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The 'Massive, Little' Houses: 'Prefabs', A Solution for Informal Settlement Housing Crisis in South Africa! A Scoping Review

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Abstract:

Unlike most continents, Africa still grapples with urban informality, where housing shortages affect most people living in substandard conditions. Prefabricated housing (PH) presents an alternative option that provides a quicker and cheaper housing supply, although it currently lags behind demand. This paper examines whether 1) informal settlements can be upgraded using prefabricated/modular houses, 2) these housing types are desirable to occupants, and 3) alternative houses should receive as much emphasis and policy support as possible, particularly considering the challenges experienced during the COVID-19 pandemic. Based on a comprehensive literature survey utilising a scoping review methodology, the paper indicates that stakeholders such as developers, financiers, and occupants of prefabricated housing increasingly embrace PH despite its challenges. The literature unanimously agrees that substantial efforts are required to catalyse more investment in PH regarding further research, education, supply chain improvements, and enhanced communication and collaboration among industry stakeholders. Additionally, numerous research gaps need addressing, including in-depth examinations of PH's contextual feasibility and performance across different geographical areas. The paper recommends that South African governments adopt PH as an alternative housing solution, as it is faster and cheaper, thereby aiding in achieving the 2030 Sustainable Development Goal 11.

Keywords:

Informal settlements, Modular housing, Prefabricated housing, Sustainable development, Urbanisation

1 Introduction

Adequate housing encompasses a set of minimum criteria, including legal security of tenure, affordability, availability of services, materials, facilities, infrastructure, habitability, accessibility, location, and cultural adequacy (Maphumulo, 2016). Providing sustainable and affordable housing remains a global challenge, and Africa is no exception to this crisis. Despite some progress, reducing the affordable housing backlog has been formidable since 1994 (Turok & Visagie, 2018). The challenges of affordable housing delivery arise from various market spheres, including political, socio-economic, and environmental factors. Consequently, these multifaceted challenges have no singular solution (Turok & Visagie, 2018). Current mechanisms for affordable housing delivery predominantly focus on conventional 'brick and mortar' solutions. However, modular

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alternatives, proven viable over decades, account for only a negligible portion of efforts to address the housing deficit despite their recognition for being more environmentally friendly, cost-effective, faster to develop, and of higher quality than traditional construction methods (Turok & Visagie, 2018). The limited adoption of modular housing solutions highlights the need for a broader, more innovative approach to housing policy and practice.

Extensive research conducted globally, and to a lesser extent in South Africa and other African countries such as Nigeria, generally identifies prefabricated housing (PH) as a viable alternative to affordable housing (Maphumulo, 2016). Researchers from other developing countries, including India and Malaysia, advocate exploring PH to meet their affordable low-cost housing targets (Husain & Shariq, 2018). However, some studies, such as those on shipping container homes in Lagos, have found that costs can be comparable to, or even exceed, those of conventional buildings when similar standards are applied (Sholanke et al., 2019). Unlike most continents, Africa struggles with urban informality, where housing shortages affect most people living in substandard conditions. The provision of housing in Africa remains slow and costly, posing significant challenges to meeting the 2030 Sustainable Development Goal 11, which aims to make cities and human settlements inclusive, safe, resilient, and sustainable (Weaich et al., 2023).

In the past decade, there has been significant debate across Europe regarding the housing crisis, primarily focusing on issues of affordability. However, there has been limited discussion about 'tiny, manufactured houses' as a potential solution. Given the more severe challenges it faces concerning urban informality, housing provision, and affordability (Simbanegavi et al., 2021), South Africa could benefit significantly from this debate.

2 Literature Review – How Best to Deliver Prefabricated Housing

The most effective approach to overcoming knowledge barriers related to prefabricated housing (PH) is targeted training. These barriers primarily stem from limited experience, skills, and understanding of PH processes (Jiang et al., 2020). A crucial barrier is the limited comprehension of the PH business model, which includes understanding the business framework, tools, stakeholder roles, PH approaches and inspections, PH designs and module installations, and the associated costs across the entire supply chain (Gan et al., 2018a). A significant knowledge barrier in developing countries is the lack of on-site experience. This includes a shortage of experienced technicians, collaborative groups, manufacturers, designers, PH component suppliers, and skilled operators, such as crane operators, alongside a general lack of specialised expertise (Wuni & Shen, 2020). Given the relative newness of the modern PH industry, one of the more challenging barriers to overcome is the objective determination of value-added benefits (Arif et al., 2017).

There is a need to standardise prefabricated housing (PH) to address technical barriers effectively. Complex interfacing between modules, extended lead times, highly restrictive tolerances, and other technical anomalies differentiate the design and engineering of PH from conventional construction methods. PH is less forgiving and more costly regarding error rectification (Wuni & Shen, 2020). Design changes are inflexible due to the inability to modify designs once inaccuracies are identified on-site (El-Abidi & Ghazalia, 2015). Additional design barriers include insufficient integrated design capacity, transportation restrictions, poor cooperation between multi-interface components, and issues such as

leakages, cracks, and joining problems. Designs also necessitate the repetition of consistent layouts to achieve greater efficiency and economic feasibility (Wuni & Shen, 2020). The lack of standardised components, research centres, research information, development centres, technology, and testing institutes, coupled with insufficient manufacturing and supply capacities, further complicates the situation (Gan et al., 2018a). While improvements in handling strong winds and other turbulences, such as earthquakes, have been reported, they still need to be validated with certainty, preventing large-scale implementation (Wuni & Shen, 2020).

Innovative financing mechanisms are essential to overcoming financial barriers in prefabricated housing (PH). These barriers include challenges related to project costs, risks, cash flows, and financial decision-making in PH projects. The most significant barrier is PH's high initial capital cost, which encompasses establishing modular factories, securing yards, hiring specialised labour, and managing exorbitant fixed overheads and sunk capital costs in factories (Wu et al., 2019). These high initial costs translate to higher bidding prices by contractors, leading small to medium enterprises to opt for lower bids instead of value-added benefits (Wuni & Shen, 2020).

Due to the uncertain demand for prefabricated housing (PH), developers may face prolonged periods of holding onto properties post-completion, making it challenging to achieve economies of scale and secure quicker returns on investment (Wuni & Shen, 2020). Breaking even or realising returns on substantial initial capital investments can take an extended period, which serves as a significant disincentive for developers and complicates the process of obtaining finance for PH projects (Wuni & Shen, 2020). The necessity for early commitment and upfront payments is a significant deterrent for banks; typically, clients or banks must make a full payment before the modules leave the factory, leaving them without a tangible asset as collateral (Feutz, 2019; Harikrishnan, 2019). In some countries like New Zealand, banks will not release funding until the modules are assembled on-site. Although the rapid construction process of PH can facilitate faster solvency and cash flow generation, the fragmented supply chain and the complex network of stakeholders complicate contractual payment terms for banks (Wuni & Shen, 2020).

In some countries with limited manufacturing capacity, exorbitant logistics costs arise from the necessity of transporting prefabricated housing (PH) components from neighbouring countries (Wuni & Shen, 2020). Additionally, many countries lack innovative financing mechanisms tailored to the PH process (Feutz, 2019). While PH can achieve cost savings through reduced labour requirements, these savings are often offset by the higher wages associated with the specialised and high-skill labour needed (Wu et al., 2019). Further, the unexpected costs related to redesigning, additional planning, and error rectification further complicate PH's financial feasibility and adoption (Wu et al., 2019).

Prefabricated housing (PH) can be positioned as a cheaper and more robust alternative if researchers and project managers focus on analysing, modelling, configuring, and optimising the supply chain to achieve cost minimisation (Wu et al., 2019). Identifying, quantifying, and monetising the intangible benefits of PH can enhance the existing cost-benefit analysis framework, thereby strengthening the case for PH as a cost-effective solution (Wuni & Shen, 2020). To improve lending for PH projects, innovative financing

vehicles tailored to the specific processes of PH could be developed, such as long-term loan schemes provided in advance to developers and contractors (Feutz, 2019). Additionally, public-private partnerships should be considered as potential financing sources and investment vehicles for PH (Gan et al., 2018).

Optimising supply chain management strategies for prefabricated housing (PH) is crucial due to the inherent conflicts with conventional construction processes. The PH supply chain involves a longer value chain, a complex web of stakeholders, and intricate procurement and contractual arrangements (Wuni & Shen, 2020). PH's unique, relatively nascent, unintegrated, and untested business model presents multi-layered barriers that intertwine with other challenges, slowing the industry's adaptation (Gan et al., 2018). Transportation logistics pose additional overlapping barriers, affecting both financial and technical aspects. These include cross-border logistics, insufficient modes of transporting larger modules, load restrictions, and damages incurred during transportation, significantly hindering the PH process (Jiang et al., 2020). Adequate storage of modules, whether on-site or offsite, can also be challenging if schedules are not meticulously managed and synchronised (Salama et al., 2018). The frequent need for mobile cranes to hoist modules and components further complicates operations, especially in underdeveloped areas. A lack of standardisation, collaborative contracts, information and communication platforms, best management practices, training, labour upskilling, and capable managers exacerbates these challenges (Wuni & Shen, 2020).

Supply chain management strategies must be optimised through the collaboration of research institutions and industry practitioners (Gan et al., 2018a). Reducing the complexity of project management and ensuring the collaboration of all stakeholders from the early stages of projects are essential to prevent PH processes from becoming a legitimate barrier (Gan et al., 2018a). Enhancing coordination and communication between fragmented parts of the supply chain can be achieved by leveraging various smart technologies and integrated project delivery models, such as Building Information Modelling (BIM) and electronic file transfers, to decrease risk and improve project performance (Jiang et al., 2020). Additionally, the industry should consider prefabricating modules closer to construction sites, where feasible, to mitigate transportation logistics challenges (Wuni & Shen, 2020).

Broad regulatory systems and government support are essential to guide, ignite, and regulate the implementation of valuable innovations in the prefabricated housing (PH) industry (Jiang et al., 2020). The absence of standards and regulations presents significant barriers. The lack of government incentives, subsidies, and preferential tax policies are major policy obstacles to investment in the PH sector (Aziz & Abdullah, 2015). Additional barriers include the lack of technical guidance and information, design codes and standards, and inadequate policies and regulations. However, countries such as Japan, the United States, Sweden, and the United Kingdom, where the investment in PH is highest, have made significant advancements in these areas (Gan et al., 2018). Restrictive and unfavourable planning and building regulations further challenge the adoption of PH in some countries. Therefore, most countries need to establish regulatory frameworks to implement, assess, rate, and certify PH systems (Wuni & Shen, 2020).

Governments and developers, possessing the highest degree of power and centrality, must ensure the establishment of comprehensive policies, guidelines, and regulations in developing countries (Jiang et al., 2020). Governments should act as catalysts for changing perceptions by investing in prefabricated housing (PH) projects, stimulating the market through incentives for developers, and establishing PH tenders (Aziz & Abdullah, 2015). Legal, regulatory, and technical support structures should include risk aversion measures, design codes and standards, technical guidance, best practice manuals, and success factors for industry practitioners (Wuni & Shen, 2020). These efforts should also extend to novice developers and potential clients who may be interested in PH but need to be more informed about the technology (Gan et al., 2018). The COVID-19 pandemic has underscored the importance of alternative housing solutions, highlighting the need for these to receive equal emphasis and policy support.

Nurturing a cultural shift is essential to overcoming industry barriers in developing more prefabricated housing (PH) projects. The industry's historical reputation for being conservative and slow to adopt new and innovative solutions is a primary recurring barrier (Wong et al., 2018). This barrier is further reinforced by the dominance of established conventional systems, with stakeholders fearing structural industry change (Wuni & Shen, 2020). Additionally, the lack of standardisation in PH forces the industry to cost modules using standard measurement methods from conventional construction, further hindering progress (Jiang et al., 2020). One of the most frequently cited overlapping barriers is the unfavourable organisational systems of PH and its fragmentation at both the industry and project levels (Steinhardt et al., 2019).

Product demand uncertainty and supplier availability exacerbate risk aversion among clients and banks in the prefabricated housing (PH) industry. The monopoly of construction techniques by prominent manufacturers and suppliers is another counterproductive tactic, as it hinders knowledge dissemination and slows down investor and developer interest in utilising PH. Turok and Visagie (2018) also highlight the challenge posed by the quality and quantity of retiring shipping containers relative to demand. Suppose the technology were to be rapidly adopted. In that case, it is unlikely that the number of retiring containers would meet the demand, and even if the supply were sufficient, there would be concerns about whether these containers are of habitable quality (Turok & Visagie, 2018).

Nurturing a cultural shift in the prefabricated housing (PH) industry is a collaborative effort that requires investment from governments, researchers, and industry practitioners. This collaborative effort is crucial for raising awareness, changing perceptions, and improving investment in PH (Wong et al., 2018). Governments should take the lead in stimulating demand, as demonstrated in some Asian countries and the UK (Wuni & Shen, 2019). Additionally, technical and research institutions need financial support to pursue innovative technologies, such as Building Information Modelling (BIM), and to develop inventions that address current technical challenges, including structural solutions for natural disasters and severe weather conditions like typhoons (Jiang et al., 2020).

To overcome aesthetic barriers, with designs often referred to as 'brutalist architecture', less monotonous designs and structures are essential in the prefabricated housing (PH) industry. There is a perceived fear that PH leads to monotonous designs and structures,

resulting in urban fabrics with poorer aesthetics and standardised cities of blandness and uniformity, breeds scepticism toward PH (Wuni & Shen, 2020). Concerns also exist regarding PH's flexibility and customisation capabilities, as customisation and flexibility of modules often come at a financial loss for those specific units (Agatsiva, 2019). Additionally, space and height limitations are frequently cited as challenges (Nduka et al., 2018). Social acceptance poses a significant barrier, with associations of the raw steel aesthetic of containers being perceived as 'poor' and lower-value housing (Zaki & Danraka, 2015). These perceptions negatively affect clients' acceptance of shipping container housing as a viable construction alternative to traditional building methods (Kamara, 2018).

However, architects, contractors, designers, and engineers have already begun pushing boundaries with groundbreaking design options. Improved engineering and module design can further enhance this progress. Turok and Visagie (2018) documented that while 60% of users initially reject the method due to its steel aesthetic, 88% of participants are swayed to accept it when cladded with other materials to resemble conventional housing methods. This approach also addresses concerns of monotony in appearance, as various materials can be used to create diverse and appealing designs.

3 Research Methodology

This research study employs a scoping review methodology to map the key concepts, types of evidence, and research gaps related to upgrading informal settlements using prefabricated/modular houses. Scoping reviews are beneficial for examining emerging areas, clarifying concepts, and identifying the types of available evidence in a given field (Arksey & O'Malley, 2005). The primary research question guiding this scoping review is: "What is the current state of research on upgrading informal settlements using prefabricated/modular houses?" This question aims to uncover the breadth of research available, key themes, and gaps that must be addressed. A comprehensive literature search was conducted across multiple databases housed by Google Scholar. The search terms included combinations of keywords such as "prefabricated housing," "modular construction," "informal settlements," "sustainable housing," and "upgrading." The search was limited to peer-reviewed articles, conference papers, and published dissertations or theses focusing on relevant literature published in English over the past ten years.

Inclusion criteria:

- Studies focused on using prefabricated or modular housing for upgrading informal settlements.
- Research articles, review papers, and case studies.
- Publications in English.

Exclusion criteria:

- Studies not focused on housing or informal settlements.
- Articles not available in full text.
- Publications in languages other than English.

Data was extracted from selected articles using a standardised data extraction form. The form was used to capture information on the author(s), year of publication, study location, objectives, methodology, key findings, and conclusions. This process ensured consistency

and comprehensiveness in capturing relevant data from each source. The extracted data was analysed thematically. Themes were identified based on the recurring concepts and findings across the studies. This thematic analysis aided in mapping out the key areas of focus in the existing literature and identifying gaps where further research is needed (Braun & Clarke, 2006; Weaich et al., 2024). The results are presented in a narrative format. The narrative discussed the main themes identified, the types of evidence available, and gaps in the research. This presentation provides a clear and comprehensive overview of the current state of knowledge on the topic. As this is a review of existing literature, no primary data collection involving human subjects was conducted. This methodology ensures a systematic and comprehensive approach to reviewing existing literature, providing valuable insights into using prefabricated housing for upgrading informal settlements.

4 Findings and Discussion

Theme 1: Why Prefabricated Housing Can Be an Alternative for Informal Settlements.

Terms such as offsite, prefabricated, and modular construction are often used interchangeably to describe various systems and approaches to offsite construction. Modular construction specifically involves the creation of standardised, complete modules offsite (typically in a factory), which are then transported to and assembled on-site to form more significant buildings, such as townhouses, apartments, and high-rise offices (Thompson, 2019). Modular construction is widely recognised for its significant cost, time, and energy savings. Feutz (2019) states that recent modular projects have demonstrated a "solid track record of accelerating project timelines by 20-50 per cent," while achieving 20 per cent and above construction cost savings. Offsite/modular construction is experiencing a revival and driving a paradigm shift to revolutionise the real estate sector. The industry has grown significantly due to numerous global real estate challenges (Feutz, 2019). Many researchers believe modular construction could address some of the industry's long-standing challenges if fully realised (Wuni & Shen, 2020). Despite the construction industry's general conservatism and slow adoption of progressive innovation, modular construction offers various benefits, including repeatable structures, transportable unit sizes, quality control, affordability, and consistency (Thompson, 2019). Prefabricated housing (PH) also enhances workplace safety, as high-rise buildings can be constructed at ground level and in safer factory environments (Thompson, 2019).

The following continuum of prefabrication construction methods and components enables the realisation of these benefits. Complete/mobile prefabrication comprises factory-completed buildings delivered to a building site (Thompson, 2019). Pods are smaller volumetric units (such as toilets or kitchens) connected to larger structural units on-site (Wuni & Shen, 2020). Panels are non-volumetric frames, such as timber/steel-framed, structural insulated, and precast concrete panels, joined on-site to form volumetric units (Thompson, 2019). Finally, subassembly components, such as doors, windows, and trusses, are pre-cut or preassembled and are not feasible to produce on-site; these components are essentially part of the conventional construction industry (Steinhardt et al., 2019).

Theme 2: Investments into Prefabricated Housing – Challenges and Risks

Investment in prefabricated housing (PH) is occurring at much slower rates globally than expected, especially considering its well-documented benefits over conventional housing. These benefits include lower running costs, faster all-weather turnaround times due to factory production, safer working environments, and better environmental outcomes due to minimised waste (Steinhardt et al., 2019). Consequently, tiny, manufactured housing offers a quicker and cheaper housing supply, lagging behind demand in most African cities. Despite these advantages, stakeholders such as developers, financiers, and occupants of modular/prefabricated housing face significant challenges. Given the overwhelming benefits and feasibility claims, the global consensus is that the development of PH as a viable alternative is progressing too slowly (Gan et al., 2018).

The sluggish uptake of PH has prompted researchers to document the barriers contributing to slow investment. Wuni and Shen (2020) highlight how uninformed perceptions, conservatism, and scepticism among stakeholders unduly hinder investment in modular construction. Since its modern resurgence in the 1990s, modular construction (PH) has faced poor attitudes, low confidence, negative mindsets, and stigmas from the construction industry, and these long-standing barriers persist today (Wuni & Shen, 2020). Claims that modular homes have lower values and are too expensive lead to poor social acceptability due to suspicions around quality and value. Additionally, perceptions that rapid uptake will limit design creativity and negative sentiments from past failures hinder acceptance (Wuni & Shen, 2020). Despite numerous global examples contradicting these perceptions in recent decades, the belief that PH is more expensive than conventional housing remains one of the longest-standing barriers. This perception is particularly difficult to dispel given the many factors that must be considered, such as size and quality (Arif et al., 2017).

Theme 3: Minimising the Risks Associated with Prefabricated Housing

Though variable, the supply chain of PH consists primarily of four stages: planning, modular design, and statutory approval; concurrent site preparation and offsite manufacturing of modules/components; temporary storage and transportation of modules to the destination; and on-site installation and assembly of modular units to form the finished building. This prefabrication process affords numerous benefits to all stakeholders involved, central to the contracting firms and the supply network (Sooriyamudalige et al., 2019). Three classes of firms are involved in modular construction: integrated firms that manufacture products and perform site installations, manufacturing firms that only produce products, and builder firms that only conduct on-site installation of prefab products (Steinhardt et al., 2019). Other central stakeholders include designers and engineers, flanked by end-users, investors, and developers who commission the project and use the final product (Gan et al., 2018). Supporting these central stakeholders are regulatory and institutional frameworks and other technical support institutions that provide the macroeconomic, environmental, technical, regulatory, social, and other industry-related policy frameworks that enable the prefabrication industry (Steinhardt et al., 2019).

Developers often avoid affordable housing due to insufficient returns, complex financing processes, and a lack of sustainability (Thompson, 2019). Some consider offsite manufacturing a panacea to traditional affordable housing construction challenges, and researchers have documented its benefits for decades to support this narrative (Harikrishnan, 2019). While the uptake has yet to be at the expected rates, several

developed and developing countries are beginning to embrace alternative construction methods to alleviate their severe affordable housing deficits (Husain & Shariq, 2018). Modular construction has gained popularity globally due to challenges such as rising construction costs, unprecedented housing demand, and tight labour markets. The sector grew by 62% in the US to reach $3.3 billion in 2016 alone (Feutz, 2019).
Some sceptics of modular construction have valid arguments against its adoption in specific contexts. For example, some container housing programs, though well-intentioned, end up compromised due to political interference. In Shanghai, container housing has created class and social divisions, with policies evicting unwanted social groups into inadequate conditions under the guise of public safety and urban planning (Ling, 2020). Such practices reinforce social hierarchies and contribute to a lifetime aversion to container housing among those affected.

The Shanghai example mirrors the experiences of many African citizens enduring inadequate housing conditions. Agatsiva (2019) notes that Kenyan survey participants view non-brick housing as second-grade. Social status is attached to the steel aesthetic of container housing, which is considered less trendy, leading people to prefer what is popular (Sholanke et al., 2019). In Lagos, Sholanke et al. (2019) advocate that shipping container houses should only be considered once they are made cheaper and trendier. Similar findings apply to Nigeria (Nduka et al., 2018). Social acceptability is a significant barrier to adopting shipping containers as housing alternatives in most developing countries. In Malaysia, there is a 45% acceptance rate for container housing, while in South Africa, the acceptance rate is 40%. However, studies confirm that many participants who reject the raw corrugated finish are swayed when the container is clad to resemble conventional buildings (Kamara, 2018). Maphumulo (2016) found that shipping containers are more accepted in rental housing typologies in Johannesburg but not for permanent homes. Turok and Visagie (2018) suggest that cost savings in container housing only manifest with repetition, and single-story developments are often more expensive than conventional housing equivalents.

Despite the modular industry's benefits, global growth, and momentum, even the most progressive countries face unique hurdles (Feutz, 2019; Harikrishnan, 2019). Some attitudinal barriers are valid and more challenging to shift, requiring stakeholders' time, education, and training. Risk aversion among clients who view modular homes as "untested" technology perpetuates poor attitudes and sentiments (Wuni & Shen, 2020). Addressing attitudinal barriers requires collaboration among all key real estate practitioners to change mindsets and stigmas associated with PH (Aziz & Abdullah, 2015). As the most significant construction clients, governments should lead by initiating PH projects and demonstrating the feasibility of PH, as seen in Hong Kong, the UK, Singapore, Sweden, and China (Jiang et al., 2020; Wuni & Shen, 2020). Researchers can use their platforms to disseminate knowledge about PH and eliminate unwarranted stigmas. Knowledge barriers can be overcome through collaborations between educational institutions, engineers, and leading industry practitioners, offering more seminars, courses, and training programs to improve the skills and knowledge of developers, contractors, lenders, and end-users (Sholanke et al., 2019; Jiang et al., 2020).

5 Conclusion and Further Research

The literature consistently identifies prefabricated housing (PH) as a viable alternative for individuals living in informal settlements, primarily due to its affordability. Research unanimously agrees that significant efforts are required to catalyse more investment in PH, including enhanced research, education, supply chain improvements, and better communication and collaboration among industry stakeholders. The paper recommends that African governments adopt PH as a strategy to achieve the 2030 Sustainable Development Goal 11, which aims to make cities inclusive, safe, resilient, and sustainable. PH is recommended due to its lower construction costs and the critical need for faster delivery in an increasingly urbanised world. Expediting investments in PH could significantly contribute to eradicating housing informality in many African countries. From a research perspective, numerous gaps still need to be addressed, including the need for in-depth examinations of the contextual feasibility and performance of PH across different geographical areas.

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