

Appendix A: COVID-19 Mitigation Measures (Source: Authors own work)

No.	COVID-19 Mitigation Measures	Description	Reference
1	Lockdown	Lockdown is implemented to restrict people or communities to stay where they are due to specific risks to others if they move and interact freely or to themselves. The Lockdown has been implemented in the form of stay-home orders, curfews, and similar societal restrictions, hence serving as an effective mitigation measure for the COVID-19 pandemic. Though effective, the lockdown has interrupted the construction industry supply chain, including the Cb-CLSC. The supply of materials is delayed amidst the pandemic, affecting the project quality. Moreover, the lockdown caused a delay in construction activities due to the halting of site activities, impacting construction progress and quality.	Hsiang et al. (2020), Lau et al. (2020), Allen-Coghlan and McQuinn (2020), Brown et al. (2020)
2	Social Distancing	Social distancing tends to prevent the spread of a contagious disease by maintaining a physical distance among workers or people at the workplace, including reducing the number of people coming into contact. Cb-CLSC is highly collaborative and has been impacted by the social distancing measure leading to low workplace productivity. The quality of a project is distorted as there is a likelihood of delay from experiencing low productivity. Also, more time has been reported to be spent on work due to the few people allowed at work and running shifts of work activities due to limited space	Kinlaw and Levine (2007), Johnson et al. (2020), Harris et al. (2020), Brooks et al. (2020), (Raoufi and Fayek (2022)
3	Travelling Restrictions	Travelling restrictions are enforced to prevent the spread of COVID-19 across borders. This has affected the volume of international flights among countries, resulting in extensive social and economic costs. In Cb-CLSC, flight restrictions adversely affected workers travelling offshore to check and validate construction works in different countries. This affects services such as QA of international projects, causing delays in task executions.	Suzumura et al. (2020), Kwok et al. (2021)
4	Workplace Capacity Limit	Workplace capacity limit has become a recommended practice in minimising the spread of the COVID-19 virus. In the construction sector, this measure may be associated with low construction output due to the small number of workers at a workplace at any given time. Procedures may take longer than expected, which may delay construction activities, affecting cost and quality. QA activities are likely to be delayed due to not getting the full capacity of workers to execute the tasks, causing work to be overloaded on the multi-skilled workers.	International Labour Organisation [ILO] (2020)
5	Use of Personal Protective Equipment (PPE)	PPE, including gloves, goggles, face shields, nose masks, hand sanitisers, disinfectants, and respiratory protection, is effective in minimising exposure to COVID-19. On the construction site, the employer must bear the extra cost of providing workers with PPE to minimise the pandemic's spread. PPE, such as nose masks, have been noticed to have side effects once put on. Study reports that participants were safe from side effects once masks were removed. Putting on the nose mask for longer may affect the worker's ability to perform efficiently, especially when the worker has breathing problems. This then affects the quality of the processes involved in delivering projects to meet client needs.	Occupation Safety and Health Act [OSHA] (2020), Rosner et al. (2020)
6	Quarantine days	Quarantine separates and restricts people exposed to contagious diseases (e.g., COVID-19) from moving to determine whether they become well whilst reducing the risk of infecting others. Quarantine may be used interchangeably with isolation. In Cb-CLSC, extra cost and time may be incurred for quarantine. This, if not handled carefully from the planning stage of the project, may affect the project quality by causing a delay in activities whilst increasing construction cost, affecting client requirements on quality.	Brooks et al. (2020), Centre for Disease Control and Prevention [CDC] (2017)
Keywords used for the literature search		"COVID-19 mitigation measures", "COVID-19 policy measures", and "Pandemic policy measures"	

Appendix B: Informed Consent Form

Dear Sir/Madam,

Quality Assurance of Cross-border Construction Logistics and Supply Chain in the Covid-19 Pandemic Era

You are invited to participate in an ongoing study that forms part of a PhD research by XXXXXXXXXXXXX in the Department of XXXXXX, the University of XXXXXXXXXXX.

I hope to collect data based on your knowledge and experience regarding the implications of COVID-19 on the quality assurance of construction projects. The survey/interview will only take you about 15-20 minutes to complete. I would like to stress that all information collected will remain strictly confidential. Individual details will not be disclosed or identifiable from this survey.

It is important for you to consider if you fall in the following criteria before responding to the questionnaire:

1. You have extensive experience and were theoretically versed in the construction QA processes;
2. You have sufficient direct hands-on experience in construction QA; and
3. You have been involved in at least QA processes in their organization.

If you have any questions about the research, please feel free to contact Mr. XXXXXXXXXXXXX. If you have questions about your rights as a research participant, please contact the Human Research Ethics Committee (HREC), XXXX.

HREC Reference Number: EA210435

I understand the procedures described above and agree to participate in this study (tick the box and proceed to Part II).

Appendix C: Questionnaire

A. Demographic Data Section

Kindly respond to the questions by carefully ticking [√] the appropriate box OR typing in the appropriate space for each item based on your valuable knowledge and experience.

1. Please state your country/economy?.....

2. Which sector do you belong?

a. Industry [] b. Academia []

3. What is your designation?

a. Academician [] b. Quality Auditor [] c. Quality Engineer [] d. Quality Assurance/Control Manager [] e. Authorised person from the government [] f. Client representative [] g. Other [] Please specify.....

4. How long have you been working in the organisation?

a. Less than 5 years [] b. 5-10 years [] c. 11-20 years [] d. 21-30 years [] e. More than 30 years

B. Main Questions

Kindly respond by carefully ticking [√] the appropriate section of the tables based on your valuable knowledge and experience.

Question 1:

a. What has been the experience with the areas of quality assurance practices during the COVID-19 pandemic? Please rate using **Negative, Neutral, or Positive.**

(Source: Authors own work)

No.	Quality Assurance Practices	Experience		
		Negative	Neutral	Positive
QAP1	Clearly defining responsibilities based on the quality requirements.			
QAP2	Assigning clear responsibilities to qualified workers.			
QAP3	Understanding requirements, norms and standards of quality.			
QAP4	Keeping close contact with clients to realise their demands.			
QAP5	Providing quality training for workers toward project execution.			
QAP6	Maintaining quality standards.			
QAP7	Recording and documenting work processes, steps, project routine, and seamless implementations.			
QAP8	Communicating and coordinating with other workers to obtaining information about the project.			
QAP9	Strategic planning based on client requirements and corporate capability.			
QAP10	Analysing results of work operations and quality records.			
	Other, please state clearly and rank			

Question 2:

- a. What has been the experience/influence with the following COVID-19 mitigation measures on the quality assurance practices of cross-border construction logistics and supply chain? Please, rate using **Negative, Neutral, or Positive**.
- b. And what is their level of impact on the quality assurance practices? Using the Five-point Likert Scales: **1= Very low impact; 2=Low Impact; 3=Moderate; 4=High impact; 5=Very high impact.**

(Source: Authors own work)

No.	COVID-19 Mitigation Measures	Experience/influence			Level of impact				
		Negative	Neutral	Positive	1	2	3	4	5
CMM1	Social distancing								
CMM2	Lockdown								
CMM3	Travelling restrictions								
CMM4	Workplace capacity limits								
CMM5	Use of personal protective equipment, such as nose masks, disinfects, etc.								
CMM6	Number of days for quarantine								
CMM7	Electronic/virtual meetings								
	Other, please state clearly and rank								

Appendix D: Interview Questions

A. Demographic Data Section

1. What is your country of origin?
2. What is your designation?
3. What is your qualification?
4. How long have you been working in the firm?

B. Main Question

How has COVID-19 mitigation measures impacted the quality assurance process of your organisation, especially in the course of executing cross-border construction projects and assuring their quality?

Prompt 1: negative?

Prompt 2: Positive?

Appendix E: Detailed references to Table 1 (Source: Authors own work)

Serial Number	References	Detailed Reference
1	Kinlaw and Levine (2007)	Kinlaw, K and Levine, R. (2007). <i>Ethical guidelines in pandemic influenza</i> , https://web.archive.org/web/20200205095942/https://www.cdc.gov/od/science/integrity/phethics/docs/panflu_ethic_guidelines.pdf
2	Johnson et al. (2020)	Johnson, C. Y., Sun, L., and Freedman, A. (2020). <i>Social distancing could buy U.S. valuable time against coronavirus</i> . The Washington Post. https://www.washingtonpost.com/health/2020/03/10/social-distancing-coronavirus/ .
3	Harris et al. (2020)	Harris, M., Adhanom Ghebreyesus, T., Liu, T., Ryan, M. J., Van Kerkhove, M. D. D., Foulkes, I., Ondelam, C., Gretler, C. C. (2020). COVID-19 (PDF). <i>World Health Organization</i> , https://www.who.int/docs/default-source/coronaviruse/transcripts/who-audio-emergencies-coronavirus-press-conference-full-20mar2020.pdf?sfvrsn=1eafbff_0 .
4	Brooks et al. (2020)	Brooks, S.K., Webster, R.K., Smith, L.E., Woodland, L., Wessely, S., Greenberg, N. and Rubin, G.J. (2020). The psychological impact of quarantine and how to reduce it: rapid review of the evidence. <i>The lancet</i> , 395(10227), pp.912-920.
5	Raoufi and Fayek (2022)	Raoufi, M. and Fayek, A.R. (2022). New modes of operating for construction organizations during the COVID-19 pandemic: Challenges, actions, and future best practices. <i>Journal of Management in Engineering</i> , 38(2), p.04021091.
6	Hsiang et al. (2020)	Hsiang, S., Allen, D., Annan-Phan, S., Bell, K., Bolliger, I., Chong, T., Druckenmiller, H., Huang, L.Y., Hultgren, A., Krasovich, E. and Lau, P. (2020). The effect of large-scale anti-contagion policies on the COVID-19 pandemic. <i>Nature</i> , 584(7820), pp.262-267.
7	Lau et al. (2020)	Lau, H., Khosrawipour, V., Kocbach, P., Mikolajczyk, A., Schubert, J., Bania, J. and Khosrawipour, T. (2020). The positive impact of lockdown in Wuhan on containing the COVID-19 outbreak in China. <i>Journal of travel medicine</i> , pp. 1-7.
8	Allen-Coghlan and McQuinn (2020)	Allen-Coghlan, M., and McQuinn, K. (2020). <i>Property prices and COVID-19 related administrative closures: What are the implications?</i> https://www.esri.ie/system/files/publications/WP661_0.pdf .
9	Brown et al. (2020)	Brown, S., R. D. Brooks, and Dong, X.S. (2020). <i>Impact of COVID-19 on construction workers and businesses</i> . https://stacks.cdc.gov/view/cdc/95397 .
10	Suzumura et al. (2020)	Suzumura, T., Kanezashi, H., Dholakia, M., Ishii, E., Napagao, S.A., Pérez-Arnal, R. and Garcia-Gasulla, D. (2020). December. The impact of COVID-19 on flight networks. In <i>2020 IEEE International Conference on Big Data (Big Data)</i> (pp. 2443-2452). IEEE.
11	Kwok et al. (2021)	Kwok, W.C., Wong, K.C., Ma, TF, Ho, KW, Fan, L.W.T., Chan, K.P.F., Chan, S.S.K., Tam, T.C.C. and Ho, P.L. (2021). Modelling the impact of travel restrictions on COVID-19 cases in Hong Kong in early 2020. <i>BMC public health</i> , 21(1), pp.1-8.
12	International Labour Organisation (2020)	ILO (2020), In the Face of a Pandemic: Ensuring Safety and Health at Work, ILO, Geneva
13	Occupation Safety and Health Act (2020)	OSHA (2020). <i>Guidance on Preparing Workplaces for COVID-19</i> , https://www.osha.gov/sites/default/files/publications/OSHA3990.pdf .
14	Rosner et al. (2020)	Rosner, E. (2020). Adverse effects of prolonged mask use among healthcare professionals during COVID-19. <i>Journal of Infectious Diseases and Epidemiology</i> , 6(3), p.130.
15	Centre for Disease Control and Prevention (2017)	CDC (2017). <i>Quarantine and isolation</i> . 2017. https://www.cdc.gov/quarantine/index.html .
16	Hantrais et al. (2023)	Hantrais, L., Allin, P., Kritikos, M., Sogomonjan, M., Anand, P.B., Livingstone, S., Williams, M. and Innes, M., 2021. Covid-19 and the digital revolution. <i>Contemporary Social Science</i> , 16(2), pp.256-270.
17	Whitelaw et al. (2020)	Whitelaw, S., Mamas, M.A., Topol, E. and Van Spall, H.G., 2020. Applications of digital technology in COVID-19 pandemic planning and response. <i>The Lancet Digital Health</i> , 2(8), pp.e435-e440.

18	Yan and Li (2023)	Yan, X. and Li, T., 2023. Construction and application of urban digital infrastructure—Practice of “Urban Brain” in facing COVID-19 in Hangzhou, China. <i>Engineering, Construction and Architectural Management</i> , 30(8), pp.3123-3141.
19	Devi (2020)	Devi, S., 2020. Travel restrictions hampering COVID-19 response. <i>The Lancet</i> , 395(10233), pp.1331-1332.
20	Gounni et al. (2022)	Gounni, A., Ouhaibi, S., Belouaggadia, N. and El Alami, M., 2022. Impact of COVID-19 restrictions on building energy consumption using Phase Change Materials (PCM) and insulation: A case study in six climatic zones of Morocco. <i>Journal of Energy Storage</i> , 55, p.105374.
21	Hollingsworth (2020)	Hollingsworth, J., 2020. Construction safety practices for covid-19. <i>Professional Safety</i> , 65(6), pp.32-34.
22	Lestari et al (2022)	Lestari, F., Cook, M., Johnstone, K., Wardhany, M.S., Modjo, R., Widanarko, B. and Octaviani, D.F., 2022. COVID-19 in the Workplace in Indonesia. <i>Sustainability</i> , 14(5), p.2745.
23	Pamidimukkala and Kermanshachi (2021)	Pamidimukkala, A. and Kermanshachi, S., 2021. Impact of Covid-19 on field and office workforce in construction industry. <i>Project Leadership and Society</i> , 2, p.100018.

Appendix F: Results of the Normality Test and Mann-Whitney Test (Source: Authors own work)

Code	Kolmogorov-Smirnov ^a						Mann-Whitney U test							
	Sentiments			Level of Impact			Sentiment				Level of Impact			
	K S value	df	P-value	K S value	df	P-value	U stat	W	Z-score	P-value	U stat	W	Z-score	P-value
CMM1	0.225	52	0.000	0.326	150	0.000	227.000	1047.000	-0.303	0.762	228.500	306.500	-0.276	0.782
CMM2	0.236	52	0.000	0.262	150	0.000	235.500	1055.500	-0.104	0.917	141.500	961.500	-0.295	0.022 ^a
CMM3	0.248	52	0.000	0.311	150	0.000	212.000	1032.000	-0.661	0.509	193.000	1013.000	-1.160	0.246
CMM4	0.358	52	0.000	0.220	150	0.000	232.500	1052.500	-0.183	0.855	225.000	303.000	-0.342	0.733
CMM5	0.410	52	0.000	0.184	150	0.000	231.000	309.000	-0.237	0.813	185.000	263.500	-1.237	0.216
CMM6	0.306	52	0.000	0.334	150	0.000	229.500	1049.500	-0.247	0.805	209.000	287.000	-0.799	0.424
CMM7	0.310	52	0.000	0.348	150	0.000	217.000	295.000	-0.562	0.574	152.000	230.000	-2.201	0.028 ^a

*Distribution in the data is termed to be normally distributed, W=Wilcoxon, df=degree of freedom, P-value significant at ≤ 0.050 ; “a” = significant disparity among the sectors

Appendix G: Results of Descriptive Analysis, Normality Test, and Sentiment Analysis (Source: Authors own work)

Code	Level of Sentiments (A)						Level of Impacts (B)		
	Negative	Neutral	Positive	SD	Sentiment score	Ns	Overall		
							Mean	SD	Ns
CMM1	12 (23.08%)	22 (42.31%)	18 (34.62%)	0.758	2.12	0.560	3.75	0.860	0.583
CMM2	19 (36.54%)	20 (38.46%)	13 (25.00%)	0.784	1.88	0.440	4.19	0.817	0.730
CMM3	17 (32.69%)	25 (48.08%)	10 (19.23%)	0.715	1.87	0.435	3.96	0.685	0.653
CMM4	11 (21.15%)	11 (21.15%)	30 (57.69%)	0.817	2.37	0.685	3.81	0.971	0.603
CMM5	5 (9.62%)	12 (23.08%)	35 (67.31%)	0.667	2.58	0.790	3.75	1.169	0.688
CMM6	15 (28.85%)	12 (23.08%)	25 (48.08%)	0.864	2.19	0.595	4.04	0.593	0.520
CMM7	3 (5.77%)	24 (46.15%)	25 (48.08%)	0.605	2.42	0.710	3.71	0.825	0.678

Ns=Normalisation score= (actual mean–minimum mean)/(maximum mean–minimum mean), only normalisation scores ≥ 0.5 are deemed critical by the experts; SD=Standard deviation

Appendix H: Mean's Confidence Level at 95%

S1: Quality assurance (QA) practices of Cb-CLSC (Source: Authors own work)

Code		95% Confidence level for mean	
		Lower bound	Upper bound
QAP1	Clearly defining responsibilities based on the quality requirements.	2.01	2.38
QAP2	Assigning clear responsibilities to qualified workers.	2.31	2.65
QAP3	Understanding requirements, norms, and standards of quality.	1.94	2.33
QAP4	Keeping close contact with clients to realise their demands.	1.95	2.33
QAP5	Providing quality training for workers toward project execution.	1.83	2.10
QAP6	Maintaining quality standards.	1.91	2.28
QAP7	Recording and documenting work processes, steps, project routine, and seamless implementations.	1.96	2.35
QAP8	Communicating and coordinating with other workers to obtaining information about the project.	1.89	2.27
QAP9	Strategic planning based on client requirements and corporate capability.	2.10	2.44
QAP10	Analysing results of work operations and quality records.	2.00	2.23

S2: COVID-19 mitigation measures (Source: Authors own work)

Code	95% Confidence level for mean			
	Level of Sentiments (A)		Level of Impacts (B)	
	Lower bound	Upper bound	Lower bound	Upper bound
CMM1	1.90	2.33	3.51	3.99
CMM2	1.67	2.10	3.96	4.42
CMM3	1.67	2.06	3.77	4.15
CMM4	2.14	2.59	3.54	4.08
CMM5	2.39	2.79	3.42	4.08
CMM6	1.95	2.43	3.87	4.20
CMM7	2.25	2.59	3.48	3.94

Appendix I: Specific Interviewee Responses Regarding the CMMs (Source: Authors own work)

Interviewee	Responses	Remarks on Specific CMM
C	<i>"Due to the government's COVID-19 lockdown policy, we employees cannot be at work for a long time."</i>	CMM2
E	<i>"Measures such as personnel rework isolation, procurement of epidemic prevention materials, and strengthening daily monitoring and monitoring will lead to increased costs. The centralised start of work after the end of the epidemic may increase the cost of rework."</i>	CMM5
F	<i>"Restrictions on travel have had a serious impact on the departure of in-country operatives to resume work and carry out their work. The control of traffic and logistics creates an obstacle to the transport of people and equipment. Isolation observations have had an impact on the work of staff."</i>	CMM3
G	<i>"The greatest opportunity would be to demonstrate the importance of skilled workers. Because of the frequent stoppages, many projects are now not allowed to be worked on by new people because they are slow. So, the importance of skilled workers increases, and it would definitely be good to have skills that can assist with quality control."</i>	All the CMMs
I	<i>"Under the epidemic prevention and control policy, if the management personnel cannot be present, fully automated and digital quality management is very necessary."</i>	All the CMMs

J	<i>“We are unable to directly travel between the territory and the territory. If we have to travel, we need to be quarantined according to the policy, which increases the labour cost in the factory.”</i>	CMM6
K	<i>“The main impact is on quality management personnel, as they are restricted by the government's epidemic prevention and control policies.”</i>	All the CMMs
L	<i>“In particular to the off-site fabrication factory/yard in China, there is a critical impact that the quality check to items fabricated in the factory/yard could not be checked because of the lock-down.”</i>	CMM2

Appendix J: Standardised Indirect Effects of CMMs on QA (Source: Authors own work)

	CMM7	CMM6	CMM5	CMM4	CMM3	CMM2	CMM1
IQAP	-0.256	0.194	0.386	0.301	0.229	0.265	0.288
QAP10	-0.254	0.192	0.383	0.299	0.227	0.263	0.286
QAP9	-0.253	0.192	0.382	0.298	0.226	0.262	0.285
QAP8	-0.252	0.190	0.379	0.296	0.224	0.260	0.283
QAP7	-0.252	0.191	0.380	0.296	0.225	0.260	0.283
QAP6	-0.253	0.191	0.381	0.298	0.226	0.261	0.285
QAP5	-0.255	0.193	0.384	0.300	0.227	0.263	0.287
QAP4	-0.251	0.190	0.379	0.296	0.224	0.260	0.283
QAP3	-0.252	0.190	0.379	0.296	0.224	0.260	0.283
QAP2	-0.253	0.192	0.382	0.298	0.226	0.262	0.285
QAP1	-0.252	0.191	0.380	0.297	0.225	0.261	0.284

IQAP=Impact on QAP

Appendix K: Standardised Indirect Effects - Two-Tailed Significance (Source: Authors own work)

	CMM7	CMM6	CMM5	CMM4	CMM3	CMM2	CMM1
IQAP	0.039	0.018	0.018	0.018	0.030	0.008	0.006
QAP10	0.039	0.018	0.018	0.018	0.030	0.006	0.006
QAP9	0.039	0.018	0.018	0.018	0.030	0.008	0.006
QAP8	0.039	0.030	0.018	0.018	0.030	0.008	0.006
QAP7	0.039	0.018	0.018	0.018	0.030	0.008	0.006
QAP6	0.039	0.018	0.018	0.018	0.030	0.011	0.006
QAP5	0.039	0.018	0.018	0.018	0.030	0.011	0.006
QAP4	0.039	0.024	0.018	0.018	0.030	0.008	0.006
QAP3	0.039	0.030	0.018	0.018	0.030	0.006	0.006
QAP2	0.039	0.018	0.018	0.018	0.030	0.008	0.006
QAP1	0.039	0.018	0.018	0.018	0.030	0.008	0.006

P-Value = Two-tailed significance level at 95% confidence level after bootstrapping