OFFSITE CONSTRUCTION IN IRELAND'S HOSPITALS: UNVEILING THE COMPLEXITIES OF OSC ADOPTION

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Ireland's construction industry has increasingly embraced Offsite Construction (OSC) in hospitals, moving away from more traditional methods. This pilot study explores the strategic decision-making process behind this shift, including the impact of digital technologies. Using a phenomenological research approach, 11 in-depth interviews were conducted with purposely selected industry professionals, revealing the complexities of Ireland's OSC market through Thematic Analysis (TA). TA unveiled a range of factors influencing the adoption of OSC; including, but not limited to, programme efficiency, cost, quality assurance and digital technologies. Indeed, notwithstanding digital technology benefits, findings indicate a plethora of dominant concerns, including standardisation, building regulations, procurement strategies, and skills shortages. A high degree of industry unpreparedness for the variety of challenges introduced when adopting OSC was identified. The study strongly suggests enhancing stakeholder collaboration, revising building regulations, and innovating procurement strategies will all be necessary to ensure the successful use of OSC for hospitals. This research contributes significantly to understanding the decision-making dynamics in construction method selection for Irish hospital projects, the role of digital technologies, and the sector's readiness (or not) for OSC.

Keywords: digitalisation; hospital; offsite; offsite construction; thematic analysis

INTRODUCTION

The Irish construction industry has increasingly embraced OSC in hospitals, moving away from more traditional methods. This study explores the path of adopting OSC in hospitals, filled with innovation and challenges. As the construction sector faces the pressures of modernisation, efficiency, and sustainability, OSC emerges as a potential solution (at least on paper), that traditional methods struggle to match (Farmer, 2021; Gibb and Pendlebury, 2019). This introduction sets the stage for an examination of the decision-making process that has driven the increased adoption of OSC in Ireland's healthcare facilities. The apparent reasons behind this shift are diverse, involving factors such as efficiency, cost effectiveness, quality assurance and the growing impact of digital technologies (Pan *et al.,* 2018). However, the journey is not

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without its obstacles. Implementing OSC in hospital projects poses challenges related to standardisation, building regulations, and procurement methods, amongst others (Duke McCaffrey, 2023). These issues point to a level of unpreparedness within the industry. This study aims to unpack these complexities, by providing an analysis of the factors influencing OSC adoption and highlighting how digital technologies play a role, in shaping this evolving landscape. Using a phenomenological approach, interviews of 11 purposely selected professionals in the Irish OSC industry were conducted, to explore the current stance of OSC within Ireland, with a specific emphasis on hospitals. This approach allowed for the capture of first-hand experiences from information-rich participants (Creswell and Poth, 2018). Thematic Analysis (TA) of the interviews was employed, to identify, sort and analyse emergent themes from interview data.

LITERATURE REVIEW

Literature review of OSC methods with respect to hospital construction reveals a paucity of publications, particularly focusing on Ireland. However, those identified tended to be predominantly generated through industry and trade association published works as opposed to the more traditional academic publication reporting scholarly research. According to Taylor (2020) 'the definition of offsite construction (OSC) continues to be the subject of debate and ongoing fettling.' Taylor (2020) continues to suggest that the OSC sector has experienced significant rebranding over the years with many companies choosing different terminology such as off-site and Modern Methods of Construction (MMC) on their websites and other marketing material. Wang *et al. (*2020) further add to the list of terms when they claim that it can also be known as prefabricated construction, precast construction, or modular construction, amongst other terms. Ginigaddara *et al. (*2019) conducted a detailed study focusing on the various typologies on OSC, based on available literature. They cite Steinhardt *et al. (*2016) in their research quoting that "there are different types of OSC such as pre-finished manufactured products (doors, windows, light fittings), panelised walls, pre-furnished modules and the like." Nevertheless, Ginigaddara *et al. (*2019) argue that a notable limitation in the research on OSC is the lack of an established and universally accepted typology that accurately captures the diverse combinations of onsite and offsite elements. For this paper, the author has chosen Offsite Construction (OSC) as the preferred terminology. Ireland's overall construction industry is forecast to grow at the strongest rate amongst 19 other European Countries, which expanded by 3.2% in 2023, and predicted for further growth of 4.4% in 2024, according to a Euroconstruct report, published by Ernst and Young (2023). Furthermore, the Allied Research Market (2023), states that the global OSC market is expected to reach €235 billion by 2030, rising from €130 billion in 2020.

OSC for Hospitals

With the growing demand for healthcare infrastructure across the world, OSC has become increasingly more popular as a construction method choice for hospital projects, as "OSC is touted as cheaper, faster, higher in quality and more environmentally friendly than onsite construction." (Broadhead *et al.,* 2023). Hospitals, known for their complex construction and strict regulatory requirements pose both challenges and opportunities for adopting OSC. According to Liew *et al. (*2019), the repeatability of hospital layout designs makes OSC an attractive option as a construction method over conventional 'stick built' buildings. For example, OSC is applicable to a new hospital building or indeed as a method of extending an existing

building. In either case, such a construction site brings with it a set of complexities due to being considered 'live,' with vulnerable people, public, hospital staff, vehicles, etc. Any delays or mistakes, during this phase can have consequences, impacting patient care, project schedules and overall expenses; hence, the interest in OSC. Keegan *et al. (*2018) affirm that the Irish Government made a commendable commitment of increasing public hospital beds by 2,600 by the year 2027. However, further analysis conducted by the Economic and Social Research Institute (ESRI) projects a much larger number, with an estimated demand for 4,000 to 6,300 beds across both public and private hospitals by the year 2030. As reported by Eolas (2023), the current state of the Irish healthcare infrastructure requires immediate attention. According to their report, Ireland has on average 7.7 hospital beds per 100,000 of the population, falling well below the 2020 OECD average of 12. Acknowledging this, the Irish Government's Department of Health announced the publication of the Health Service Executives (HSE) Capital Plan for 2023, with a total budget of over €1 billion. According to the HSE (2023), of this budget €325 million will be solely allocated for the provision of at least 1,500 hospital beds, wards, theatres, and other facilities across 18 hospital sites in 2024 and 2025, utilising OSC.

Drivers and Barriers

In their white paper, Duke McCaffrey (2023) state that in "addition to the required funds and investment, there are a multitude of factors, ranging from skills shortages to fluctuations in material costs, intricate bidding processes, and regulatory demands that are posing significant obstacles", to addressing Ireland's healthcare construction needs. In 2023, the Irish Governments Department of Housing published an introductory guide to Modern Methods of Construction (Gov.ie, 2023). Whilst this announcement was encouraging, Duke McCaffrey (2023) suggests that uptake of OSC is still a challenge, identifying that many sectors within the Irish construction industry are not ready to adopt such techniques and technologies. Indeed, the recent setbacks faced by modular construction companies in the UK, including business failures and market exits, has further added to the struggles this industry is facing in terms of adopting OSC. In a survey conducted by KPMG (2017), it was found that only 8% of construction companies globally could rank as 'Cutting Edge Technology Visionaries'. The survey continued to state that 64% of contractors and 73% of project owners rank as 'behind the curve' in terms of advanced technologies in the sector. Furthermore, and quite alarmingly, 60% of construction companies surveyed were not 'planning to invest in any modern construction methods or emerging technologies over the next five years.' Notwithstanding the Irish Government's positive efforts to support and drive the uptake of OSC over recent years, most of this support leans towards the residential sector. This is mainly due to the Governments 'Housing for All' plan which aims to produce 33,000 homes per year from 2021 - 2030. Indeed, a new report by Sweeney (2024) specifically focuses on the barriers and benefits of MMC for Irish Housing. Again, a paucity of research is apparent in relation to the uptake and use of OSC in the commercial sector, but specifically for hospitals, given the vast budget set aside by the HSE for OSC on 18 hospital sites. However, many drivers and challenges identified by Sweeney (2024) towards OSC in Ireland's housing sector are also applicable on commercial projects such as hospitals. Obvious drivers were identified such as controlled factory environments leading to less waste, increased productivity times, increased safety, reduced emissions, etc. In contrast, the barriers identified include the lack of widespread adoption of OSC, leading to uncertain pipelines of work and therefore increased risk and costs. Additionally, the report states that the Irish 'public sector procurement was deemed to

be less flexible' towards OSC, which in turn can be a deterrent to those considering using OSC. The Royal Institute of Architects of Ireland (RIAI, 2022) suggest that OSC is at a 'very low level of maturity' and that most of the produced items are being exported. Similarly, Reddy (2020) implies that the supply chain in OSC is also more fragmented due to a limited number of OSC suppliers, when compared to more traditional construction methods. Sweeney (2024) describes how financing and procurement models for OSC projects are very different from traditional construction due to the upfront costs required, with the costs associated with running an OSC factory nearing 30% of the completed project in some circumstances. Risk is therefore high, as a downturn could push OSC manufacturers into insolvency, which unfortunately has happened to several UK companies of late, according to Gerard (2023).

Literature on OSC highlights its potential benefits to enhance programme efficiency, reduce costs in areas, and improve overall quality on projects (Farmer, 2021). Digital technologies play an important role in realising these benefits. Building Information Modelling (BIM), for instance, facilitates detailed planning and coordination, reducing errors and delays (Sacks *et al.,* 2018). Common Data Environments (CDEs) enhance collaboration among stakeholders by providing a centralised platform for information sharing (Cao *et al.,* 2017). The integration of digital technologies such as Internet of Things (IoT), Augmented Reality (AR), and Virtual Reality (VR) further optimises the OSC process by enabling real-time monitoring and virtual simulations (Wang *et al.,* 2022). However, implementing these technologies in OSC encounters obstacles. Lack of standardisation in OSC and the fragmented structure of the construction sector often impede the integration of digital solutions (Liu *et al.,* 2019). Additionally, decision-making in OSC projects is intricate, involving multiple stakeholders with varying priorities and viewpoints (Gibb *et al.,* 2003). Digital technologies therefore play an important role in decision making through their current and future capabilities. Overall analysis of the literature therefore reveals a significant knowledge gap in respect of; (#1) the use of OSC in hospital projects within Ireland specifically, and (#2) the importance of OSC methods to progression of the industry. This works sets out to begin to address this knowledge gap.

METHOD

In this work, a literature review of OSC methods in respect of the construction of hospitals, specifically within Ireland, was undertaken. Based upon the knowledge gap identified, a methodological approach was developed, consisting of a pilot study, designed by the researcher "to test various aspects of the methods planned for a larger, more rigorous, or confirmatory investigation". (Arain *et al.,* 2010). According to Polit *et al. (*2017), the main objective of a pilot study is not to provide definitive answers to research questions, but rather to prevent researchers from initiating a large-scale study without sufficient understanding of the proposed methods. In essence, a pilot study serves as a preventive measure against potential critical flaws that could be both time-consuming and costly in terms of resources. Furthermore, it is anticipated that this study will be hypothesis generating; in so far as aiming to develop key hypotheses pertaining to the posed questions, thorough the analysis of collected responses.

The primary data collection method for this pilot study was a qualitative phenomenological approach, that involved the use of online semi-structured interviews. The sample for this study included 11 Irish based stakeholders,

encompassing a diverse range of roles such as the client, main construction contractors, OSC contractors and OSC design consultants. The intention was to obtain varying viewpoints from the different stakeholders involved in OSC hospital projects. Importantly, it was requested that all stakeholders answer the questions specifically referring to their experience of complex OSC hospital projects. This approach allowed for the capture of "first-hand experience from information-rich participants" (Creswell and Poth, 2018). With regards to the sample population studied, the geographic constraints of Ireland mean that there are a limited number of firms involved in OSC for healthcare facilities, which narrows down the options for research. To address this the research utilised a 'purposeful sampling' method to carefully choose participants from a group of firms operating in this sector, without introducing any intentional biases that could impact the outcomes of the study. Purposeful sampling enables the selection of individuals "who do not only have experiences and knowledge related to the phenomenon of interest, but who are also willing and able to participate in the research" (Palinkas *et al.,* 2015). Table 1 presents information on the selected participants for this study.

Table 1: Overview of Pilot Study Participants

Stakeholder Category	No. of Participants	Rationale for Selection	Interview No's
Clients	2	Senior Estates Managers from largest public and private hospital providers in Ireland.	2, 4
Main Contractors	3	Senior Management from 3 top 10 ranked Irish construction companies, with extensive OSC and hospital construction experience.	1, 5, 6
OSC Contractors	3	Senior Management/Directors of 3 of the largest Irish based OSC companies, with vast experience in healthcare sector.	3, 7, 9
OSC Design Consultants	3	Senior Design Managers/Architects with vast OSC experience in Ireland and the UK, particularly healthcare.	8, 10, 11

Interview questions were devised through identified knowledge gaps evident from the preceding literature review, with a specific emphasis on OSC use on Irish hospitals, and the role of digital technologies on such projects. Each interview comprised of eight questions aimed at obtaining the individual stakeholders experienced based perspectives on OSC for hospital projects versus more traditional approaches. Initially, all stakeholders were presented with five general questions focusing on the essential considerations for choosing between OSC and traditional construction methods, observed benefits and challenges of OSC, applicability of OSC techniques to new buildings or extensions, and potential barriers to the adoption of OSC techniques for hospital projects. Subsequently, each stakeholder group received three specifically tailored questions that focused on their unique experiences and insights. These queries delved into comparative satisfaction levels between OSC and traditional methods, reflections on the quality of construction outcomes, the utilisation and impact of digital technologies beyond design and manufacturing phases, and stakeholder-specific experiences with digital technologies in enhancing OSC processes, collaboration efforts, and the role of digital technologies in ensuring quality and regulatory compliance in OSC projects.

FINDINGS

The researcher completed an evaluation of the verbatim interview transcripts through content-driven Thematic Analysis (TA). This approach aligns with the methodological framework proposed by Braun and Clarke (2022), "which emphasizes the systematic identification, analysis, and reporting of patterns within qualitative data." Upon completion of all 11 interviews, responses were thoroughly analysed, with obvious keywords, reoccurring themes and patterns being coded. Reanalysis of

the refined datasets allowed for key themes to emerge, thus completing the TA process. Outcomes of the TA concluded with six predominant themes emerging.

Unsurprisingly, nearly all (9/11) of those interviewed acknowledged the need and requirement for digital technologies on OSC projects. However, most interviewees referred to the fact that the construction industry as a whole has become more digitalised, and OSC projects are simply utilising the same products. More specifically, BIM and CDE's were at the forefront, with just over a third (4/11) of the interviewees mentioning other technologies such as AR, VR or Robotic Surveying. As alluded to in the literature review, Liew *et al. (*2019), specifically identified how 'the repeatability of hospital layout designs makes OSC an attractive option'. However, just under three quarters (8/11) of interviewees mention how the lack of standardised designs for OSC hospital projects is 'a major issue for planning building services, multi-storey projects and having to adapt the factory multiple times throughout the manufacturing process, leading to excessive lead times of production.' This absence of standardisation therefore introduces a layer of complexity and inefficiency for prospective OSC hospital projects, such as necessitating frequent modifications or rework, to production processes that not only elevate costs but also detract from one of OSC's primary benefits: expedited project delivery.

Of those interviewed, over half (7/11) stated that Irelands current building regulations are not yet suitable for the OSC industry, with one participant stating that "compromises have to be made with regards to building regulations on certain aspects of OSC projects". Furthermore, the analogy of "trying to fit a square peg into a round hole" was offered by another interviewee when discussing the applicability of the current building regulations towards OSC. As noted in the literature review, Duke McCaffrey (2023) stated that the 'Irish construction industry is not set up or suitable for such techniques' presently. Interview responses concur, and it is apparent that the Building Regulations and associated TGD's (Technical Guidance Documents) will require amendments to facilitate the future of OSC projects within Ireland. Like Building Regulations, over half (7/11) of the interview participants referred to the current procurement strategies in Ireland, and its unsuitability for the OSC sector. According to one interviewee, "Procurement is one of main barriers we face for any OSC project. Ireland has a tradition of using stage payments for conventional construction projects. This simply does not suit OSC." This statement aligns with Sweeney (2024), "how financing and procurement models for OSC projects are very different from traditional construction due to the upfront costs required." Furthermore, Sweeney (2024) suggests that "public sector procurement was deemed to be less flexible' towards OSC. This may impact business models for OSC contractors, as it may be 'easier to export modules across Europe, rather than carrying the risk and cost in the Irish Market', as suggested by one interviewee.

Perceptions and pre-conceived mindsets towards OSC were mentioned by half of the interviewees (6/11). The RIAI (2022) suggest that OSC is at a 'very low level of maturity', which may be linked to a multitude of factors, such as those already mentioned. However, in a multi-stakeholder industry such as construction, mindsets and perceptions can often dictate how a building will be built, and the methods or techniques used. Interviewees who discussed perceptions towards OSC, specifically mentioned the word 'Prefab', alluding to a lesser quality modular style building, which became very popular in the 1990's in Ireland, particularly for additional school classrooms. According to one interviewee 'there is a certain generation of the workforce who see OSC or MMC as glorified prefabs. They don't believe that new

OSC volumetric buildings have the same spec, quality, or longevity as a traditionally build project'. As discussed by Taylor (2020) and Wang *et al. (*2020), numerous terminologies associated with OSC, may be causing confusion and skewing mindsets. Finally, early stakeholder engagement was highlighted by less than half (5/11) of the interviewees as a critical component for the successful delivery of OSC hospital projects. Particularly, it was suggested that for hospital projects, the clients should be deeply involved in the design and kept informed throughout the projects, as they 'know how a hospital operates, room by room'. A key point raised was the lack of engagement between certain specialists, leading to incorrect works being performed and costly amendments on site in terms of budgets and schedule. 'M&E engineers don't work in 3D and tend to give a basic performance spec design. That doesn't really work with us. We need to know the exact size of the pipe, what unit they're using, and where the holes are going.' With identified digital technologies already in use (BIM and CDE), this finding was surprising yet aligns to the KPMG (2017) survey "where 64% of contractors and 73% of project owners rank as 'behind the curve' in terms of advanced technologies in the sector."

In respect of the data previously presented, the TA undertaken clearly unveils a multifaceted, multi stakeholder complexity to OSC adoption within the health sector in Ireland. This study therefore contributes to the existing body of knowledge by identifying emergent themes that signal both opportunities and challenges within the OSC sector. To contextualise the six emerging themes; BIM and CDE, Lack of Standardisation, Building Regulations, Procurement Methods, Perception of OSC, and Engagement; and to put their collective impact on the OSC domain into context, as well as their contribution to knowledge and implications for conclusions and recommendations, this discussion piece aims to synthesize their commonalities.

The TA results show a connection between the potential for innovation using OSC and digital technologies, and the resistance that exists within the construction industry. This relationship is marked by a growing recognition of the need for solutions such as BIM and CDE's to handle complex construction processes. These technological advancements align with the shift towards digitalisation in construction with the goal of improving project planning, execution, and management by leveraging data insights and decision making. However, efforts by the industry to modernise and fully utilise OSC and digital technologies face challenges due to barriers, such as lack of standardisation, stringent building regulations and procurement methods not well suited for OSC. Similarly, as stated by Wang *et al. (*2022), "challenges for digital technology implementation in OSC are caused by people's negative attitude toward adopting new technologies, lack of standardisation in OSC, inefficient organisational structure and poor management of technology implementation". These obstacles highlight a fundamental contradiction within the construction sector where endeavours to boost efficiency and innovation are hindered by barriers, as well as preconceived ideologies of OSC. As mentioned by over half of the interviewee's, there is still a perspective on OSC, where it is often seen as inferior to traditional construction methods despite its proven benefits in terms of cost efficiency, speed, quality, and environmental friendliness. Resolving this contrast requires an endeavour to bridge the gap, between the benefits of digital technologies and OSC practices, and their actual implementation. An important part of this work includes creating and implementing guidelines throughout the OSC field to make it easier to incorporate technologies smoothly. By setting up data formats, design rules and communication norms, OSC companies can improve project effectiveness and teamwork, as well as

tackle the obstacles related to acquiring resources and following regulations that currently hinder the wider acceptance of OSC methods.

The push to encourage the use of OSC in hospital projects faces challenges due to building regulations and procurement processes that do not cater to the unique characteristics of OSC, as alluded to by Duke McCaffrey (2023). These frameworks originally created with traditional construction methods in mind create obstacles for integrating OSC, highlighting a broader issue of resistance to change within the Irish construction industry. To overcome these hurdles, it is crucial to reform the current building regulations by adjusting building codes and procurement strategies to suit OSC features and benefits, making it an attractive and viable option for hospital construction. Additionally, in line with Taylor (2020) and Wang *et al. (*2022), educational campaigns aimed at stakeholders in the construction industry play a role in changing perceptions about OSC. By showcasing OSC projects and sharing information about cutting edge advancements, these initiatives can challenge the outdated belief that OSC is inferior to traditional methods. Such educational efforts can also enhance stakeholder involvement, promoting an approach to project development that maximises the strengths of OSC. Tackling these challenges requires a strategy that embraces the changing landscape of technologies and methods, paving the way for OSC to establish a foothold, in the Irish construction industry.

Further challenges emerged from the TA, specifically the lack of standardisation and insufficient engagement of stakeholders. Ironically, the applicability of OSC to standardised construction is one of its key benefits, making hospitals particularly an attractive option, according to Liew *et al. (*2019). Conversely, the absence of standardisation in Irish hospital designs leads to increased expenses and project delays, as modifications and reworks are frequently required, contradicting the efficiency OSC aims to achieve. Furthermore, most respondents (6/11) did not fully appreciate the significance of engagement, emphasising the necessity of including clients and experts, from the projects inception to avoid alterations later. "Considering the fragmented stakeholders, modular construction confronts various challenges due to a lack of information sharing" (Liu *et al.,* 2019). This issue is compounded by the increased integration of technologies like BIM and CDE across the industry, which are meant to enhance coordination and effectiveness. "In fact, lack of adequate collaboration is one of the main factors impacting modular construction performance" (Mohamad *et al.,* 2023). To address these hurdles, it is crucial to establish procedures for OSC in healthcare construction, while fostering a culture that prioritises stakeholder participation from the outset. Leveraging technology effectively can help address communication challenges and streamline project implementation, ultimately unlocking OSC's potential in delivering hospital projects.

CONCLUSION

This pilot study has significantly improved our understanding of the crucial themes essential for promoting OSC on hospital construction projects in Ireland. It addresses a paucity in existing literature within an Irish context, by providing insights into the application of OSC in hospital construction. The study addresses a gap in knowledge in several ways. Firstly, it informs how OSC methods are used on hospital projects, offering a new perspective on its benefits and challenges specific to Ireland. Secondly it explores the dimensions of these challenges and opportunities covering regulatory, perceptual, and procedural aspects that impact the adoption of OSC. Thirdly, it

highlights the role and potential impact of digital technologies in improving OSC processes, despite facing constraints from current regulatory and procedural frameworks. Through conducting in-depth interviews with 11 stakeholders, this study uncovers the complexities involved in integrating OSC into Irelands healthcare industry. It identifies themes such as technologies, deficiencies in standardisation practices, regulatory limitations, procurement methods, perceptions about OSC, and stakeholder engagement, as key areas that need attention for OSC to achieve its full potential. From the interviews and thematic analysis, several key hypotheses have emerged: integrating digital technologies like BIM and CDEs enhances decision-making processes; the lack of standardisation is a significant barrier to effective OSC adoption; predictive analytics and real-time data monitoring can improve project planning and execution; and stakeholder hesitation to adopt digital technologies is primarily due to concerns over cost, training, and reliability. These hypotheses will guide future research to address these challenges and leverage opportunities for improving OSC in the healthcare sector. The research results identify a gap; between the recognised advantages of OSC and its practical use. This is hindered by regulations, procurement methods and established industry views that overlook the effectiveness, speed, quality, and environmental benefits of OSC. The implications of these findings are straightforward; to utilise the benefits of OSC in hospital projects requires an approach that goes beyond just technological advancements. It involves addressing obstacles to adoption. Proposed solutions include creating standardised design protocols for OSC, updating building regulations to better suit OSC needs, realigning procurement strategies for OSC projects, and altering industry perceptions through education efforts and showcasing ventures. Moreover, emphasising efficient stakeholder engagement, boosted by tools like BIM and CDE, can encourage better teamwork among all project contributors, hence reducing misunderstandings and minimising costly alterations. Recommendations include creating guidelines for OSC design, updating construction regulations to support OSC, adjusting procurement methods for OSC projects, and promoting OSC through initiatives and the showcasing of successful examples.

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