	0.81	2nd
Poor communication & coordination	0.79	3rd
Lack of leadership skill	0.78	4th
Lack of periodic meeting with laborers	0.77	5th
Variation orders	0.71	6th
Improper planning & scheduling of work	0.63	7th
Construction managers lack Leadership	0.57	8th
Misunderstanding between the agency & contractor	0.51	9th

3.5.8. Group of Factors Affecting Low Labor Productivity

Figure 1 shows the seven groups of related factors affecting construction low labor productivity. It was determined by calculating the average Relative importance index (RII) value per group of factors affecting low labor productivity in road construction. Health and safety-related factors were ranked 1st with RII 0.81. While, schedule compression group ranked 2nd with an RII of 0.78, followed by a workforce group-related factors with an RII of 0.77. The three groups of factors indicated low construction labor productivity in the entire study area due to the pandemic's effect. Commonly, all construction industries in the Philippines are affected by the Covid-19 pandemic, specifically the labor sectors.

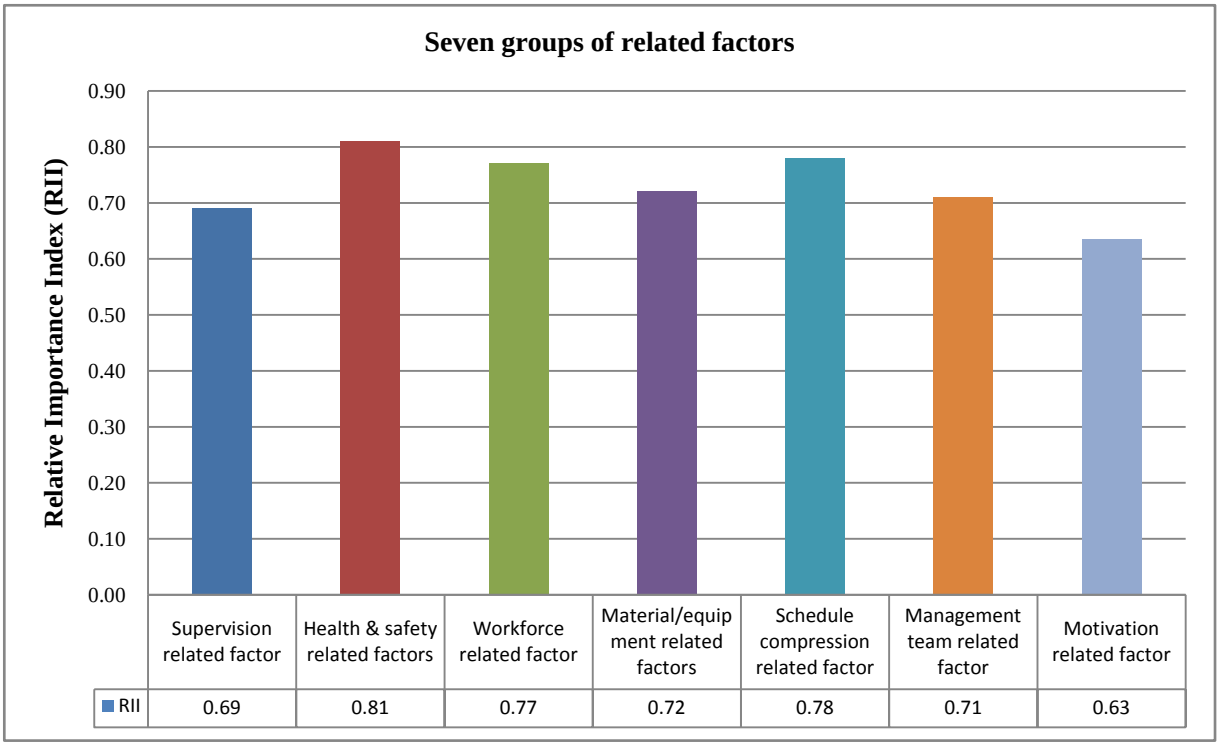

Figure 1. Groups of influencing factors affecting low labor productivity

Table 13 depicts the ranking of all 53 different factors based on the importance and effect of the Covid-19 pandemic on low productivity in the study area.

Table 13. Ranking of all related factors affecting low labor productivity

No.	Various factors affecting low labor productivity	Relative Importance Index (RII)	Ranked
1	No health workers on the construction site	0.97	1st
2	No safety engineer on construction site	0.93	2nd
3	Shifting of work or reassignment of work	0.91	3rd
4	Lack of empowerment (training/ Seminar)	0.89	4th
5	Lack of labor safety	0.88	5th
6	Working six days/week	0.87	6th
7	Poor condition of equipment & tools	0.86	7th
8	Unsafe working conditions	0.86	7th
9	Poor relations between labor supervisors	0.85	8th
10	Absenteeism of laborers due to health issues	0.85	8th
11	Poor work planning	0.85	8th
12	Ignore safety precaution	0.84	9th
13	Changing instruction order	0.83	10th
14	Lack of equipment and tools	0.83	10th
15	Improper observance of Covid-19 protocol	0.83	10th
16	Frequency of working overtime	0.82	11th
17	Lack of labor surveillance	0.81	12th
18	Low labor morals or commitment	0.81	12th
19	Awareness of Covid-19 protocol	0.81	12th
20	Poor relations among laborers	0.8	13th
21	Poor communication & coordination	0.79	14th
22	Lack of skills and experience of Laborers	0.79	14th
23	Material shortages	0.79	14th
24	Lack of leadership skills	0.78	15th
25	Inspection delay	0.78	15th
26	Lack of periodic meeting with laborers	0.77	16th
27	Accident awareness	0.77	16th
28	Low salary or underpaid	0.75	17th
29	High workforce turnover	0.72	18th
30	Inadequate safety plan	0.72	18th
31	Lack of labor recognition program	0.72	18th
32	Variation orders	0.71	19th
33	Poor or no supervision methods	0.71	19th
34	Changing of foreman	0.7	20th
35	Inadequate lightings	0.7	20th
36	Redo of works	0.69	21st
37	Lack of place for eating & resting	0.68	22nd
38	Increase of laborer age (above 40 years)	0.67	23rd
39	Low quality of raw materials	0.67	23rd
40	Unskilled supervisors	0.66	24th
41	Lack of Health & safety provisions	0.65	25th
42	Improper planning & scheduling of work	0.63	26th
43	Little or no financial rewards	0.63	26th
44	Improper material's storage location	0.61	27th
45	Poor health of the laborers	0.6	28th
46	Construction managers lack Leadership	0.57	29th
47	Late payment of salary	0.57	29th
48	Poor condition of a bunkhouse	0.55	30th
49	Poor Arrangement of Materials	0.54	31st
50	No security of tenure	0.54	31st
51	Misunderstanding between the agency & contractor	0.51	32nd
52	Overcrowding (overlapping)	0.45	33rd
53	Supervisors' absenteeism	0.43	34th

3.5.9. Correlation Analysis

Table 14 summarizes the calculation of "d" values based on the ranking of factors using equation (3), while Table 15 indicated the correlation coefficient (*Rho*). The coefficient indicates that there was a strong correlation between all three groups of respondents. The highest *Rho* value between the CTDEO group and Contractors' group showed a 0.893, a very strong correlation. It indicated most of the respondents have the same perception of the factors affecting construction's low labor productivity during the Covid-19 Pandemic.

Table 14. Calculation of "d" values based on the ranking of related group of factors

No.	Group of factors	Group of respondents						The difference in ranks (d)		
		CTDEO		IFDEO		Contractors				
		RII	Rank	RII	Rank	RII	Rank	CTDEO vs. IFDEO	CTDEO vs. Contractor	IFDEO vs. Contractor
1	Supervision-related factor	0.68	6	0.68	6	0.75	6	0	0	0
2	Health & safety-related factors	0.92	1	0.84	1	0.88	1	0	0	0
3	Workforce-related factor	0.69	5	0.74	4	0.82	3	1	2	1
4	Materials & equipment-related factors	0.76	3	0.79	3	0.77	4	0	-1	-1
5	Schedule Compression related-factor	0.81	2	0.80	2	0.83	2	0	0	0
6	Management-related factor	0.70	4	0.64	7	0.75	5	-3	-1	2
7	Motivation-related factor	0.65	7	0.73	5	0.72	7	2	0	-2

Table 15. Correlation result on the group of respondents by organization

Group of respondents	The correlation coefficient *(Rho)*	Relationship strength of a group of respondents
CTDEO vs. IFDEO	0.750	Strong
CTDEO vs. Contractors	0.893	Very Strong
IFDEO vs. Contractors	0.821	Very Strong

3.5.9. Results of Hypotheses Testing and Analysis

Table 16 indicated the hypothesis testing results to support the findings of the study. It was done to identify the significant and non-significant factors affecting the highway construction low labor productivity during the Covid-19 pandemic. The rejection area and explanation are: when Ha: p ≠ po; reject Ho if T is greater than $Z_{0.025}$= 1.96, or less than −1.96. A test was carried out using the equation. A T-*values* that are higher than 1.96 means, it means that there are significant influencing factors affecting low labor productivity in road construction. Testing of Hypothesis, Ho: p = 0.50 vs. Ha: $p \neq 0.50$, where p = represents that the proportion of respondents suggested the influencing factor that affects low labor productivity is significant or non-significant.

Results showed that the top 8 significant factors out of 53 factors affecting labor productivity with values ranging from 3.48 to 4.80. These related factors are: No health workers on construction site to implement the Covid-19 protocols, no safety engineers on areas which are considered hazardous, lack of empowerment for laborers, working 6 days per week, frequent working overtime to cope with the target accomplishment, sifting of work or reassignment of work to other sites, poor condition of equipment & hand tools, and lack of laborer's safety practice & standard. It means that more than 50% of respondents affirmed that significant factors were affecting low labor productivity during the pandemic. These results reconciled with the ranking factors using the Relative importance index (RII) from the initial results of related groups of influencing factors in low labor productivity.

Table 16. Hypotheses Testing on Significant and Non-Significant Factors

No.	Influencing factors affecting low construction productivity of labor	Hypothesis Testing				Remarks
		Alt.	Null	Std. Dev.	T-*Value* Results	
I. Supervision-related factors						
1	Poor or no supervision	46.43	53.57	1.36	-0.26 T-not rejected	Non-significant factor affecting low labor productivity
2	Unskilled supervisor	39.29	60.71	1.42	-0.75 T-not rejected	Non-significant factor affecting low labor productivity
3	Changing of supervisor	67.00	33.00	1.16	1.47 T-not rejected	Non-significant factor affecting low labor productivity
4	Changing instruction order	79.00	21.00	0.92	3.16 T-rejected	More than 50% suggests significant factor affecting low labor productivity
5	Inspection delay	85.71	14.29	1.25	2.87 T-rejected	More than 50% suggests significant factor affecting low labor productivity
6	Rework (Redo of work)	20.00	80.00	1.24	-2.43 T-not rejected	Non-significant factor affecting labor productivity
7	Supervisors' absenteeism	46.43	53.57	1.36	-0.26 T-not rejected	Non-significant factor affecting labor productivity
II. Health & safety-related factor						
8	Ignore safety precautions	79.78	20.22	1.09	2.73 T-rejected	More than 50% suggests significant factor affecting low labor productivity
9	Accident awareness	66.00	34.00	1.17	1.37 T-not rejected	Non-significant factor affecting labor productivity
10	Inadequate lightings	42.86	57.14	1.01	-0.71 T-not rejected	Non-significant factor affecting low labor productivity
11	No health workers on construction site	85.71	14.29	0.74	4.80 T-rejected	More than 50% suggests significant factor affecting low labor productivity
12	Awareness of Covid-19 protocol	25.00	75.00	0.94	-2.65 T-not rejected	Non-significant factor affecting low labor productivity
13	Improper observance of Covid-19 protocol	71.43	28.57	1.06	2.02 T-not rejected	More than 50% suggests significant factor affecting low labor productivity
14	No safety engineer on construction site	95.67	4.33	1.01	4.51 T-rejected	More than 50% suggests significant factor affecting low labor productivity

No.	Influencing factors affecting low construction productivity of labor	Hypothesis Testing				Remarks
		Alt.	Null	Std. Dev.	T-*Value* Results	
15	Unsafe working area	79.67	20.33	1.07	2.77 T-rejected	More than 50% suggests significant factor affecting low labor productivity
16	Inadequate safety plan	34.00	66.00	1.07	-1.49 T-not rejected	Non-significant factor affecting low labor productivity
17	Lack of laborer's safety practice & standard	81.35	18.65	0.90	3.48 T-rejected	More than 50% suggests significant factor affecting low labor productivity
18	Lack of health & safety provisions	63.56	36.44	1.08	1.26 T-not rejected	Non-significant factor affecting low labor productivity
III. Workforce-related factor						
19	Lack of skills and experience of Laborers	81.00	19.00	1.07	2.89 T-rejected	More than 50% suggests significant factor affecting low labor productivity
20	Lack of empowerment (training/Seminar)	103.57	-3.57	1.20	4.46 T-rejected	More than 50% suggests significant factor affecting low labor productivity
21	Absenteeism of laborers	90.00	10.00	1.32	3.04 T-rejected	More than 50%, suggests significant factor affecting low labor productivity
22	High-workforce turnover	35.71	64.29	1.26	-1.14 T-not rejected	Non-significant factor affecting low labor productivity
23	Low labor moral or commitment to work	82.00	18.00	1.18	2.71 T-rejected	More than 50% suggests significant factor affecting low labor productivity
24	Increase of laborer age (above 40 years)	25.00	75.00	1.19	-2.10 T-not rejected	Non-significant factor affecting labor productivity
25	Poor health of the laborers	67.00	33.00	1.34	1.27 T-not rejected	Non-significant factor affecting labor productivity
26	Poor relations among laborers	85.00	15.00	1.26	2.78 T-rejected	More than 50% suggests significant factor affecting low labor productivity
IV. Material & equipment-related factors						
27	Material shortages	63.00	37.00	0.50	2.58 T-rejected	More than 50% suggests significant factor affecting low labor productivity
28	Low quality of construction materials	77.00	23.00	1.26	2.15 T-not rejected	More than 50% suggests significant factor affecting low labor productivity
29	Unsuitable material storage location	66.75	33.25	1.17	1.43 T-not rejected	Non-significant factor affecting low labor productivity
30	Poor Arrangement of Material	62.00	38.00	1.22	0.98 T-not rejected	Non-significant factor affecting low labor productivity
31	Equipment and tools shortages	83.65	16.35	1.05	3.19 T-rejected	More than 50% suggests significant factor affecting low labor productivity
32	Poor condition of equipment & tool	94.00	6.00	1.23	3.58 T-rejected	More than 50% suggests significant factor affecting labor productivity.
V. Schedule compression-related factor						
33	Working 6 days per week	103.00	-3.00	1.27	4.17 T-rejected	More than 50% suggests significant factor affecting low labor productivity
34	Frequency of work overtime	89.29	10.71	1.21	3.26 T-rejected	More than 50% suggests significant factor affecting low labor productivity
35	Shifting of work or reassignment of work	85.71	14.29	0.90	3.95 T-rejected	More than 50% suggests significant factor affecting low labor productivity
36	Poor work planning	89.29	10.71	1.20	3.28 T-rejected	More than 50% suggests significant factor affecting low labor productivity
37	Overcrowding (overlapping)	53.57	46.43	0.98	0.37 T-not rejected	Non-significant factor affecting labor productivity
VI. Management team-related factor						
38	Lack of leadership skills	85.71	14.29	1.07	3.33 T-rejected	More than 50%, suggests significant factor affecting labor productivity
39	Poor relations between labor supervisors	83.00	17.00	1.27	2.59 T-rejected	More than 50%, suggests significant factor affecting labor productivity
40	Lack of labor surveillance	90.00	10.00	1.07	3.75 T-rejected	More than 50%, suggests significant factor affecting labor productivity
41	Lack of periodic meeting with laborers	83.00	17.00	1.10	2.99 T-rejected	More than 50%, suggests significant factor affecting labor productivity
42	Poor communication & coordination	80.00	20.00	1.13	2.65 T-rejected	More than 50%, suggests significant factor affecting labor productivity
43	Improper planning & scheduling of work	58.00	42.00	1.09	0.73 T-not rejected	Non-significant factor affecting labor productivity
44	Construction managers lack Leadership	60.00	40.00	1.19	0.84 T-not rejected	Non-significant factor affecting labor productivity
45	Variation orders	77.00	23.00	1.23	2.20 T-not rejected	More than 50%, suggests significant factor affecting labor productivity
46	Misunderstanding between the agency & contractor	33.00	67.00	1.15	-1.48 T-not rejected	Non-significant factor affecting low labor productivity
VII. Motivation-related factor						
47	Late payment of salary	55.35	44.65	0.96	0.56 T-not rejected	Non-significant factor affecting low labor productivity
48	Low salary or underpaid	75.67	24.33	0.98	2.61 T-rejected	More than 50% suggests significant factor affecting low labor productivity

No.	Influencing factors affecting low construction productivity of labor	Hypothesis Testing				Remarks
		Alt.	Null	Std. Dev.	T-*Value* Results	
49	Little or no welfare	68.75	31.25	0.86	2.17 T-not rejected	More than 50% suggests significant factor affecting low labor productivity
50	Little or no financial reward	45.60	54.40	0.74	-0.59 T-not rejected	Non-significant factor affecting low labor productivity
51	Lack of labor recognition	73.68	26.32	0.82	2.90 T-rejected	More than 50% suggests significant factor affecting low labor productivity
52	Poor condition of a bunkhouse	57.14	42.86	1.14	0.63 T-not rejected	Non-significant factor affecting low labor productivity
53	Lack of place for eating & resting	78.57	21.43	1.35	2.12 T-not rejected	More than 50% suggests a significant factor affecting low labor productivity.

4. Conclusion

Construction industries in the study area are experiencing the pandemic's effect, causing low labor productivity and huge profit losses in the construction industries. The local authorities imposed intermittent Enhance Community Quarantine on all places to avoid the possibility of spreading the Coronavirus.

Results show that there was laxity on the health protocols. No health workers in the construction project sites ranked the highest in the health & safety factor related group with an RII of 0.97 and ranked 1st among all 53 influencing factors. Also, no safety engineer was assigned to the projects and ranked 2nd with an RII of 0.93. Among all the seven groups of related factors, the health and safety group was ranked 1st with 0.81, next to the schedule compression related factors group with an RII of 0.78. So, these two groups with related sub-factors have a strong relationship. The hypothesis testing provided that working 6 days a week was one of the significant factors affecting labor productivity during the Covid-19 Pandemic, as suggested by more than 50 percent of the respondents. The workforce group-related factor with an RII of 0.77 indicated a slight difference with the schedule compression-related group. These two groups with related factors have strong inter-relationships influencing low labor productivity in the study area.

Likewise, the materials and equipment groups and management team-related factors ranked 4th and 5th with RII of 0.72 and 0.71, respectively. It means that these two groups with related sub-factors also have a strong inter-relationship due to slight variation. The poor efficiency of equipment & tools is evident in its effect on the low labor productivity.

From the correlation analysis, the calculated coefficient indicates that there was a strong correlation between all three groups of respondents. The highest *Rho* value between CTDEO and Contractors depicted a 0.893, a very strong correlation. It means that most of the respondents have the same perception of the factors affecting construction low labor productivity during the Covid-19 Pandemic. More so, it was supported by more than 50 percent of respondents in the study area; there was a significant effect on the low productivity.

Therefore, this study suggested that a good understanding of the significant factors influencing construction labor productivity causing productivity losses during the Covid-19 pandemic is essential to adjust and regain construction labor productivity losses.

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Declaration and a Follow-up Study

This research article was prepared as a Research-II in compliance with a partial requirement for the Ph.D. of the first author. The essential factors identified and ranked in this research article will be used for the next Research-III topic on the application of System Dynamics(SD) in construction labor productivity.

Disclosure of conflict of interest

The authors disclosed no conflict of interest with any organization.

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