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Impact of COVID-19 on the use of project management methodologies, tools, and techniques in the construction sector in Auckland, New Zealand

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Abstract

The construction sector plays a significant role in New Zealand's economic growth through its substantial contribution to gross domestic product and employment. Following the outbreak of the COVID-19 pandemic in late 2019, the sector faced considerable disruption. This study examines the impact of COVID-19 on the project management methodologies, tools, and techniques used in the construction sector in Auckland, New Zealand, and provides practical insights for stakeholders, policymakers, and project management professionals. We adopted a qualitative research design using 10 semi-structured interviews with project managers and construction professionals selected using purposive non-probability sampling. Thematic analysis identified six themes and 23 sub-themes. The findings show that COVID-19 substantially disrupted the traditional Waterfall method, while Agile and hybrid approaches demonstrated greater adaptability. Key drivers of change included remote working policies, supply chain disruptions, and skilled labor shortages. The findings highlight the need to optimize the mix of project management methodologies through an appropriate combination of Waterfall, Agile, and hybrid approaches, strengthen risk management, build more resilient and diversified supply chains, and invest in training and upskilling to improve project efficiency and reduce rework.

Keywords: Construction sector; Project management methodologies; Tools; Techniques; Virtual communication and collaboration; COVID-19; New Zealand

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1. Introduction

The construction sector is an essential part of global economic growth, providing employment opportunities worldwide.[1] In New Zealand, the construction sector contributed over NZD 17 billion to the gross domestic product by the end of the fiscal year in September 2024 and employed approximately 200,000 individuals in the fourth quarter of 2024, a notable increase compared to a decade earlier, as reported by Muschter.[2] Despite being affected by substantial COVID-19 disruptions, the construction sector globally demonstrated remarkable resilience and capacity to drive postpandemic recovery.[3]

Amid these global and local developments, the importance of effective project management methodologies (PMMs) has become increasingly evident. The implementation of traditional and modern PMMs ensures project success through efficient resource allocation, risk mitigation, and time management.[4,5] Project managers in the construction sector play a central coordinating role, bringing together architects, engineers, contractors, and suppliers to ensure projects progress smoothly from planning to completion.[6]

The onset of COVID19, however, was an unprecedented disruption that compelled project managers to rethink their established practices.[7] Agile, hybrid, and other adaptive PMMs became increasingly valuable in maintaining productivity under volatile and uncertain conditions.[8] Managers employed tools such as Gantt charts, work breakdown structures (WBS), and critical path methods (CPM) to manage communication, resource constraints, and compliance with pandemic regulations.[9]

Although international research has begun to document these shifts—focusing on delays, cost overruns, and supply chain instability—studies in New Zealand have remained largely macrolevel, investigating government responses and sectorwide outcomes.[10-12] There remains a critical gap concerning how construction project managers in Auckland, the country's largest urban and economic hub, adapted their PMMs, tools, and techniques during the pandemic, particularly regarding digitalization, workforce management, and methodological flexibility.

To address this gap, the present study aims to examine the impact of COVID19 on the use, choice, and effectiveness of PMMs, tools, and techniques in Auckland's construction sector. Specifically, the study pursues four research objectives:

(i) To determine the preCOVID–19 use of PMMs, tools, and techniques in the construction sector in Auckland, New Zealand.
(ii) To analyze how COVID19 has affected the use and choice of PMMs, tools, and techniques in the same sector.
(iii) To identify the key reasons for these changes, particularly those attributable to the direct impact of COVID19.
(iv) To assess the effectiveness and suitability of alternative PMMs, tools, and techniques adopted during the pandemic.

These objectives guide the following research questions:

(i) What were the commonly used PMMs, tools, or techniques in the construction sector in Auckland, New Zealand, before COVID19?
(ii) How has COVID19 affected the choice and use of these PMMs, tools, and techniques?
(iii) What factors contributed to the observed changes in the choice and use of PMMs, tools, and techniques brought about by COVID19?
(iv) How effective and suitable were the alternative PMMs, tools, and techniques adopted during the pandemic?

By exploring these questions, this research contributes to the literature on project resilience and adaptive management and offers practical insights for project management in times of crises. Given Auckland's economic and infrastructural significance, the research contributes to understanding how local practices evolved in response to COVID19, and offers valuable insights into resilience, adaptability, and the future of construction project management in New Zealand.

2. Literature review

2.1. History of project management in the construction sector

According to Seymour and Hussein[13], throughout history, monumental projects were completed and remain extant to this day. The Egyptian Pyramids, the Roman Colosseum, the Greek Parthenon, the Great Wall of China, and many others are testaments to such achievements.[14] For each of these projects, someone had to lead, manage, and ensure the supply of resources from the start to the completion of the project, as well as ensure timely completion.[13] Historically, construction projects were informally managed, relying on the experience or expertise of craftsmen and builders. However, across the centuries, construction project management has witnessed a transformative evolution. Project growth led to a more structured approach, which in turn led to the development and adoption of formal PMMs.[14]

Henry Gantt, an American engineer and consultant for scheduling diagrams, introduced the Gantt chart in 1917. This Gantt chart was beneficial—it divided large project tasks into smaller, manageable components. It was first used for the Hoover Dam, a large-scale project in the United States of America. Today, the Gantt chart is widely used and has become an important tool in a project manager's portfolio.[15]

The mid-20th century was a period during which the construction sector project management saw another important transformative shift—the CPM, the Programme Evaluation and Review Technique (PERT), and the Waterfall method were introduced.[4] Their introduction was revolutionary due to their systematic scheduling, planning, and critical path analysis, enabling project managers

to identify critical activities, dependencies, and project timelines.[4] During the same period, the Waterfall method gained popularity in the construction sector for presenting a linear and sequential approach to managing projects.[16] This method emphasizes step-by-step progress through phases, with each phase building upon the completion of the previous one.[17]

While the Waterfall method provides a solid structural framework, it has drawbacks, particularly in its lack of adaptability to changes or unexpected challenges.[16] Another important step toward formal PMMs was the establishment of the Project Management Institute (PMI) in 1969 to standardize project management practices through the publication of the Project Management Body of Knowledge (PMBOK). The PMBOK publication serves as a comprehensive guide to project management best practices.[16]

During the 1980s, the rapid advancement of personal computer technology facilitated the development of related software programs to manage and coordinate complex data and information required for project implementation.[18] Following this, Projects IN Controlled Environments (PRINCE2) was released in 1996 by the United Kingdom government's Central Computer Agency, though PRINCE2 originated in 1989.[18] In 1997, Critical Chain Project Management was introduced, focusing on resources required to complete a project rather than specific tasks, as in CPM or PERT.[9]

Agile methodologies emerged in the late 20th and early 21st centuries as a flexible, iterative approach to project management.[9] Its flexibility and cooperation marked a new perspective on the traditional linear methods.[18] In recent years, organizations have been shifting toward project management that combines the strengths of traditional and Agile methodologies, referred to as hybrid PMMs.[6] Hybrid PMMs integrate elements from traditional and agile methodologies, enabling organizations to benefit from the structured planning and predictability of traditional methodologies and simultaneously incorporating Agile principles such as flexibility, continuous collaboration, and swift response to changes and challenges.[19,20]

Overall, the historical evolution from informal practices to structured PMMs, and more recently to Agile and hybrid approaches, highlights a steady shift toward greater flexibility and responsiveness in project management. However, much of this literature focuses on tools and methods in stable conditions and has focused less on how these approaches perform under extreme uncertainty, such as a global pandemic, particularly within specific regional construction markets like Auckland.

Table 1 provides a comprehensive overview of

Table 1. Evolution of project management: A historical timeline

Period	Development and key characteristics of project management methods, tools, and techniques	Relevance to the construction sector during COVID-19
1917	Development of the Gantt chart by Henry Gantt: The Gantt chart is a scheduling tool used in project management for planning, scheduling, and tracking progress. As a visual representation, it illustrates tasks/activities, timelines, dependencies, and milestones	(i) Used to track delays and reschedule resources during lockdown periods (ii) Critical for managing approximately 7–15% productivity losses in construction projects
1957	Development of the CPM by DuPont Corporation: CPM is a project management technique used to plan and manage complex projects by identifying the critical path, which is the sequence of tasks that determines the overall duration of the project	(i) CPM/PERT used for managing uncertainty (ii) CPM enabled identification of cascading delays arising from supply disruptions (iii) PERT was essential for addressing unpredictability in construction scheduling during COVID-19
1958	Development of PERT by the US Department of Defense: PERT is a project management method used to analyze and represent tasks involved in completing a project. It is particularly useful for projects with high uncertainty in task duration.	

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Table 1. ***(Continued)***

Period	Development and key characteristics of project management methods, tools, and techniques	Relevance to the construction sector during COVID-19
Early 1960s	Introduction of the Waterfall method: The Waterfall method outlined a sequential flow of phases, including requirements, design, implementation, testing, deployment, and maintenance. The method gained prominence during the 1980s as a dominant project management approach due to its structured, linear, and predictable nature. However, in the late 1980s and 1990s, it faced criticism for its inflexibility in accommodating changes once a project was underway. Critics argued that its sequential structure limited responsiveness to evolving requirements and stakeholder feedback. Despite these limitations, the Waterfall model remains applicable to projects with well-defined requirements and minimal anticipated changes	(i) Waterfall limitations became evident during pandemic-related disruptions (ii) Struggled to accommodate mid-project changes arising from safety protocols (iii) More suitable for projects with well-defined, stable requirements
1962	Development of the WBS by the US Department of Defense: WBS provides a systematic and structured approach to defining, planning, and executing project activities. Its primary purpose is to decompose a project into manageable and well-defined components, facilitating planning, execution, and control. It is one of the most widely used project management tools	(i) WBS supported workforce management (ii) Enabled workforce reallocation despite labor shortages (iii) Facilitated coordination of remote teams
1969	Establishment of the PMI as a global professional organization for project management practitioners: PMI published the PMBOK Guide, which provides a comprehensive and standardized set of terminology, processes, and guidelines for project management. It serves as a foundational reference for practitioners and organizations and contributes to the global development of the discipline through standards, certifications, education, and professional networks	(i) Provided standardized frameworks for managing force majeure events, delays, and cost escalations (ii) Supported decision-making during unprecedented disruptions
1984	Release of the first version of Microsoft Project: Microsoft Project is a project management software developed by Microsoft that provides tools for project planning, scheduling, resource management, and collaboration. Throughout the 1990s, the software evolved with additional features and improvements, becoming a widely adopted project management tool that remains in use today	(i) Microsoft Project supported the remote coordination of project activities (ii) Essential for remote monitoring and real-time schedule updates (iii) Enabled coordination of distributed teams during lockdown periods
1986	Introduction of Scrum as an agile software development: Scrum is based on multiple small teams that are organized to promote collaboration, flexibility, and efficient product delivery. The core roles in Scrum include the Scrum Master, the Product Owner, and the Development Team. Although Scrum is intended to manage software development projects, it can be used as a general project and program management approach	(i) Scrum promoted adaptive collaboration (ii) Supported real-time monitoring and schedule updates (iii) Enabled coordination of distributed teams during lockdown periods (iv) Facilitated rapid adaptation to changing safety protocols (v) Daily stand-up meetings improved communication in remote work settings

(*Cont'd...*)

Table 1. (***Continued)***

Period	Development and key characteristics of project management methods, tools, and techniques	Relevance to the construction sector during COVID-19
1987	PMI published the PMBOK Guide: PMBOK provides a comprehensive and standardized set of terminology, processes, and guidelines for project management. It serves as a foundational reference for practitioners and organizations involved in project management	(i) Provided standardized frameworks for managing force majeure events, delays, and cost escalations (ii) Helped organizations navigate unprecedented project disruptions
1989	Introduction of PRINCE methodology by the UK Government, developed from PROMPT II: PRINCE was adopted for managing public sector projects due to its structured approach. In 1996, it evolved into PRINCE2, extending its applicability beyond IT projects to a wide range of industries. PRINCE2 is built on seven core principles: continued business justification, learning from experience, defined roles and responsibilities, managing by stages, managing by exception, focusing on products, and tailoring to the project environment	(i) Stage-based approach enabled re-baselining when disruptions exceeded tolerance thresholds (ii) Supported go/no-go decision-making as project conditions changed
1997	Development of CCPM: CCPM is a project management approach developed by Eliyahu Goldratt and grounded in the Theory of Constraints. It focuses on improving scheduling and execution efficiency by managing the critical chain of dependent tasks, incorporating strategically placed buffers to mitigate uncertainties, resource constraints, and variability in task durations. It aims to optimize resource utilization, reduce multitasking, and improve overall project efficiency and on-time delivery	Strategic buffers helped protect against unpredictable labor and material delays
Early 2000s	Agile Manifesto: Agile was formally articulated in 2001 by a group of software developers in the US. Since then, it has led to the development of multiple frameworks, including Scrum and Extreme Programming. These frameworks emphasize iterative development, frequent delivery, customer feedback, and collaboration within cross-functional teams. Agile emerged in response to the limitations of the Waterfall model, particularly its rigidity and linear structure. It prioritizes adaptability, iterative development, and continuous stakeholder engagement, enabling teams to respond effectively to changing requirements throughout the project lifecycle	(i) Agile promoted flexibility in project execution (ii) Supported rapid adaptation to changing safety protocols (iii) Daily stand-up meetings improved communication in a remote work environment
Present	Development and adoption of hybrid project management models: Hybrid models reflect a pragmatic approach to project management, acknowledging that no single methodology is universally applicable. Organizations increasingly combine structured traditional methods (e.g., Waterfall) with adaptive Agile practices to address diverse project requirements	Optimal for post-COVID contexts, combining structure planning in early phases with flexibility in execution phases

Note: This table was developed by the author based on literature from Doskočil,[16] Horning,[21] McCormick,[19] Seymour and Hussein,[13] and Walker.[14]
Abbreviations: CCPM: Critical chain project management; CPM: Critical path method; IT: Information technology; PERT: Program Evaluation and Review Technique; PMBOK: Project Management Body of Knowledge; PMI: Project Management Institute; PRINCE: Projects in Controlled Environments; PROMPTII: Project Resource Organisation Management Planning Technique II; UK: United Kingdom; US: United States; WBS: Work breakdown structure.

the evolution of project management, detailing key developments during different historical periods.

2.2. Use of project management methodologies, tools, and techniques in construction sector project management

Construction sector project management encompasses several important phases, such as planning, coordination, and execution of different tasks and resources to deliver a construction project successfully and within the given budget, schedule, and stakeholder requirements.[22] Managing these projects to ensure progress also involves addressing different complexities, such as constantly changing regulations, project delays, and complex supply chain issues, while coordinating many specialized disciplines such as architects, civil engineers, and mechanical engineers.[12,23-25]

Different dimensions of project organization—such as PMMs (e.g., Waterfall, Agile, PRINCE2)—and tools (e.g., Gantt charts, Kanban boards) play a distinct role in shaping project outcomes.[26] Furthermore, project management techniques, such as CPM, PERT, and risk management, contribute significantly to effective project planning and implementation. To provide a clearer view of the relationship between different elements of project organization, methodologies, tools, and techniques, a visual representation (Figure 1) is presented to illustrate their interconnections.

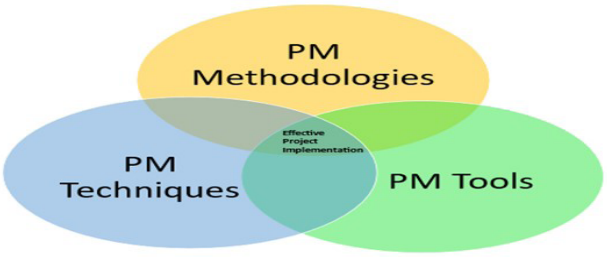

Figure 1. Interconnections among key dimensions of project management (PM). Conceptualized by the author, drawing on insights from Cagliano *et al.*,[27] Raz *et al.*,[28] Patanakul *et al.*,[29] and Richardson and Carstens.[26]

2.2.1. Project management methodologies

Project management involves a series of activities with defined start and end points, aimed at accomplishing project objectives with regard to schedule, budget, and performance.[30] PMMs encompass the application of knowledge, skills, tools, and techniques to meet project requirements.[16] In simpler terms, employing the appropriate methodology enables a project manager to identify and mitigate risks, control costs, and adhere to project schedules.[31]

To manage a construction sector project, project managers apply different PMMs, tools, and techniques to achieve the objectives set during the pre-construction and post-construction phases.[16,23,32] These PMMs, tools, and techniques assist the project manager in planning and completing the necessary project tasks efficiently.[16] Depending on the project type (e.g., large or small buildings or infrastructure), the project manager can choose and use the appropriate PMMs, tools, and techniques to manage and control the project effectively.[14,33]

Figure 2 illustrates some of the most common PMMs in use today, offering a visual representation of the diverse approaches employed by project managers to plan, execute, and control projects effectively in dynamic environments.

In the context of construction sector project management, the Waterfall method is one of the most widely used traditional methods. It requires a step or phase to be fully completed prior to proceeding to the subsequent one.[33] It is frequently compared to alternative PMMs, such as Agile, which is a flexible and iterative approach that involves developing a project in stages, as opposed to meticulously planning it from the beginning before commencing.[19] This method involves distinct phases, such as requirements specification, analysis, design, construction, integration, validation (testing), installation, and maintenance.[19]

Figure 3 shows the Waterfall method flowchart with steps involved in a project, where each phase must be completed before moving to the next.[16,33] The Waterfall flowchart assumes that all phases are known upfront and that the project can proceed through a series of well-defined phases.

Phases below are modified based on Al-Zwainy *et al.*[33]

(i) Planning phase: Detailed planning and documentation are carried out before construction work commences. In this phase, the project scope is defined, including the objectives, deliverables, constraints, and assumptions. It also includes a feasibility study, risk assessment, resource planning, budgeting, quality planning, a communication plan, procurement planning, and approval and permits.

(ii) Design phase: The design phase comes after the planning phase. This phase starts with the architectural design of the layout, structure, and spatial relations, followed by structural design, mechanical, electrical, and plumbing design, material specifications, cost estimation, client approval, regulatory compliance, design documentation, and design review.

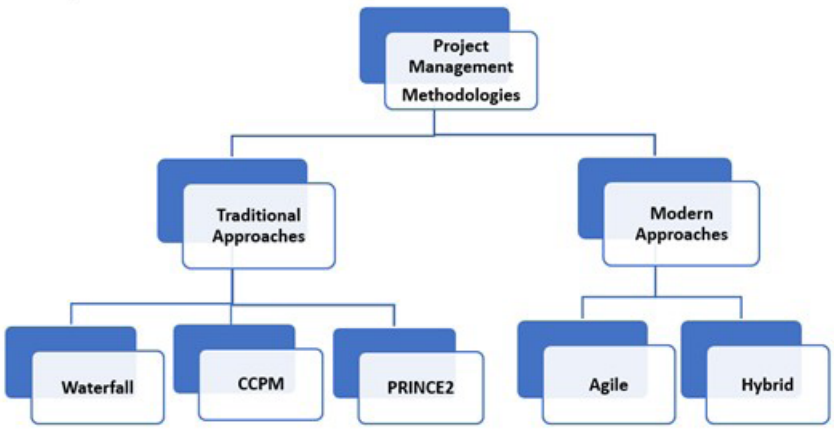

Figure 2. Commonly used project management methodologies in current practice. Conceptualized by the author, drawing on insights from Doskočil,[16] Al-Zwainy *et al.*,[33] Islam and Evans,[18] and McCormick.[19]
Abbreviations: CCPM: Critical chain project management; PRINCE2: Projects IN Controlled Environments.

(iii) Implementation phase: This phase involves the implementation of the construction project according to the specifications of the finalized design. The main activities in this phase include construction work, material procurement, quality assurance, project management, communication and reporting, risk management, change control, health and safety compliance, and client updates.
(iv) Verification phase: This phase involves inspection to determine if the project is built according to the requirements and design specifications, and to determine whether the project deliverables satisfy the intended use and the client's expectations.
(v) Handover phase: This is the final phase after construction work is completed and verified. The project is formally handed over to the client.
(vi) Maintenance phase: This phase takes place after handover, where there is ongoing maintenance to ensure the project continues to function effectively.

This methodology simplifies project execution through a sequential approach, enabling the construction team to comprehend and progress toward the project objectives easily. The Waterfall sequential approach provides a structured framework for managerial control, aligning activities with predefined deadlines and defining the project objectives and deliverables.[19,33] However, using the Waterfall approach in construction sector projects is not without challenges.[33] The requirement to restart the entire project in case of a fault or error can be a significant disadvantage, potentially leading to time and resource inefficiency.[34] Furthermore, the sequential nature of the Waterfall approach restricts the overlap of phases, potentially reducing efficiency, particularly in construction sector projects that often involve iterative and overlapping activities.[33] While advantageous for projects with well-defined scopes, the method may not be suitable for complex construction projects that require adaptability and concurrent task processes.[16] Therefore, project managers should adopt the Waterfall approach when it suits the unique characteristics of their construction projects.[16,19,35]

One of the traditional methodologies is PRINCE2—a process-oriented methodology employed for effective project management, originally developed in response to the United Kingdom government's need to address common challenges in project management.[18] It was created during the 1980s, with the aim of ensuring timely, cost-effective, scope-compliant, and quality-driven project delivery.[18]

According to Lalic *et al.*[6], project managers in the construction sector engage in coordinating stakeholders to ensure successful project completion. To achieve this, they rely on established and proven traditional PMMs.[18] While they can rely on traditional PMMs, they can also explore modern PMMs like Agile and hybrid approaches that align with the iterative characteristics of construction sector projects.[6,18]

The Agile approach is popular in the information technology (IT) industry.[36] Agile was first introduced by Mohammed and Syam Chambrelin[20] as a departure from the traditional PMMs' structured approach, moving toward more flexible project management styles.[20] Construction sector projects are, by nature, dynamic, with significant time and budget investments, and in most cases, they undergo several changes requiring rework, resulting in time and cost overruns as major drawbacks.[37] Therefore, the Agile approach enables responsiveness to change, ensuring project success and profit during unforeseen situations.[36] Because Agile emphasizes adaptability, collaboration,

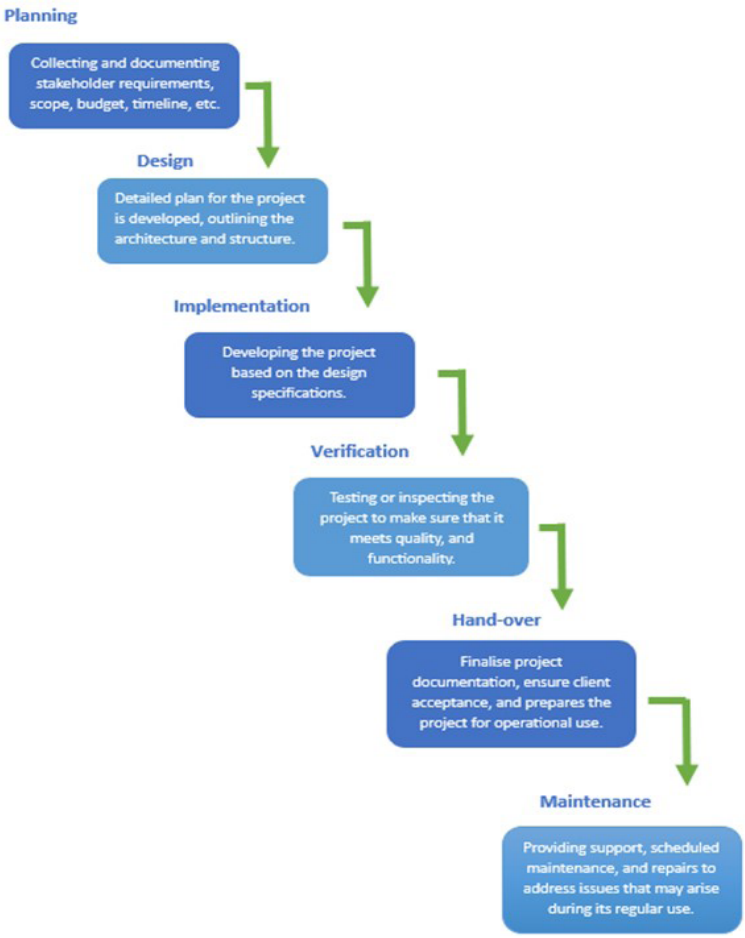

Figure 3. Waterfall methodology flowchart. Conceptualized by the author, drawing on insights from Al-Zwainy *et al.*,[33] Kerzner,[34] McCormick,[19] and Doskočil.[16]

and continuous improvement, it enables the construction team to respond effectively to changing priorities.[19] This makes Agile appropriate for managing change impacts and enabling successful project implementation.[36] One well-known Agile approach is Scrum, initially applied in the IT sector and consisting of a scrum team, scrum events (sprints or daily goals), and scrum artifacts (Figure 4).[38]

Project managers are flexible when it comes to choosing the most appropriate PMM for their projects and can decide to combine elements of traditional and agile PMMs[39], known as a hybrid approach. A hybrid approach offers better adaptability while still offering a structured framework for project delivery.[39] Streule *et al.*[38] reported that the Scrum approach can be adapted for construction sector projects. It is possible to implement the Scrum framework in the design and planning stage of construction while combining it with a traditional sequential PMM, such as the Waterfall method. Using Scrum during these phases has proven to be efficient by offering more clarity, better communication and cooperation, improved information flow, and faster project progress. Using daily Scrum meetings in construction projects ensures that the construction team is informed of progress and daily goals set by other working teams on the same site. Similarly, Scrum is valuable in construction sector projects for its daily updates on project details, which improve project management performance.[39]

Besides these PMMs reviewed, several international institutions, such as PMI, have developed project management frameworks to support project managers in effectively managing their projects. PMI offers a structured methodology with a set of best practices to guide project managers in planning, executing, and monitoring projects.[40] PMI has played a significant role by establishing standards, offering certifications, providing educational resources, and fostering a community of professionals in the project management field.[40] With its development of the PMBOK Guide, it has provided construction professionals

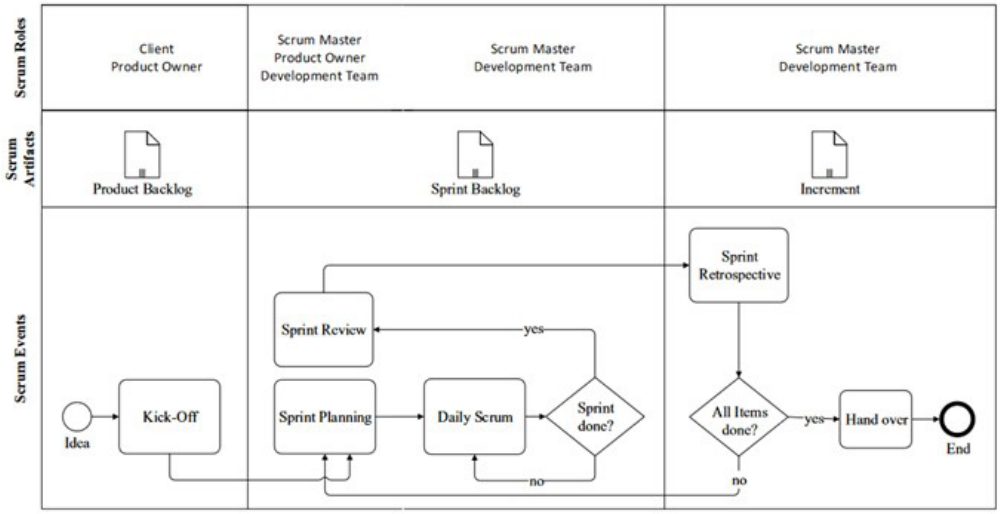

Figure 4. Scrum–Agile project management method. Reprinted from Streule *et al.*[38]

with a framework and tools to plan, execute, and control construction sector projects effectively, ensuring that resources are optimally utilized, financial aspects are well-managed, risks are identified and mitigated, and health, safety, and environmental factors are appropriately addressed.[39]

2.2.2. Project management tools and techniques

Project management tools and techniques are resources, methods, or software solutions employed for effective project management.[17] These tools and techniques assist in organizing project tasks, resources, and timelines, enabling project managers to monitor progress, manage risks, and ensure successful project completion.[26,27] Various tools and techniques used in the construction project sector are examined based on their functionalities to enhance planning, scheduling, communication, and overall project control.[30]

Doskočil [16] highlights that project management tools encompass software solutions that aid in project planning and management and typically integrate various tools and techniques for effective project management. Microsoft Project is widely recognized and used in projects for efficient and effective project planning, scheduling, portfolio management, resource management, risk management, contract management, project execution, and project reporting.[4,41,42] The use of Microsoft Project enables project managers to use Gantt charts, project tables, and network diagrams to plan and schedule projects, create scope, perform risk analysis, and establish resource baselines.[43,44] This software also provides strong project reporting functionality, assisting project managers in preparing and generating reports on costs, resources, and activity timelines.[42,45]

Microsoft Project offers a handy solution for managing construction sector projects as it provides numerous benefits, such as the ability to create a detailed construction schedule, use the CPM, and effectively organize one or multiple teams. This enables project managers to ensure that tasks are well distributed, thereby meeting project deadlines.[42,45] Project managers also use various other tools and techniques—such as Gantt charts, CPM charts, PERT, and the WBS—to schedule and monitor their project activities.[43,44]

The Gantt chart, introduced in 1917 by Henry Gantt, has been used in construction projects since 1931[15] and is accepted as a standard technique for construction project management.[16,46] It is a visual representation of tasks and a common scheduling technique, which is easily understood in project scheduling.[16] Gantt chart tasks are represented through bars indicating the start, duration, and end. This technique is used to communicate the entire project plan status, guiding the activity sequences and providing task dependencies.[47] Figure 5 shows a Gantt chart created using Microsoft Project.

Network charts such as PERT or CPM were developed by different professionals around the 1950s.[9] Both techniques continue to be used in conjunction with one another.[23] The CPM is a popular scheduling technique used in the construction sector projects due to its simplicity and effectiveness.[23] This technique offers a graphical view of the project activities, showing the interdependencies between them, calculating the required resources and time, and

determining critical activities that require attention.[9] The utilization of this technique enables the project manager to focus on critical path activities, facilitating the completion of work within the allocated time and budget.[23]

Figure 6 illustrates the CPM for a construction project, providing an overview of task sequences and dependencies within the project. This, in turn, contributes to effective time management, as emphasized by PMI in 2013.[23] It identifies the critical path, which represents the sequence of project tasks that determines the shortest duration for project completion.[23] Any possible delay in completing a task will impact the project timeline.[9] The duration and dependencies between tasks are established, helping to understand the order in which tasks must be completed. The technique also estimates slack (float), which represents the amount of time a task can be delayed without affecting the project completion date.[9] The CPM also provides early start and early finish times determined by the forward pass, as well as late start and late finish times determined by the backward pass, thereby aiding the project manager in optimizing the project schedule.[23]

The CPM is often integrated with other project management techniques, such as PERT, for a more comprehensive approach.[9] According to Landau[9], PERT is a project network analysis method employed for the planning and control of large construction sector projects. It places significant emphasis on understanding the interplay between the duration and costs of individual activities and their cumulative impact on the projected completion time and overall project expenses.[48,49] In addition to CPM and PERT, the WBS is a method for organizing project activities into smaller, more manageable components, each of which represents a work phase or deliverable.[9] As outlined by Doskočil[16], as one moves down the hierarchy, each lower level provides a more detailed breakdown of the project's tasks and responsibilities. The WBS, as highlighted by Alotaibi *et al.*[23] and Zecheru and Olaru[50], facilitates project managers in efficiently allocating time to different embedded tasks within the project, promoting timely completion and manageability, and enabling easy planning and scheduling of activities.

Project management tools also include communication tools that ensure effective communication, playing a significant role in successful outcomes.[51] The Kanban board is a widely used communication tool.[51] It is a visual management tool that comprises a large board with moving

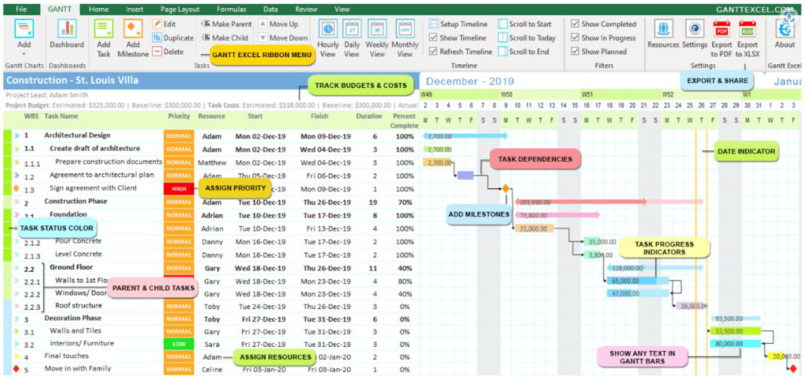

Figure 5. Construction Gantt charts. Construction Gantt chart sourced from GanttProject (https://www.ganttproject.biz), distributed under the GNU General Public License (GPL v3).

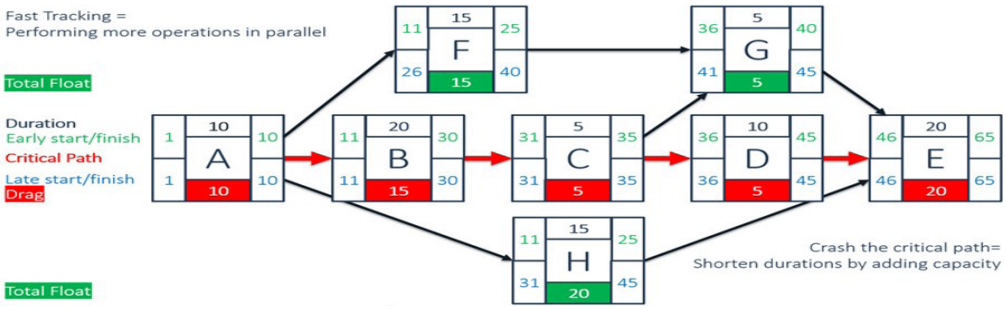

Figure 6. Critical path method in construction projects. Adapted from STAEDean Bentley https://bcdocs.staedean.com/md/en-US/IEMAJMCriticalPath. The red arrows indicate the critical path, representing the sequence of project activities that determines the shortest possible project duration.

cards representing project activities, and project managers use it for task assignment and progress reporting.[51] It is employed in different ways—either as a physical board placed in a main conference room for in-person team meetings or as virtual Kanban software, which offers a simpler and more convenient solution for remote team meetings.[38]

Figure 7 depicts a virtual Kanban board created using Trello. Trello is a popular project management and collaboration tool that uses boards, lists, and cards to aid project managers or project teams in organizing their tasks and setting priorities.[52] This tool helps to represent project work visually and allows the creation of multiple boards for different projects or teams.[52] It provides efficient exchange of information, progress reporting, and task assignment. It facilitates communication between the project team and stakeholders.[53] There are various communication tools used in project management, such as video conferencing, individual or group e-mail exchanges, telephone calls, messaging tools, and the use of control rooms.[53] Control rooms are centralized spaces or hubs where project activities are monitored, coordinated, and controlled.[53] These rooms are equipped with tools and technologies that provide real-time information and enable decision-makers to oversee various aspects of a project.[30,32]

According to Elia *et al.*[54] and Kapsali[55], the choice and use of PMMs, tools, and techniques depend on project management practices and the project manager's professional experience and personal preferences. With effective use of the PMMs, tools, and techniques, project managers can optimize the outcomes of their projects and contribute to the overall understanding and advancement of the project management field. Burke[30] reported that the effective use of PMMs, tools, and techniques is critical to managing construction projects toward successful outcomes.[30]

2.2.3. Impact of COVID-19 on construction sector project management

As COVID-19 emerged globally in December 2019[56], causing global disruption and uncertainty, businesses across many sectors worldwide were severely impacted. The construction sector particularly experienced significant challenges and obstacles.[3,57] Construction sector project management encountered unforeseen disruptions, resulting in delays, workforce shortages, and supply chain interruptions.[3,8,58,59]

Several studies consistently highlighted the unexpected difficulties that projects in the construction sector faced during COVID-19. These challenges included unprecedented project delays, border closures, social distancing requirements, project halts and postponements, health and safety issues, permitting (authorization) delays, and potential conflicts and disputes.[3,8,58,60] The present study further discusses the challenges and the effects of COVID-19 on the construction sector.

(a) Social distancing

The COVID-19 pandemic impacted the construction sector through measures such as social distancing[61], closures, and health and safety regulations.[3] To control COVID-19 and protect all individuals, including construction workers[62], many countries implemented social distancing and phased lockdowns[12], resulting in the suspension of business operations, including those in the construction sector.[12] The COVID-19 situation affected the entire construction process. In response to the rapidly evolving COVID-19 situation, businesses across various sectors, including construction, adapted their operations to comply with government rules and regulations on social distancing and health and safety requirements. While many businesses continued their services through remote working, construction projects faced a unique challenge due to their nature, which typically requires physical presence and collaboration.[8]

Waheeb *et al.*[62] stated that construction project success depends, among other factors, on the availability of a skilled workforce to execute project plans and deliverables. As social distancing measures were imposed, the workforce on construction sites was reduced, causing delays and thereby extending project completion timelines.[8] The reduction in on-site workforce also contributed to delays in project completion and negatively affected the quality of deliverables and site operations.[63] Social distancing measures also affected recruitment and training of construction workers[64], thereby disrupting normal construction sector operations. In addition, lockdowns restricted workers' mobility, making it difficult for them to reach construction sites and further limiting construction activities.[63]

(b) Supply chain disruptions

The construction sector was further impacted as countries closed their borders and widespread COVID-19 restrictions were implemented. However, overseas construction sector projects deemed essential, such as healthcare facilities and public utilities, continued to operate.

A notable disruption emerged in the supply chain as certain manufacturing facilities, material suppliers, and transportation companies—key components of construction project delivery—faced temporary closure, as they were classified as non-essential.[3] Non-essential projects were generally defined as those not prioritized

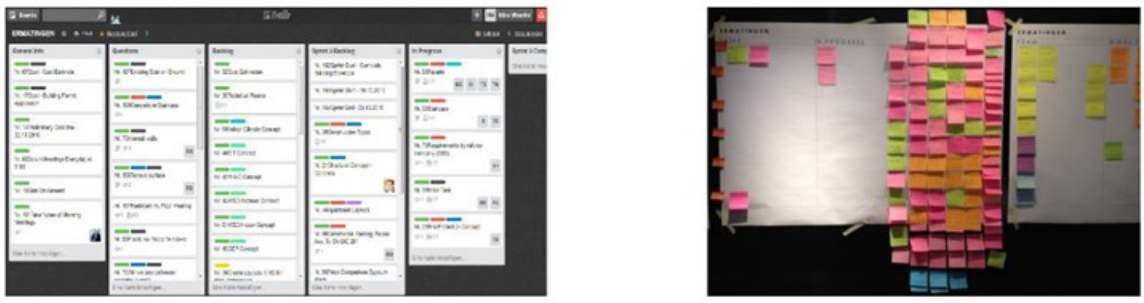

Figure 7. Kanban boards: (A) Virtual and (B) physical Kanban boards. Reprinted from Streule et al.[38]

for immediate implementation, such as hospital facilities, roads, and other public infrastructure projects.[3] Supply chain disruptions occurred due to social distancing and health and safety measures implemented to reduce COVID-19 transmission[65], which subsequently affected the production of essential construction materials.[63,65]

This situation led to delays and interruptions in the supply chain, disrupting the flow of materials required for construction activities.[65] These supply chain issues were a consequence of strict COVID-19 restrictions, where workforce absences due to infection or quarantine periods further strained supply chain operations.[62]

Social distancing and quarantine protocols[12] also contributed significantly to supply chain disruption by reducing the workforce within supply chain organizations, thereby intensifying operational challenges across the supply chain network.[62] Material delivery delay, particularly from international sources, further slowed construction progress, resulting in substantial schedule disruptions.[3,57]

According to Ghandour[63], project managers were required to map their entire supply chain in detail and implement anticipatory strategies in response to COVID-19. This included identifying alternative sourcing options, determining suitable stockpiling locations, and reassessing contingency budgets for procurement and expedited delivery of critical materials.[62]

(c) Communication challenges

The COVID-19 pandemic imposed challenges on communication dynamics within the construction sector, necessitating immediate adjustments in both internal and external project management practices.[62] According to Ghandour[63], although the construction sector is not traditionally associated with remote working, the implementation of COVID-19 restrictions led to the adoption of remote communication practices, requiring greater organizational adaptability.

Remote working, although new to construction project management, was applied in areas such as reporting, daily and weekly meetings, work schedule distribution, and attendance tracking. The construction sector had to adapt to virtual meetings as a feasible substitute for face-to-face interactions. Despite this, the loss of informal communication posed a significant challenge, as such interactions are an important component of effective coordination.[66,67] Remote or online communication also required considerable effort from project teams, as some members lacked familiarity with digital communication tools.[3,64,67]

While some project managers worked remotely, on-site work was limited, and certain projects could only operate a few days per week.[64]

(d) Project delays and postponements

The construction sector, similar to other sectors, encountered substantial disruptions due to COVID-19, such as project delays and postponements. Government-mandated COVID-19 restrictions, including lockdowns and limitations on movement, led to a reduction in on-site workforce availability, thereby hindering construction project continuity.[12] These restrictions were implemented to slow and stop virus transmission, but inevitably disrupted construction operations and delayed project progress.[12]

According to Zamani *et al.*[57] and Ghandour[63], project delays and postponements became a major concern, reshaping the construction sector landscape. These challenges prompted a re-evaluation of project timelines, costs, and implementation strategies. Projects were delayed not only due to site closures but also because of delays in obtaining administrative approvals from relevant authorities, as many offices were closed during restrictions.[57,63]

Several construction projects experienced extensions of contract durations approaching twice their initial estimates,

resulting in increased costs and further contributing to schedule delays and project postponements.[62] Social distancing and health and safety protocols[61] emerged as significant contributors to operational inefficiencies and delays.[62] The need to ensure on-site worker health and safety led to reduced workforce presence and modifications in construction practices.[68]

Additionally, the global impact of COVID-19 prompted foreign construction workers to return to their home countries for quarantine, further affecting the availability of skilled labor and disrupting project implementation.[3,62,68] As a result, project deliverables were significantly affected, adding further challenges to construction project planning and delivery timelines.

(e) Risk management challenges

According to Waheeb *et al.*[62], project risk management planning enables project managers and teams to make appropriate decisions and implement suitable strategies for project completion, while accounting for associated risks. These processes were critically important during COVID-19, where adaptive action and flexibility were essential in the construction sector.[62,67] As the construction sector faced disruptions in supply chains, social distancing requirements, workforce availability issues, and changing regulations, risk-related complications requiring active management became unavoidable.[67] Iqbal *et al.*[67] stated that the primary responsibility of construction companies includes ensuring continuity of project delivery while prioritizing worker health and safety.

The COVID-19 pandemic introduced new challenges to risk management planning. Traditional risks, such as cost overruns[37], schedule delays, and design changes, were exacerbated by COVID-19–related disruptions[67]. These challenges included extended project timelines, workforce shortages, travel restrictions, and mandatory quarantine measures.[62, 63,67]

Furthermore, the rapidly evolving health and safety regulations required more flexible and adaptive risk management approaches, involving continuous monitoring of the COVID-19 situation to mitigate potential infection risks among the construction workforce.[66]

2.3. Impact of COVID-19 on project management methods, tools, and techniques

Building on the existing literature on COVID-19 impacts within the construction sector is essential to further understand how these challenges were mitigated, particularly through PMMs, tools, and techniques. This subsection focuses on the dynamic relationship between these challenges and the corresponding adaptations made to project management practices in the construction sector during the pandemic.

As the impact of the COVID-19 pandemic persisted, the construction sector was required to adapt and adopt PMMs, tools, and techniques capable of addressing emerging challenges and evolving project conditions.[65] Adapting to new work practices, adhering to government restrictions and guidelines, and embracing technology became critical components of effective project management.[8] Despite these challenges, COVID-19 also created opportunities for project managers and construction professionals to explore and implement alternative PMMs that could better mitigate these disruptions.[60] According to Alsharef *et al.*[3], construction companies facing reduced workloads and project postponements during COVID-19 leveraged temporary governmental restrictions as an opportunity to reassess and improve their operational processes and procedures.

Traditional PMMs such as the Waterfall method, PRINCE2, and frameworks such as PMBOK are characterized by structured planning, defined budgets, and clearly specified task allocations, deliverables, and timelines established upfront with stakeholders.[69] Projects using these traditional PMMs typically follow a sequential, phase-based approach, ensuring that each step is completed before progressing to the next.[60] However, the COVID-19 pandemic introduced sudden disruptions, including project postponements, site closures, supply chain interruptions, and social distancing requirements. These factors created complexities that traditional PMMs were not inherently designed to accommodate, resulting in cascading effects across construction projects.[57]

The inherent rigidity of traditional PMMs, which emphasizes linear progression and strict adherence to pre-established plans, limits their effectiveness under rapidly changing pandemic conditions.[60] Project managers were required to adopt adaptive strategies to navigate these disruptions while ensuring worker health and safety.[3] Consequently, some construction companies shifted toward more flexible PMMs to better respond to evolving project environments.[65] Risk management within traditional PMMs typically involves formalized processes, extensive analysis, and predefined response plans. In contrast, Agile PMMs provide a more flexible approach, enabling project teams to identify and respond to risks continuously and in real time during iterative cycles.[3,8,65] This approach emphasizes collaboration, communication, and responsiveness to change, allowing teams to address emerging risks more effectively under uncertain conditions.[8] As a result, the construction sector increasingly adopted proactive risk management strategies

and agile methodologies to mitigate disruptions and maintain project continuity.[66]

Agile PMMs emerged as a potential solution due to their practicality, flexibility, and capacity to accommodate change.[59,63,69] Bushuyev *et al.*[66] emphasized that frequent and direct communication within Agile PMMs promotes open and transparent collaboration among team members. However, COVID-19–related requirements, including health and safety protocols and social distancing measures, constrained face-to-face interactions.[61] Consequently, communication among team members became increasingly critical during the pandemic. Traditional PMMs were less effective in maintaining rigid communication structures, such as predefined reporting lines and scheduled in-person meetings.[8] This shift highlighted the need for more adaptive communication approaches to sustain effective collaboration and decision-making amidst COVID-19–related disruptions.[59,63,69]

Pamidimukkala and Kermanshachi[64] emphasized the importance of adopting digital tools and promoting technology-driven solutions, such as virtual meetings, within the construction workforce during COVID-19. This facilitated remote working, helping to mitigate challenges related to social distancing, work scheduling, and communication constraints. Other strategies included extending project deadlines, performing risk analyses, and developing supply chain mapping as preventive measures against disruptions while maintaining project schedules.[59,63,69] The adoption of digital communication platforms, such as Zoom and Microsoft Teams, enabled construction companies to sustain essential communication through virtual meetings.[3,69] Additionally, for companies using Kanban boards to visualize and track project progress, COVID-19 necessitated the digitalization of these tools to ensure continuous project monitoring.[57]

The impact of COVID-19 on PMMs extended beyond social distancing, communication, and risk management. Increased integration of digital technologies, greater emphasis on risk mitigation and preparedness, and the promotion of supportive work environments are expected to influence the future of PMMs in the post-COVID–19 context.[36] Amid ongoing uncertainty in the construction sector, the ability to adapt to change, leverage technological solutions, and prioritize workforce well-being remains critical for achieving project success in the evolving operational landscape.[8]

2.3.1. Construction project management in New Zealand

The impact of COVID-19 on industries worldwide, including the construction sector, was substantial.[8] As countries implemented countermeasures to mitigate their effects, it is crucial to understand both the impacts and the strategies adopted within the construction sector.[12] This section examines the impact of COVID-19 on the construction sector in New Zealand, with a focus on PMMs, tools, and techniques, while also identifying existing research gaps.

This section specifically focuses on the construction sector in Auckland, New Zealand. This focus is justified for several reasons. Auckland, the largest and most densely populated city in New Zealand, is characterized by complex urban dynamics, extensive transportation networks, and high infrastructure demand.[70] The construction sector in Auckland experienced significant growth in 2019 and emerged as a key driver of economic development.[71] Auckland plays a central role in New Zealand's economy, with its construction sector contributing significantly to national growth and development.[8] Several major infrastructure projects are underway in Auckland, including the rail network rebuild, housing programs, water infrastructure projects, and the Northern Seawall development.[72]

In New Zealand, relatively few studies have examined the impact of COVID-19 on the construction sector.[8] However, Mirhosseini *et al.*[8] specifically investigated New Zealand's response to COVID-19 and its implications for the construction sector. Their study analyzed governance measures implemented in New Zealand and examined how the construction sector responded and adapted across different alert levels.[8] Cumming[12] investigated government strategy during COVID-19 and found that the "go hard, go early" approach has substantial impacts on the construction sector, resulting in delays to approximately 4,600 projects and affecting around 40% of construction companies due to material and equipment shortages.[8] However, this study primarily focused on government policies rather than project management practices within the construction sector.

Table 2 presents a summary of COVID-19 restrictions across different alert levels in New Zealand and their corresponding impacts on the construction sector.[73]

According to PwC[74], New Zealand experienced weaknesses in construction project management and planning, partly due to insufficient project management competencies among project managers. Therefore, it is suggested that the sector prioritize upskilling initiatives and promote the adoption of appropriate PMMs, particularly in the context of COVID-19.[75] Additionally, the New Zealand government was advised to implement supportive measures and allocate funding to ensure the continuity of

construction projects.[75] However, despite these efforts, the sector continued to experience delays and extended project timelines, largely due to lockdown measures imposed during the pandemic. Similarly, Townsend[76] highlighted the effects of COVID-19 on the sector, emphasizing that limitations in professional services—particularly project management capacity—were exacerbated by supply chain disruptions, inadequate project processes, financial constraints, and reduced communication efficiency associated with remote working.

As the New Zealand construction sector responded to the impacts of COVID-19, Mirhosseini *et al.*[8] and Cumming[12] highlighted the challenges arising from government-imposed restrictions, emphasizing the significant disruptions and slowdowns experienced by the sector. Furthermore, Gunasekera and Omisakin[77] provided further insight into how construction companies navigated these challenges through structured project management practices. Their study explored perceptions of project success, critical success factors, and the utilization of formal project management processes, offering more detailed insights into sector performance. The study also acknowledged the importance of project management technology adoption as a key determinant of successful project outcomes in New Zealand.

2.3.2. Research gap

Collectively, the literature indicates that only a limited number of academic studies have examined the impact of COVID-19 on construction project management in New Zealand, with even fewer focusing specifically on Auckland. Existing studies have primarily addressed government responses, governance measures, and broad sectoral impacts, rather than examining how COVID-19 influenced the selection and application of PMMs, tools, and techniques at the project level. The present study addresses this gap by exploring how project managers and construction professionals in Auckland adapted their project management practices during COVID-19 and assessing the implications of these adaptations for future construction project management in New Zealand.

3. Methodology

3.1. Research design

The research design was informed by an interpretivist paradigm and employed a qualitative approach for data collection and analysis. The interpretivist approach focuses on understanding and interpreting the meanings individuals ascribe to their experiences, recognizing that reality is subjective and shaped by context, culture, and human perspectives. This approach was appropriate for this study because it aimed to generate in-depth insights into how construction project managers and professionals experienced and responded to the impacts of COVID-19 on project management practices.

A non-probability purposive sampling approach was used to recruit participants with relevant expertise and experience.[21] This decision reflected the unique characteristics of the construction sector and the diverse roles and responsibilities of project managers and construction professionals.[21,78] The present study focused on project managers and construction professionals working on projects in Auckland, New Zealand, as they were directly involved in managing projects before and during COVID-19 and were therefore well-positioned to provide informed perspectives on changes in the use of PMMs, tools, and techniques.

Primary qualitative data were collected through semi-structured interviews conducted with participants. The open-ended nature of the interviews facilitated in-depth exploration of participants' experiences, contributing to a richer understanding of the subject matter.[3] These interviews enabled participants to articulate their perspectives on the impact of COVID-19 on construction project management practices in Auckland, New Zealand.

The data were analyzed using thematic analysis, a widely adopted qualitative method for identifying, analyzing, and reporting patterns (themes) within data.[3,57,59] This approach provided a structured framework for organizing and interpreting the data, ensuring systematic and rigorous analysis of the research findings.

Ethical considerations were integrated throughout the research design. Appropriate measures were implemented to ensure confidentiality, obtain informed consent, and protect participants' rights and well-being, thereby maintaining the overall integrity of the study.

3.2. Semi-structured interview design and participant selection

The research methodology provides a systematic framework that guides the inquiry process, enabling a structured investigation and understanding of complex phenomena.[79] This study employed a qualitative approach, which offers flexibility through a range of data collection techniques and facilitates in-depth exploration of participants' experiences.

In this study, the qualitative approach was selected based on its demonstrated effectiveness in prior research, particularly in studies conducted by Alsharef *et al.*[3] and Zamani *et al.*[57] These studies used qualitative methods to

Table 2. COVID-19 restrictions according to alert levels in New Zealand

Alert level	Restriction applied under each alert level
Level 1 (prepare)	• All businesses, facilities, schools, education providers, and workplaces can open • NZ COVID Tracer QR codes issued by the NZ Government must be legally displayed in workplaces and on public transport • The following places are legally required to have systems and processes to ensure visitors keep a record of where they have been (whether via the NZ COVID Tracer app or otherwise), including healthcare facilities, aged care facilities, close-contact businesses, hospitality venues, public facilities, and social gatherings such as weddings, funerals, and *tangihanga* • In all other places, keeping a record of movements is encouraged, as this helps contact tracing identify potential COVID-19 spread
Level 2 (reduce)	• You can connect with friends and *whanau* (family) in person, socialize in groups, and go shopping and travel domestically, provided public health guidance is followed • You can return to your workplace or place of learning, but alternative arrangements are still encouraged • Businesses, schools, early learning services, tertiary education providers, and public facilities, such as museums, libraries, and pools, can open with additional health measures in place • Gatherings of up to 100 people in a defined space are allowed, including weddings, funerals, and *tangihanga*. Mandatory record keeping (as in Alert Level 1) and physical distancing are legally required • Hospitality businesses must legally keep customer groups separated and seated. Physical distancing of 1 meter must be applied; this determines the maximum capacity of the venue • Event facilities, including cinemas, stadiums, concert venues, and casinos, can open. Physical distancing of 1 meter must be applied; this determines the maximum capacity of the event •Individuals aged 12 and over are legally required to wear face coverings
Level 3 (restrict)	• Stay home and keep your bubble small. You can expand it to reconnect with close *whanau* (family), enable caregiving, or support isolated people. This extended bubble must remain exclusive under legal requirements • Travel remains restricted; stay local. Inter-regional travel is highly limited and permitted only under specific conditions. Travel is allowed for work, education, access to necessities, contactless purchase collection, or low-risk recreational activities. Work and study from home where possible • Only individuals who cannot work from home should return to businesses that are permitted to operate under Alert Level 3 • Individuals aged 12 and over are legally required to wear a face covering in specified settings. It is recommended to wear a face covering whenever leaving the home • Gatherings of up to 10 people are permitted for weddings, civil union ceremonies, funerals, and *tangihanga* (excluding staff). Up to five staff may be present. Physical distancing and record-keeping are legally required
Level 4 (lockdown)	• Stay at home within your household bubble • No travel is permitted except for essential purposes or approved low-risk recreational activities. Work and study must be conducted from home • No gatherings are allowed. All public and educational facilities are closed • Individuals working in Alert Level 4 permitted services may extend their household bubble to include a carer for children if no alternative childcare is available • Businesses must close except for essential services (e.g., supermarkets, pharmacies, petrol stations) and lifeline utilities. Greengrocers, butchers, bakeries, and fishmongers may sell uncooked food online and must deliver all orders

Note: Adapted from Pacific Economic Cooperation Council.[73]

examine the early impacts of COVID-19 on construction project management. Alsharef *et al.*[3] employed semi-structured interviews with construction project managers and professionals, revealing significant disruptions such as project delays and material shortages, alongside new opportunities including accelerated medical facility construction and workforce adjustments. Similarly, Zamani *et al.*[3] conducted interviews with project managers and construction company owners, providing insights into the need for financial support and access to comprehensive information to address operational and financial challenges, thereby informing policy responses. These studies demonstrate the suitability of qualitative approaches for capturing nuanced perspectives and lived experiences related to COVID-19 impacts within the construction sector, thereby supporting the methodological choice and alignment with the research objectives of the present study.[3,57]

The semi-structured interview template was developed to capture perspectives on the impact of COVID-19 on the construction sector in Auckland, New Zealand. Primary data were systematically collected from participants, forming the foundation of a rigorous and comprehensive investigation.[78,80] Interviews were conducted to elicit in-depth insights into construction project management practices during COVID-19 in Auckland, New Zealand.

The interviews involved construction project managers and professionals who possessed substantial experience in both pre- and post-COVID–19 contexts, ensuring

a comprehensive exploration of the challenges and adaptations encountered within the construction sector. The selected participants had direct, hands-on experience managing construction projects during the pandemic.

To ensure that participants could provide relevant and informed insights, we utilized professional networks and purposive selection criteria to identify individuals with project management experience across pre- and post-COVID–19 periods. Participants were selected based on their extensive involvement in project management throughout the pandemic. This approach enabled the study to examine the impact of COVID-19 on the selection and application of construction PMMs, tools, and techniques, as highlighted by Doskočil[16], Koch and Schermuly[59], and Ogunnusi *et al.*[60]

3.3. Primary data collection procedure

When undertaking research, data collection plays a fundamental role.[57] Data collection refers to the systematic process of gathering information required to address a research problem.[81] Primary data collection can involve multiple methods, including observations, interviews, questionnaires, and database analysis.[57,81] After careful consideration of the research topic and objectives, semi-structured interviews were selected as the primary data collection method.

The semi-structured interview guide comprised 16 open-ended questions aimed at exploring the use of PMMs, tools, and techniques before and during the COVID-19 pandemic, as well as associated impacts and adaptations. The questions were developed based on existing literature on construction project management, PMMs, and COVID-19 impacts.[3,8,62], and were aligned with the four research objectives.

A draft set of questions was reviewed by two academic experts in project management and one senior construction project manager to assess content validity, relevance, and clarity. Their feedback led to refinement of wording, removal of overlapping items, and reordering of questions to ensure a logical progression from pre-COVID–19 practices to COVID-19 adaptations and reflections on future practices.

A mock interview with a construction management professor at Otago Polytechnic Auckland International Campus (OPAIC) was conducted to determine an appropriate interview duration, and it was established that 30–40 min was sufficient to collect the required data for the study objectives. The interview questions were organized into three sections in alignment with the research objectives, ensuring a focused and structured interview flow that facilitated in-depth exploration of key themes.

This study adopted Microsoft Teams as the primary platform for conducting interviews[57], as it enables automatic recording and transcription, thereby enhancing data management efficiency and transparency. However, ethical considerations were strictly observed throughout the research process to uphold participant rights and research integrity. The ethical principles and guidelines of OPAIC were followed, and the researcher obtained formal ethical approval (OPAIC-RE-2023-10).

In total, 10 semi-structured interviews were conducted with construction project managers and professionals working on construction projects in Auckland, New Zealand, to collect primary data. Data collection continued until saturation was reached at the 10th interview, when no new meaningful insights or patterns emerged, indicating that further data collection was unnecessary. The sample size (n = 10) is consistent with qualitative research guidelines that prioritize depth and richness of data over statistical generalizability[82], particularly when the participant group is relatively homogeneous in terms of role and context.

The interviews were transcribed immediately after completion of all recordings. Data analysis was conducted using thematic analysis. No numerical scoring was applied; instead, the 16 questions served as guiding prompts to elicit rich qualitative narratives, which were then inductively coded. The resulting codes were organized into six overarching themes and 23 sub-themes, reflecting consistent patterns in participants' experiences.

3.4. Research participants and participant recruitment

Participants were selected using non-probability purposive sampling, enabling the deliberate inclusion of project managers and construction professionals with specialized knowledge and relevant experience.[21] Purposive sampling is particularly useful for studying hard-to-reach populations, as it provides more in-depth and nuanced data than probability sampling methods.[21,60] This approach facilitated the targeted selection of participants with extensive experience and specific characteristics aligned with the research objectives.[83,84]

Participants were required to be aged 18 and above, ensuring an adequate level of professional experience to provide informed responses. Given the limited accessibility of construction project managers and professionals due to demanding roles, purposive sampling served as a key methodological approach.[84] It enabled the inclusion of participants with experience before, during, and after COVID-19, supporting a comprehensive understanding of

their role in shaping construction projects.

The selection criteria were extended beyond age to include a comprehensive understanding of construction sector practices. Research participants were expected to have substantial professional experience and active involvement in construction projects in Auckland, New Zealand, ensuring contextual relevance to the local construction landscape. Furthermore, these criteria strengthened the external validity of the study by enhancing the representativeness of the findings within the specified geographical context. This approach supported a comprehensive exploration[16,60] of the impact of COVID-19 on PMMs, tools, and techniques.

After establishing the participant selection criteria and developing the interview questions, a recruitment email was prepared. A personalized approach was used to invite construction project managers and professionals through professional networks, including personal contacts, colleagues, and industry connections. Participants were informed that participation was voluntary and that confidentiality would be maintained. Prior to the interviews, informed consent was obtained, including permission for audio recording, and participants were required to review the participant information sheet and sign a consent form.

4. Results

This study adopted a thematic analysis approach to analyze the collected data. Thematic analysis is a widely recognized qualitative method used to identify, analyze, and interpret patterns (themes) within a dataset.[82] The process begins with systematic data coding[85], involving the comparison of text segments within and across codes to identify and develop emerging themes.[85,86] This approach provided insights into the diverse perspectives and experiences reported by the participants.[3,57,59] Figure 8 illustrates the initial stages of the thematic analysis process.

In this study, Rosala's[87] six-phase iterative framework for thematic analysis was adopted, comprising: (i) data familiarization, (ii) code generation, (iii) theme identification, (iv) theme review, (v) theme definition and naming, and (vi) report production.

The data were analyzed using an iterative process involving multiple rounds of coding, enabling refinement and development of themes throughout the analysis.[88] The analysis followed an inductive (data-driven) approach, meaning that themes emerged directly from the data rather than being predetermined.[87] Data were obtained from 10 participants, with interview durations averaging 28 min (range: 24–41 min). Interviews were conducted via Microsoft Teams, and participants provided consent for audio recording. Recordings were transcribed using the platform's automated transcription feature to support the analysis.

This study employed an anonymization procedure to protect participant identity and privacy (Table 3). All personal identifiers were removed from the transcripts to ensure that participants could not be identified.[89,90]

4.1. Identification of themes and categories

After generating and assigning initial codes, the study proceeded with a comprehensive analysis of the coded data to identify recurring themes and sub-themes. This process was iterative, involving multiple rounds of refinement to ensure alignment with the research questions. Six main themes and 23 sub-themes were identified, as presented in Table 4. Each theme was supported by corresponding sub-themes, providing a detailed representation of the participants' practical and professional experiences.

4.2. Findings from thematic analysis

The research findings are presented in a structured manner in relation to the four research questions. The interview consisted of 16 questions designed to elicit information aligned with the research objectives. The findings are presented according to the identified themes and their respective sub-themes, as follows:

4.2.1. Theme 1: Construction project management approaches and strategies

Participants were asked to provide specific examples of PMMs and approaches used in the construction sector prior to COVID-19, as well as to describe any notable trends or changes in project management practices within their organizations during the pre-pandemic period. The thematic analysis revealed a diverse range of project management approaches employed within the construction sector (Table 5). This finding is consistent with the study by Abdulai and De-graft.[22]

As presented in Table 5, the majority of participants (n = 7) reported using or having used the Waterfall method, Agile, or hybrid PMMs. Furthermore, participants indicated familiarity with and experience in PRINCE2, traditional project management (TPM), and CPM. A participant shared, "For implementing our construction projects, we follow the structured approach of Waterfall, progressing through well-defined stages to ensure a systematic and organized workflow." (Golf). Another participant noted, "Generally, we do prefer Agile, but sometimes we do use Waterfall depending on the project" (Delta).

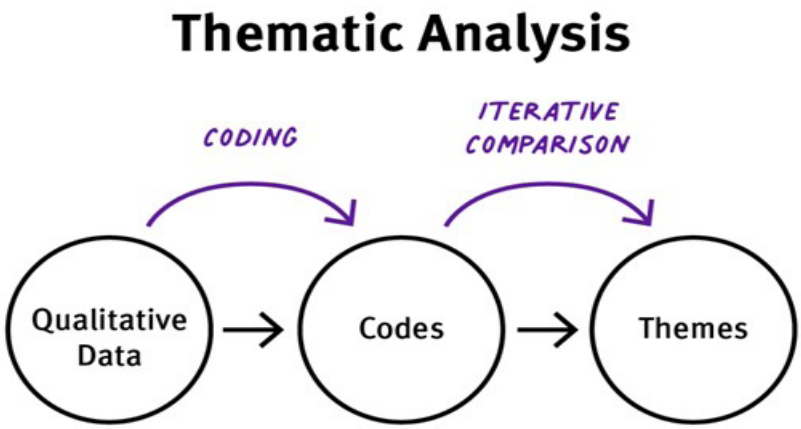

Figure 8. Thematic analysis. Reprinted from Rosala.[87]

Table 3. Participants' pseudonyms

Participant number	Pseudonym
1	Alpha
2	Bravo
3	Charlie
4	Delta
5	Echo
6	Foxtrot
7	Golf
8	Hotel
9	India
10	Juliet

Note: Participants' pseudonyms, developed by the authors.

These findings suggest that the Waterfall method, Agile, and hybrid approaches were the primary PMMs used before COVID-19. Seven participants reported using these PMMs, indicating a level of consensus within Auckland's construction sector. These findings align with those reported by Abdulai and De-graft.[22]

4.2.2. Theme 2: Technological adaptations in construction project management

To explore the use of project management tools or techniques in the construction sector, participants were asked to share insights from their professional experiences regarding technologies or software that significantly influenced project management practices. Their responses were analyzed, and two sub-themes were identified and presented in Table 6.

Among the tools and techniques discussed in the interviews, Microsoft Project and Gantt charts emerged as the most commonly used for project planning and scheduling. Primavera was also frequently cited, while other tools mentioned included Procore, AutoCAD, BIM 360, Bluebeam, Microsoft Excel, Microsoft Planner, and Kanban. Microsoft Project and Gantt charts were mentioned by six of the 10 participants, highlighting their widespread use and perceived effectiveness in construction project management.

A participant shared, "So well, in previous and in the current company that I am working, regarding project management software, the most common one obviously was Microsoft Project" (Charlie). Another participant noted:

Gantt is the probably most commonly used tool, regardless of the metrics you have to consider cause like from my perspective, the pandemic has not really changed the way things are handled, but more like the number of metrics you have to consider (Golf).

These findings align with those reported by Patanakul *et al.*[29] regarding the role of project management tools in supporting project success in construction projects.

4.2.3. Theme 3: Impact of COVID-19 on project execution

Participants were asked to share their insights on how COVID-19 affected project execution, particularly in terms of delays, disruptions, and the ability to anticipate and mitigate emerging issues. They were also asked about challenges associated with implementing government restrictions and the strategies used to address supply chain disruptions, including ensuring material and resource availability in construction projects during the pandemic. After analyzing participants responses, six sub-themes were found as presented in Table 7.

Table 4. Identified themes and sub-themes

Themes	Sub-themes
Construction project management approaches and strategies	Commonly used project management methods in the construction sector before the COVID-19 pandemic
	Trends and changes in project management practices leading up to the pandemic
Technological adaptation in construction project management	Specific project management tools and software commonly used before the COVID-19 pandemic
	Utilization and transition to digital tools during the pandemic
Impact of COVID-19 on project execution	Extended lead times in project implementation
	Challenges in anticipating problems
	Segmentation of working groups
	Implementation of social distancing measures
	Supply chain disruptions (difficulties in securing the construction materials)
	Dependence on overseas suppliers and shift toward domestic producers
Workforce management competencies	Lack of skilled workforce due to border closures
	Limited availability of a qualified domestic workforce
	Workforce availability affected by COVID-19 illness and isolation requirements
	Employee well-being
Communication dynamics	Shift to virtual communication tools
	Implementation of remote work policies
	Restrictions on face-to-face meetings and on-site work
	Balancing communication methods to avoid overload
Lessons learned from COVID-19	Response to unpredictable events (risk management)
	Diversification of suppliers and sources
	Challenges of returning to work back in the office
	Slower construction project implementation pace
	Skill diversity and human resources planning

Table 5. Construction project management approaches and strategies

Sub-themes	Number of respondents (*n*)
Commonly used project management methods in the construction sector before the COVID-19 pandemic	(i) The Waterfall method = 7 (ii) Agile/hybrid = 7 (iii) PRINCE2, TPM, and CPM = 4
Trends and changes in project management practices leading up to the pandemic	7

Abbreviations: CPM: Critical path method; PRINCE2: Projects IN Controlled Environments; TPM: Traditional project management.

Table 6. Technological adaptations in the construction sector

Sub-themes	Number of respondents (*n*)
Specific project management tools or software commonly used before the COVID-19 pandemic	(i) Microsoft Project and Gantt chart = 6 (ii) Microsoft Excel and Microsoft Suite = 2
Utilization and transition to digital tools during the pandemic	7

Note: Technological adaptation in the construction sector, developed by the authors.

All participants reported that COVID-19 significantly affected construction project management across multiple dimensions. All participants indicated that the pandemic led to extended project timelines, while social distancing measures implemented by the government to limit the spread of COVID-19 negatively affected project execution. These measures also led to supply chain disruptions, thereby limiting the availability of essential construction materials.

Delta and Echo shared: "We had a huge material shortage and for one of our projects, I think we got about 18 months behind schedule" (Delta); "Social distancing led to fewer people on-site, slowing down project progress and causing delays in completion" (Echo). Another participant noted, "…we had to postpone two of our projects, large ones, it also happened that we had to close two relatively small projects. So that's one thing, you need to update the way you anticipate problems" (Foxtrot).

These findings align with those reported by Waheeb *et al.*[62], who found that construction projects experienced extended contract durations, increased costs, and consequent delays and postponements. Similarly, Petrov and Omisakin[61] reported that social distancing and health and safety protocols were critical factors contributing to project delays.

4.2.4. Theme 4: Workforce management and competencies

To explore the impact of COVID-19 on workforce management and competencies in the construction sector, participants provided insights on challenges related to labor shortages caused by border closures and limited availability of skilled workers in the domestic market. Participants were asked to describe specific challenges encountered during the pandemic. Response data collected from participants were analyzed and sub-themes found are presented in Table 8.

Participants reported that a key challenge was the shortage of a qualified workforce due to border closures. Five participants (Juliet, Hotel, Foxtrot, Delta, and Bravo) reported that New Zealand faced shortages of both skilled labor and unskilled labor, which directly affected construction project implementation phases. One participant shared:

I would say one of the biggest issues for New Zealand was laborer shortage because the borders were closed. We were running very large projects and the fact that we could not get laborers, especially skilled ones it really became a bottleneck in our project's implementation, impacting on pace, work quality and stakeholders' satisfaction (Juliet).

According to Ogunnusi *et al.*[60], COVID-19 primarily affected project management through workforce shortages, travel restrictions, and evolving regulatory requirements. Due to border closures, companies relied more on the domestic workforce and adapted project workflows to enhance existing workforce capacity, including online training for upskilling. A participant noted, "When we faced laborer shortage challenges, we tried to mitigate it with using offshore specialist for example we started using teams in India and Manila for design, influencing how we run projects" (Golf).

Workforce availability was further challenged by COVID-19–related illness, resulting in employee absenteeism across projects. All participants reported that this negatively affected multiple aspects of project execution during the pandemic. A participant shared, "A lot of people being sick had a big impact on the speed of completing projects; there were delays due to the reduced workforce" (Delta). Another participant noted, "Employee well-being became a priority, and we focused on mental health support and virtual team-building activities" (Alpha).

These findings align with those reported by Petrov and Omisakin[61] and Waheeb *et al.*[62], demonstrating that there is a relationship between health and safety measures, workforce illness, and construction project delays.

4.2.5. Theme 5: Communication dynamics

The emergence of COVID-19 led to significant changes in communication dynamics within the construction sector. As the sector is traditionally dependent on hands-on work and face-to-face interactions, it encountered challenges due to government-imposed restrictions and COVID-19–related health and safety measures. In response, the sector adopted virtual communication tools and platforms. This shift required the workforce to operate remotely, while on-site teams worked with reduced staffing levels.

To explore the impact of COVID-19 on communication dynamics, participants were asked to share the communication tools and software used, their effectiveness in supporting communication, and the strategies employed to maintain collaboration among project teams under social distancing and remote working conditions. Upon analysis of participants responses, the sub-themes found are presented in Table 9.

All participants acknowledged the need to shift to virtual communication tools due to pandemic-related constraints and operational limitations. All participants reported that the use of virtual communication facilitated collaboration between employees and management despite geographical

Table 7. Impact of COVID-19 on project execution

Sub-themes	Number of respondents (*n*)
Extended lead times in project implementation	10
Challenges in anticipating problems	4
Segmentation of working groups	4
Implementation of social distancing measures	10
Supply chain disruptions (difficulties in securing the construction materials)	10
Dependence on overseas suppliers and shift toward domestic producers	6

Table 8. Workforce management and competencies

Sub-themes	Number of respondents (*n*)
Lack of skilled workforce due to border closures	5
Limited availability of qualified domestic workforce	8
Workforce availability affected by COVID-19 illness and isolation requirements	10
Employee well-being	5

Table 9. Communication dynamics

Sub-themes	Number of respondents (*n*)
Shift to virtual communication tools	10
Implementation of remote work policies	10
Restrictions on face-to-face meetings and on-site work	8
Balancing communication methods to avoid overload	6

separation and COVID-19 restrictions. Among the tools adopted during the pandemic, Microsoft Teams was widely used to reduce reliance on face-to-face meetings on-site. This enabled effective communication in remote working environments through video calls, virtual workshops to maintain close collaboration among stakeholders, informal chat channels to reduce stress associated with remote work, Viva Engage or Yammer for sharing success stories, and cloud-based project management tools for real-time collaboration and information sharing.

Echo and Charlie shared, "There was an increase in digital collaboration tools as we have shifted to remote work" (Echo); "Well, from my experience in my company, a lot of what we were doing was already on online platforms, and we were already using before COVID-19" (Charlie). Another participant noted, "The pandemic prompted us to adopt cloud-based project management tools for real-time collaboration and information sharing" (Hotel).

These findings align with those reported by Waheeb *et al.*[62] and Mirhosseini *et al.*[8] regarding the need for effective communication strategies to mitigate COVID-19 challenges in construction project management. Similarly, Alsharef *et al.*[3] and Pamidimukkala and Kermanshachi[64] highlighted the necessity of adopting flexible and advanced communication strategies in construction project management. In addition, Iqbal *et al.*[67] emphasized the role of Microsoft Teams in enabling effective communication and remote construction project management environments.

4.2.6. Theme 6: Lessons learned from COVID-19

Participants were asked to describe specific challenges encountered after COVID-19, and lessons learned that have shaped their organization's long-term approach to construction project management (Table 10).

Table 10. Lessons learned from COVID-19

Sub-themes	Number of respondents (*n*)
Response to unpredictable events (Risk management)	10
Diversification of suppliers and sources	10
Challenges of returning to work back in the office	7
Slower construction project implementation pace	3
Skill diversity and human resources planning	4

Note: Thematic analysis of lessons learned, developed by the authors.

All participants reiterated the importance of flexibility and reported that COVID-19 increased organizational focus on risk management planning. Five participants (Hotel, Alpha, Delta, Bravo, and Foxtrot) emphasized the need to modify risk management approaches to address new uncertainties arising from the pandemic. A participant shared:

Risk management planning, absolutely. There were a lot

to learn from this pandemic, mainly on the way we run our everyday business, and COVID made us be more aware that there might be other pandemics coming or unforeseen circumstances and we should always have a plan B ready (Delta).

Another participant noted, "COVID made us realize the need to rely on digital processes, rather than on people, to ensure quicker responses and adaptability" (Foxtrot). Similarly, Koch and Schermuly[59] highlighted the need for comprehensive risk management planning to enable project managers to respond effectively to unpredictable events such as COVID-19.

On diversification of suppliers and sources, all participants reported learning the importance of avoiding reliance on a single supplier for construction materials during COVID-19. They indicated that their organizations implemented strategies to diversify supply chains to mitigate risks associated with future disruptions. A participant noted:

I think new aspects had to be considered, you know, the fact that a supplier is not capable of delivering—lack of supplies. What is the likelihood? Well, this was not even on the radar before. Now it is something that we consider greatly (India).

Another participant shared, "Pandemic has increased the need for not relying on one source, one supplier for whatever it is. But let's say, 20 suppliers or even more, so you have multiple sources of material supply" (Bravo). Similarly, Echo shared: "The pandemic led to an increased focus on stock visibility and forecasting within the organization" (Echo).

According to Mirhosseini *et al.*[8], supplier and material source diversification is critical for enhancing supply chain resilience.

Moreover, participants reported that construction companies encountered difficulties with employees returning to on-site work and readjusting to pre-pandemic working routines after COVID-19. A participant shared:

It was difficult to get back to work in the office. Like you must be in the office five days a week. Working from home made us a bit more relaxed, we had flexible working hours. Because if you think about five years back, if you were involved in a project, you were in that site office and that was the end of it" (Golf).

Another participant noted, "Being back from work-from-home to working in the office has not been easy. Dealing with the 'flexible' working has not been easy either" (Alpha).

Three participants argued that COVID-19 significantly slowed down the pace of project implementation in the construction sector. The slowdown was attributed to supply chain disruptions, workforce limitations, and health and safety measures. A participant shared, "Construction has become slower than before and it has not picked up yet, maybe election, maybe wars in the world, and the fact that New Zealand is so far" (Delta).

Zamani *et al.*[57] emphasized the post-COVID–19 slowdown in construction project implementation, noting that this challenge contributed to the restructuring of project timelines.

Four participants reported that COVID-19 highlighted the need for greater skill diversity within project teams. They emphasized that human resources play a key role in achieving the required diversity to enhance teams' ability to handle different tasks and contribute to timely project completion. A participant noted:

COVID highlighted the importance of skill diversity when it comes to on-site teams and laborers. It became evident the importance of having workers that can master a broad range of skills so you could assign them to different sites and cover different tasks (Echo).

Another participant shared, "The main takeaways from the pandemic, you know, do I have enough skilled people on my team to conduct different task on my construction site" (Foxtrot).

According to Waheeb *et al.*[62], project success in the construction sector depends on the availability of a skilled workforce capable of executing project plans and deliverables effectively.

5. Discussion

This study examined the impact of COVID-19 on the use of PMMs, tools, and techniques in the construction sector in Auckland, New Zealand. Based on the research objectives, research questions were developed, and data were collected and analyzed. Findings revealed that before COVID-19, the most commonly used PMMs included the Waterfall method, Agile, and hybrid approaches. Seven participants reported using these PMMs, indicating a general consensus within Auckland's construction sector. This finding aligns with that of Abdulai and De-graft.[22] However, four participants reported that before the pandemic, they used PRINCE2, CPM, and TPM to implement various construction projects based on their professional experience.

Additionally, Microsoft Project and Gantt charts were identified as the most commonly used tools for project planning and scheduling. Six participants reported using these tools due to their effectiveness in supporting project

execution. However, six participants also reported the use of additional tools, including Primavera, Procore, AutoCAD, BIM 360, and Bluebeam. Two participants reported the use of Microsoft Excel, Microsoft Planner, and the Kanban technique for project implementation. These findings align with those of Raz *et al.*[28], who highlighted the role of project management tools in supporting project success.

On the impacts of COVID-19 on PMMs, all participants unanimously shared that due to the rigid nature of this methodology, it was difficult for their organizations to adapt to the abrupt uncertainties caused by COVID-19. The same situation was experienced due to governmental measures such as social distancing and remote working. According to Jugdev *et al.*[17], the Waterfall method has limitations in adapting to changes or unexpected challenges. This highlights the challenges and uncertainties participants faced during the pandemic, as well as the need for adaptation and flexibility.

Moreover, the pandemic significantly affected project management tools and techniques used prior to the pandemic, leading to accelerated adoption of digital collaboration and communication tools during COVID-19. During the pandemic, organizations were forced to adopt Microsoft Teams, ClickUp, and Yammer for collaboration, project management, virtual meetings, networking, and information sharing. These findings align with those reported by Alsharef *et al.*[3] and Pamidimukkala and Kermanshachi[64] on the need for adopting flexible and advanced communication strategies in construction project management.

Collectively, the findings indicate that key factors that facilitated changes in the use and choice of project management practices in the New Zealand construction sector during the pandemic included rapid implementation of remote working policies, adoption of digital communication tools, social distancing measures, shortages of skilled labor, and supply chain disruptions.

5.1. Remote working

The findings demonstrate that construction companies acted promptly and implemented remote working policies by rapidly developing virtual communication tools to adhere to government restrictions[12] These policies were implemented as a demonstration of the construction companies' flexibility to adapt to changing conditions caused by COVID-19, as well as to mitigate the risk of virus transmission among employees.

5.2. Digital communication tools

The use of digital communication tools such as Microsoft Teams was another factor that impacted the use of project management practices during the pandemic. This enabled effective communication in construction project management within remote working environments. Additionally, the use of digital communication tools enabled real-time communication, helped overcome spatial barriers, and facilitated the continuation of ongoing construction projects despite government restrictions.[3,64]

5.3. Restrictions on face-to-face or on-site work meetings

Government restrictions on face-to-face meetings and on-site work impacted the use of project management practices in construction projects. To keep track of assigned tasks and monitor project implementation stages, construction companies introduced cloud-based project management tools to enable real-time collaboration and information sharing. This helped to overcome challenges associated with restrictions on face-to-face meetings and on-site work.

5.4. Supply chain disruption

Supply chain disruption was another key factor that impacted project management practices. This resulted in delays in construction material deliveries, thereby negatively affecting project timelines. According to Ghandour[63] and Zamani *et al.*[57], project delays and postponements became frequent, contributing to the restructuring of construction project execution during the pandemic.

5.5. Shortages of skilled labor (international and domestic)

Shortages of the skilled workforce also impacted the use of project management practices during the pandemic in two ways: a reduction in both international and domestic availability of skilled and unskilled construction labor. This was due to border closure measures imposed by governments, leading to shortages of international workers as many had returned to their home countries. As a result, the construction sector had to rely on the domestic labor market, which had limited availability of skilled workers. This negatively affected construction project implementation phases and extended project delivery timelines. Waheeb *et al.*[62] stated that construction projects succeed when there is an adequate availability of a skilled workforce.

6. Research contribution

This study examined how the construction sector adapted to external challenges and the effectiveness of various project management strategies. It offers practical guidance for construction sector stakeholders. This study contributes

to the academic understanding of the implications of the COVID-19 pandemic on project management. It also offers practical insights for construction sector professionals seeking effective strategies for managing construction sector projects in a dynamic operating environment.

This study serves as a bridge to address the identified gap in the existing literature on the impact of COVID-19 on the selection and use of PMMs, tools, and techniques in Auckland, New Zealand. Despite an extensive literature review conducted across multiple databases and scholarly repositories, a limited number of studies were found addressing this specific context. Therefore, this research contributes to knowledge by narrowing this gap in the literature.

Beyond academic contributions, this study provides valuable practical insights for construction stakeholders and policymakers. By investigating how COVID-19 affected project management practices, the study provides stakeholders with practical knowledge to support decision-making, strategic planning, and risk management processes. The study highlights the resilient adaptation of the construction sector, emphasizing the importance of flexibility and innovation.

This study further supports the development of strategies and risk management frameworks for future disruptions. It identifies best practices and areas requiring improvement, providing a basis for proactive measures to mitigate future disruptions. It enhances adaptability through understanding the changing dynamics of construction project management during the COVID-19 context.

7. Conclusion

This study explored how the COVID19 pandemic reshaped the use of PMMs, tools, and techniques within Auckland's construction sector. Drawing on 10 semistructured interviews and thematic analysis, the study provides an empirically grounded understanding of how project managers adapted to crisis conditions.

The findings reveal a decisive shift from the rigid Waterfall method to more flexible Agile and hybrid approaches, accompanied by increased dependence on digital platforms such as Microsoft Teams and cloudbased scheduling tools. These adaptations were not merely technological responses but strategic realignments undertaken to address supply chain disruptions, labor shortages, and intensified health and safety requirements. Together, they illustrate how crisis conditions can accelerate methodological transformation and reframe the relationship between structure, flexibility, and organizational resilience in project management practice.

Beyond documenting these shifts, the study highlights how the intersection of methodology, technology, and human factors shaped managerial decisionmaking processes during the pandemic. Project managers balanced competing demands for control and adaptability, resulting in the development of hybrid systems that preserved formal oversight while enabling rapid response to changing conditions. This underscores that effective project management in uncertain environments depends less on adherence to a single methodology and more on the dynamic integration of multiple approaches, supported by digital collaboration infrastructure and empowered project teams.

Theoretically, this research contributes to the literature on project resilience and adaptive management by linking methodological flexibility to external environmental disruptions. It advances understanding of how crises act as catalysts for innovation in project management practice, reinforcing arguments that Agile and hybrid approaches provide both psychological and operational flexibility under conditions of uncertainty. By situating these insights within Auckland's construction sector, the study extends contextual knowledge about how localized regulatory frameworks, sectoral characteristics, and workforce structures mediate global trends in project management adaptation. The analysis thus complements existing theory by framing crisisdriven transformation as both a challenge and an opportunity for methodological evolution.

Practically, the findings suggest that construction organizations should institutionalize the adaptive learning gained during COVID19 rather than reverting to precrisis norms. Integrated PMMs that combine the discipline of traditional approaches with the responsiveness of Agile can enhance preparedness for future disruptions. Organizations should prioritize digital capability building, crossfunctional training, and workforce wellbeing initiatives to sustain engagement and productivity under volatile conditions. Additionally, strengthening supplier diversification and proactive risk management systems can transform reactive crisis strategies into long-term resilience practices.

However, the study's scope and qualitative design impose certain limitations. The focus on Auckland restricts geographic generalizability, and the modest sample size captures depth rather than breadth of experience. While these factors limit statistical extrapolation, they provide rich, contextbound insights applicable to similar urban construction environments. Recognizing these limitations, future research should broaden the analysis through mixedmethod studies spanning multiple regions

and project types to validate and extend these findings. Comparative and longitudinal designs could further reveal how temporary adaptations mature into institutionalized practices and how evolving technological and regulatory landscapes continue to shape PMMs in postCOVID settings.

In summary, this study highlights that crises such as COVID19 expose the rigidity of conventional project management while simultaneously creating momentum for innovation. By synthesizing methodological, technological, and human dimensions, it offers a conceptual bridge between crisis adaptation and enduring transformation—an insight with practical relevance for both scholars and practitioners seeking to enhance resilience in construction project management.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: All authors
Formal analysis: Rudina Leksani, Olufemi Muibi Omisakin
Investigation: Rudina Leksani, Olufemi Muibi Omisakin
Methodology: All authors
Writing–original draft: Rudina Leksani
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Ethics approval and consent to participate

This research adhered to ethical principles and guidelines to ensure respect for the rights, dignity, and welfare of participants, and was conducted in accordance with the requirements of the Ethics Committee at Otago Polytechnic Auckland International Campus. Ethical approval was granted (OPAIC-RE-2023-10).

Consent for publication

Participants signed a consent form prior to data collection. The form provided information about the study and the possibility that the collected data may be published. It also stated that participants' data would be kept confidential and anonymized.

Availability of data

Data supporting the findings of this study are available upon reasonable request to the corresponding author.

Further disclosure

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References

1. International Labour Organization. Impact of COVID-19 on the construction sector. 2021. Available from: https://www.ilo.org/sector/Resources/publications/WCMS_767303/lang--en/index.htm [Last accessed on April 7, 2025].
2. Muschter, R. Construction industry in New Zealand: statistics & facts. *Statista*. 2025. Available from:https://www.statista.com/topics/5725/construction-industry-in-new-zealand/#topicOverview.
3. Alsharef A, Banerjee S, Uddin SMJ, Albert A, Jaselskis E. (2021). Early impacts of the COVID-19 pandemic on the United States construction industry. *IJERPH*. 2021;184(4):1559.

   doi: 10.3390/ijerph18041559
4. Sears SK, Sears GA, Clough RH, Rounds JL, Segner RO. *Construction Project Management.* John Wiley & Sons. 2015.
5. Pirotti A, Mohd Rahim FA, Zakaria N. Implementation of project management standards and project success: The mediating role of the project management office. *EPPM-J*. 2021;12(1):39-46.

   doi: 10.32738/JEPPM-2022-0004
6. Ciric Lalic D, Lalic B, Delić M, Gracanin D, Stefanovic D. How project management approach impacts project success? From traditional to Agile. *IJMPB*. 2022;15(3):494-521.

   doi: 10.1108/IJMPB-04-2021-0108
7. Bednarz AL, Borkowska-Bierć M, Matejun M. Managerial responses to the onset of the COVID-19 pandemic in healthcare organizations. Project Management. *IJERPH*. 2021;18(22):12082.

   doi: 10.3390/ijerph182212082
8. Mirhosseini SF, Wilkinson S, Jelodar MB. New Zealand's response to the COVID-19 pandemic and the effects of its governance on the construction industry. *IOP Conf Ser Earth Environ Sci.* 2022;1101(3):032037.

   doi: 10.1088/1755-1315/1101/3/032037
9. Landau P. PERT and CPM: their differences and how to use them together. ProjectManager.com. 2022. Available from: https://www.projectmanager.com/blog/pert-and-cpm [Last accessed on April 7, 2025].
10. Bukhari SRA, Nasir AR, Greco R, Mollo L. The impact of COVID-19 on construction project performance: A case

study in Pakistan. *COVID*. 2024;4(8):1253-1271.

doi: 10.3390/covid4080090

11. Lagat DK, Njuguna M, Mutanu M, Mwende A, Magak A, Nyakondo S. Impact of COVID-19 on the construction industry performance: A case of contractors in Kenya. *AJIBM*. 2023;13(7):735-750.

doi: 10.4236/ajibm.2023.137040

12. Cumming J. Going Hard and Early: Aotearoa New Zealand's Response to Covid-19. *HEPL*. 2021;17(1):107-119.

doi: 10.1017/S174413312100013X

13. Seymour T, Hussein S. The history of project management. *IJMIS*. 2014;18(4):233.

doi: 10.19030/ijmis.v18i4.8820

14. Walker A. *Project management in construction*. John Wiley & Sons; 2015.

15. Gantt Chart. *History of the Gantt Chart*. GanttChart.com. Available from: https://ganttchart.com/history_of_the_gantt_chart/ [Last accessed on June 18, 2023].

16. Doskočil R. The level of use of project management methods, techniques and tools and their impact on project success—Selected region of Czech Republic. *Period Polytech Soc Man Sci*. 2016;24(1):14-24.

doi: 10.3311/PPso.8236

17. Jugdev K, Perkins D, Fortune J, White D, Walker D. An exploratory study of project success with tools, software and methods. *IJMPB*. 2013;6(3):534-551.

doi: 10.1108/IJMPB-08-2012-0051

18. Islam S, Evans N. Key success factors of PRINCE2 project management method in software development project: KSF of PRINCE2 in SDLC. *Int J Eng Mater Manuf.* 2020;5(3):76-84.

doi: 10.26776/ijemm.05.03.2020.02

19. McCormick M. Waterfall vs. agile methodology. *MPCS*. 2012;3:18-19.

20. Mohammed KN, Syam Chambrelin K. An analytical approach in usage of Agile methodologies in construction industries – A case study. *Mater Today Proc.* 2020;33: 475-479.

doi: 10.1016/j.matpr.2020.05.045

21. Horning, TM. *Successful project management*. Doctoral study. Walden University. 2018. Available from: https://www.proquest.com/docview/2024272533/abstract/9C8EBCCE670141CAPQ/1 [Last accessed on April 7, 2025].

22. Abdulai Y, De-graft OM. Project risk management and construction performance: A Ghanaian study. *Acad Mark Stud J.* 2022;26(S2). Available from: https://www.abacademies.org/articles/Project-risk-management-and-construction-performance-1528-2678-26-S2-007.pdf.

23. Alotaibi NO, Sutrisna M, Chong HY. Guidelines of using project management tools and techniques to mitigate factors causing delays in public construction projects in Kingdom of Saudi Arabia. *EPPM-J.* 2016;6(2):90-103.

doi: 10.32738/JEPPM.201607.0003

24. Babalola O, Ibem EO, Ezema IC. Implementation of lean practices in the construction industry: A systematic review. *Building and Environment.* 2019;148:34-43.

doi: 10.1016/j.buildenv.2018.10.051.

25. Moynihan GP, Harsh C. Evolution and current state of construction project delivery methods: A two-stage investigation. *Int J Constr Proj Manag.* 2016;8(1):57-70.

26. Richardson GL, Carstens DS. *Project management tools and techniques*. CRC Press. 2019.

doi: 10.1201/9780429263163

27. Cagliano AC, Grimaldi S, Rafele C. Choosing project risk management techniques: a theoretical framework. *J Risk Res.* 2014;18(2):232-248.

doi: 10.1080/13669877.2014.896398

28. Raz T, Shenhar AJ, Dvir D. Risk management, project success, and technological uncertainty. *R D Manag.* 2002;32(2):101-109.

doi: 10.1111/1467-9310.00243

29. Patanakul P, Lewwongcharoen B, Milosevic D. An empirical study on the use of project management tools and techniques across project life-cycle and their impact on project success. *J Gen Manag.* 2010;35(3):41-66.

doi: 10.1177/030630701003500304

30. Burke R. *Project management: Planning and control techniques*. John Wiley & Sons. 2013.

31. Supernaw, SA. *Impact of project management methodology use in post-disaster recovery and mitigation projects by North Carolina emergency managers*. Doctoral dissertation. Northcentral University; 2019. Available from: https://www.proquest.com/abicomplete/docview/2194824076/abstract/B732AB96BEE647DAPQ/2 [Last accessed on April 25, 2025].

32. Construction Tuts. Project management tools and techniques. ConstructionTuts. Available from: https://www.constructiontuts.com/project-management-tools-and-techniques/ [Last accessed on June 28, 2025].

33. Al-Zwainy FM, Mohammed I, Raheem S. Application project management methodology in construction sector: Review. *Int J Sci Eng Res.* 2016;7:244-253.

34. Kerzner H. *Project management: A systems approach to planning, scheduling, and controlling*. John Wiley & Sons. 2017.

35. Chen Q, Reichard G, Beliveau Y. Interface management—A facilitator of Lean construction and Agile project management. *Int Group Lean Constr.* 2007;1(1):57-66.

36. Sharma M, Luthra S, Joshi S, Joshi H. Challenges to Agile project management during COVID-19 pandemic: An emerging economy perspective. *Oper Manag Res*. 2022;15(1-2):461-474.

    doi: 10.1007/s12063-021-00249-1

37. Kumar H, Skelton L, Kularatne I. Causes of cost overrun in construction projects in Auckland, New Zealand. *J Appl Bus Res.* 2021;17(2):19-34.

38. Streule T, Miserini N, Bartlomé O, Klippel M, de Soto BG. Implementation of Scrum in the construction industry. *Procedia Eng.* 2016;164:269-276.

    doi: 10.1016/j.proeng.2016.11.619

39. Loforte Ribeiro F, Timóteo Fernandes M. Exploring Agile methods in construction small and medium enterprises: A case study. *J Enterp Inf Manag.* 2010;23(2):161-180.

    doi: 10.1108/17410391011019750

40. Project Management Institute. Global project management framework. 2009. Available from: https://www.pmi.org/learning/library/global-project-management-framework-6863.

41. Patah LA, de Carvalho, MM. Project management methodologies and project success: A quantitative study of the relationship between these concepts. *GeP*. 2012;3(2):178-206.

    doi: 10.5585/gep.v3i2.94

42. Vajjhala N. Microsoft project as a risk management tool. *Int J Risk Conting.* 2012;1(2):54-57.

    doi: 10.4018/ijrcm.2012040105

43. Chen X, Chang-Richards AY, Pelosi A, *et al.* Implementation of technologies in the construction industry: A systematic review. *Eng Constr Archit Manag.* 2021;29(8):3181-3209.

    doi: 10.1108/ECAM-02-2021-0172.

44. Jepson J, Kirytopoulos K, London K. Insights into the application of risk tools and techniques by construction project managers. *Int J Constr Manag.* 2020;20(8):848-866.

    doi: 10.1080/15623599.2018.1494673

45. Hoang, NM, Shrestha, S. (2014). *Project management software and its utilities*. Bachelor's thesis. Lahti University of Applied Sciences. 2014. Available from: http://www.theseus.fi/handle/10024/83521.

46. Ameir O. Management tools in project management of the construction of a modern facility for municipal waste management. *GEM Int Multidiscip Sci GeoConference EXPO Proc.* 2021;21:213-220.

    doi: 10.5593/sgem2021/4.1/s18.29

47. Kumar PP. Effective use of Gantt chart for managing large scale projects. *Cost Eng.* 2005;47(7):14-21.

48. Agyei W. Project planning and scheduling using PERT and CPM Techniques with linear programming: Case study. *Int J Sci Technol Res.* 2015;4(8):222-227.

49. Orumie Ukamaka C. Implementation of project evaluation and review technique (PERT) and critical path method (CPM): A comparative study. *Int J Ind Operations Res*. 2020;3(1).

    doi: 10.35840/2633-8947/6504

50. Zecheru V, Olaru BG. Work breakdown structure (WBS) in project management. *Rev Int Comp Manag.* 2016;17(1):61-69.

51. Dalton, J. Kanban Board. In: *Great Big Agile*. Apress. 2018:187-188.

    doi: 10.1007/978-1-4842-4206-3_36

52. Trello. 2023. Available from: https://trello.com/.

53. Jang JW, Kim YW. Using the Kanban for construction production and safety control. *Prod Plan Control.* 2007.

54. Elia G, Margherita A, Secundo G. Project management canvas: A systems thinking framework to address project complexity. *IJMPB*. 2021;14(4):809-835.

    doi: 10.1108/IJMPB-04-2020-0128

55. Kapsali, M. Systems thinking in innovation project management: A match that works. *Int J Proj Manag.* 2011;29(4):396-407.

    doi: 10.1016/j.ijproman.2011.01.003

56. World Health Organization. COVID-19 situation update. 2020. Available from: https://www.who.int/ [Last accessed on May 2, 2020].

57. Zamani SH, Rahman RA, Fauzi MA, Yusof LM. Effect of COVID-19 on building construction projects: Impact and response mechanisms. *IOP Conf Ser Earth Environ Sci*. 2021;682(1):012049.

    doi: 10.1088/1755-1315/682/1/012049

58. Adhikari K, Poudyal L. Future of construction industry: COVID-19 and its implications on construction projects and risk management – A review. *Preprints.org.* Preprint posted online April 14, 2021.

    doi: 10.20944/preprints202104.0383.v1

59. Koch J, Schermuly CC. Managing the crisis: How COVID-19 demands interact with Agile project management in predicting employee exhaustion. *British J of Management*. 2021;32(4):1265-1283.

    doi: 10.1111/1467-8551.12536

60. Ogunnusi M, Hamma-adama M, Salman H, Kouider T. COVID-19 Pandemic: The Effects and Prospects in the Construction Industry. *INTREST*. 2020;14(S2):120-128.

doi: 10.11113/intrest.v14ns2.71

61. Petrov A, Omisakin OM. Evaluating the impacts of COVID-19 on operations and management of community centres: An Auckland, New Zealand case study. *J Info Know Mgmt*. 2022;21(02).

doi: 10.1142/S0219649222500186

62. Waheeb RA, Wheib KA, Andersen BS, Al-Suhiili R. Impact of pandemic SARS COVID-19 on different construction project management: Problems and solutions. *Public Work Manag Policy.* 2023;28(3):306–338.

doi: 10.1177/1087724X221113579

63. Ghandour A. The impact of COVID-19 on project delivery: A perspective from the construction sector in the United Arab Emirates. *HSSR*. 2020;8(5):169-177.

doi: 10.18510/hssr.2020.8516

64. Pamidimukkala A, Kermanshachi S. Impact of Covid-19 on field and office workforce in construction industry. *Proj Leadersh Soc.* 2021;2:100018.

doi: 10.1016/j.plas.2021.100018

65. Hajiagha SHR, Mahdiraji HA, Behnam M, Nekoughadirli B, Joshi R. A scenario-based robust time–cost tradeoff model to handle the effect of COVID-19 on supply chains project management. *Oper Manag Res*. 2021;15(1):357-377.

doi: 10.1007/s12063-021-00195-y

66. Bushuyev S, Bushuiev D, Bushuieva V. Project management during infodemic of the COVID-19 pandemic. *IInnov Technol Sci Solut Ind.* 2020;2(12):13-21.

doi: 10.30837/2522-9818.2020.12.013

67. Iqbal M, Ahmad N, Waqas M, Abrar M. COVID-19 pandemic and construction industry: Impacts, emerging construction safety practices, and proposed crisis management. *BJO&PM*. 2021;18(2):1-17.

doi: 10.14488/BJOPM.2021.034

68. Chaisaard N. Ngowtanasuwan GA. Review of construction project management guidelines under the impact of COVID-19 Epidemic dispersal: A case study of Thai construction projects. Presented at: The SUT International Virtual Conference on Science and Technology. 2020; Nakhon-Ratchasima, Thailand.

69. Marnada P, Raharjo T, Hardian B, Prasetyo A. Agile project management challenge in handling scope and change: A systematic literature review. *Procedia Comput Sci.* 2022;197:290-300.

doi: 10.1016/j.procs.2021.12.143

70. StatsNZ. 2018 Census place summaries: Oceanic Auckland Region East. New Zealand Statistics. 2018. Available from: https://www.stats.govt.nz/tools/2018-census-place-summaries/oceanic-auckland-region-east [Last accessed on March 28, 2025].

71. Huang T, Wilson R. Auckland's construction sector: Industry snapshot and trends to 2019. Auckland Council. [Last accessed on July 25, 2025].

72. Auckland Council. Auckland plan 2050. Available from: https://www.aucklandcouncil.govt.nz/en/plans-policies-bylaws-reports-projects/our-plans-strategies/auckland-plan.html [Last accessed on April 23, 2026].

73. Pacific Economic Cooperation Council. 2026. Available from: https://www.pecc.org/covid19/862-new-zealand-and-covid-19-policy-response [Last accessed on April 30, 2026].

74. PwC. Valuing the role of construction in the New Zealand economy. Published 2016. Available from: https://www.pwc.co.nz/pdfs/CSG-PwC-Value-of-Construction-Sector-NZ.pdf [Last accessed on April 23, 2026].

75. PwC. Rebuild NZ Infrastructure. 2023. Available from: https://www.pwc.co.nz/publications/2020/128005083-rebuild-nz-infrastructure.pdf. [Last accessed on April 8, 2026].

76. Townsend D. *The effects of COVID-19 on project managers and their work*. PhD thesis. Bryant University.2024.

77. Gunasekera C, Omisakin OM. The use of project management techniques and its positive impacts on project outcomes in New Zealand businesses. *J Info Know Mgmt*. 2023;24(03).

doi: 10.1142/S0219649223500491

78. Draper A, Swift JA. Qualitative research in nutrition and dietetics: Data collection issues. *J Hum Nutr Diet.* 2011;24(1):3-12.

doi: 10.1111/j.1365-277X.2010.01117.x

79. Warfield D. Is/it research: A research methodologies review. *J Theor Appl Inf Technol.* 2005.

80. Rutberg S, Bouikidis CD. Focusing on the fundamentals: A simplistic differentiation between qualitative and quantitative research. *Nephrol Nurs J*. 2018;45(2):209-213.

81. Mazhar SA. Methods of Data Collection: A Fundamental Tool of Research. *JICH*. 2021;10(01):6-10.

doi: 10.24321/2319.9113.202101

82. Guest G, Namey E, Chen M. A simple method to assess and report thematic saturation in qualitative research. *PLoS ONE*. 2020;15(5):e0232076.

doi: 10.1371/journal.pone.0232076

83. Acharya A, Prakash A, Saxena P, Nigam, A. Sampling: Why and how of it? *Indian J Med Spec*. 2013;4(2).

doi: 10.7713/ijms.2013.0032

84. Bakkalbasioglu E. How to access elites when textbook methods fail? Challenges of purposive sampling and advantages of using interviewees as "Fixers". *Qual Rep.* 2020;25(3):688-699.

doi: 10.46743/2160-3715/2020.3976

85. Maguire M, Delahunt B. Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars. *All Irel J High Educ*. 2017;9(3). Available from: https://ojs.aishe.org/index.php/aishe-j/article/view/335.

86. Dawadi S. Thematic analysis approach: A step by step guide for ELT Research practitioners. *J NELTA*. 2021;25(1-2):62-71.

doi: 10.3126/nelta.v25i1-2.49731

87. Rosala M. Thematic analysis. Nielsen Norman Group. 2022. Available from: https://www.nngroup.com/articles/thematic-analysis/ [Last accessed on August 17, 2022].

88. Elliott V. Thinking about the coding process in qualitative data analysis. *Qualitative Report*. 2018;23(11):2850-2861. Available from: https://ora.ox.ac.uk/objects/uuid:5304bf7f-6214-4939-9f1b-b64415d4fac1.

89. Lerche, L. *Quantitative methods*. 1st ed. Elsevier. 2012.

90. McMullin C. Transcription and qualitative methods: Implications for third sector research. *Voluntas*. 2023;34(1):140-153.

doi: 10.1007/s11266-021-00400-3