Design Thinking on Group Housing: A Comprehensive Systematic Literature Review

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Abstract: Design thinking (DT) has emerged as a human-centred, empathy-driven, and iterative methodology with increasing relevance to architecture and built environment research. Although widely adopted in education, business, and innovation domains, its structured application in group housing design particularly in the Indian context remains limited. The present study conducts a comprehensive systematic literature review (SLR) to examine how DT has been utilized in housing, built environment innovation, user-centred frameworks, psychological needs assessment, and related interdisciplinary domains. Following PRISMA 2020 guidelines and adapting methodological rigor from established DT-based SLRs, the review synthesizes insights from six high-quality peer-reviewed publications: including systematic reviews of DT in education, innovation in sustainable built environments, user-centred design in architecture, and DT-driven community engagement. The review process involved defining search equations, applying explicit inclusion exclusion criteria, screening eligible studies, and thematically analysing selected literature. Findings reveal that while Design Thinking contributes strongly to empathy building, problem framing, co-creation, prototyping, and iterative evaluation, its integration into group housing has predominantly focused on physical and functional design rather than psychological, emotional, or socio-cultural dimensions of dwelling. The studies highlight substantial gaps in incorporating user aspirations, lived experiences, safety perceptions, community bonding, and behavioral patterns, especially within high-density urban housing. Research from the built environment domain shows that innovation frameworks integrating Design Thinking can significantly enhance sustainability, inclusivity, and user experience, yet these approaches remain underutilized in Indian housing practice. The review identifies four major thematic gaps: (1) limited empirical studies applying Design Thinking to real housing contexts, (2) insufficient integration of psychological and experiential needs in design processes, (3) weak adoption of participatory and iterative methodologies in public sector housing (e.g., JNNURM, PMAY), and (4) lack of scalable frameworks for translating user insights into design decisions. This SLR establishes a clear foundation for developing a DT-based framework for group housing, aligning user needs, psychological wellbeing, and community dynamics with spatial, functional, and policy-driven housing requirements. The review concludes that DT holds transformative potential for rethinking housing beyond physicality toward human-centred, emotionally resonant, and socially sustainable living environments.

1. Introduction

Housing has evolved beyond mere physical shelter to become recognized as a multidimensional construct encompassing psychological well-being, behavioral patterns, cultural identity, and social belonging [1–3]. This expanded understanding positions the dwelling not merely as a "house" but as a "home," a space where physical form interacts with emotional experience, memory formation, and social reproduction [4]. However, traditional architectural and planning approaches have disproportionately emphasized physical performance metrics, spatial standards, structural efficiency, environmental compliance, and typological optimization while systematically under-addresses the complex interplay of emotional comfort, lived experience, safety perception, and community dynamics that define residential quality [5,6].

This design-reality gap is particularly pronounced in rapidly urbanizing Indian contexts, where standardized housing solutions and policy-driven development models often overlook the heterogeneous needs, aspirations, and behavioral patterns of diverse resident populations [7,8]. The resulting environments frequently manifest as spatial containers that residents must adapt to, rather than spaces consciously shaped around user aspirations, cultural practices, and psychological well-being [9]. This disconnect becomes especially problematic in group housing, the dominant urban residential typology in India, where high-density living intensifies interactions between physical design, social dynamics, and individual experience [10].

Against this backdrop, DT has emerged as a powerful human-centred, iterative problem-solving methodology with demonstrated capacity for addressing complex, ill-structured challenges across diverse domains [11–14]. Characterized by phases of empathy, definition, ideation, prototyping, and testing, DT frameworks emphasize contextual inquiry, collaborative sense-making, and rapid experimental iteration [14]. Unlike conventional linear design processes, DT privileges the understanding of user experiences, motivations, and unarticulated needs, making it particularly suitable for socio-spatial systems where psychological and experiential factors are central to success [15,16].

Systematic investigations of DT applications reveal compelling patterns. In higher education, DT has proven effective in fostering user understanding, reflective inquiry, creative confidence, and interdisciplinary collaboration [17,18]. A recent systematic review of DT as an active teaching methodology confirms that empathy-building, problem framing, and iterative cycles constitute core components that enhance learning outcomes components that directly parallel the needs of housing design processes navigating diverse user requirements [19]. In healthcare innovation, DT approaches have transformed service delivery by prioritizing patient experiences and co-creating solutions with end-users [20,21].

Parallel research examining DT across applied and interdisciplinary domains consistently highlights recurring strengths: contextual sensitivity, iterative refinement, and user-experience orientation [22,23]. These studies emphasize DT's capacity to illuminate emotions, motivations, identity formation, and behavioral engagement dimensions critically important to the design of meaningful residential environments where inhabitants develop routines, attachments, and social practices [24,25]. This evidence indicates a strong conceptual

alignment between DT methodologies and the psychological and cultural dimensions of housing, dimensions that remain underrepresented in mainstream architectural practice despite their profound impact on resident satisfaction and well-being [26].

Within the built environment domain, a growing body of scholarship has begun integrating DT with sustainability transitions, inclusive foresight, and multi-stakeholder innovation frameworks [27,28]. Research demonstrates that DT enables designers and planners to anticipate long-term environmental, social, and technological scenarios, thereby improving adaptability and resilience in housing systems [29]. Evidence further suggests that DT enhances collaborative processes across architecture, planning, engineering, and community development disciplines by offering a shared language and structured approach for user-centred innovation [30,31].

Recent international studies have demonstrated increasing application of participatory and co-design approaches in multi-household housing contexts across diverse geographic settings. In European contexts, researchers have documented DT-adjacent methodologies in co-housing for older adults, participatory regeneration of public housing neighbourhoods, and co-design approaches for homeless accommodation [32–35]. Studies from Brussels have developed participatory-action research with service-design methods for ageing-in-place housing models, while Italian research has examined tools for rehabilitating large residential neighbourhoods through integrated public-private regeneration [32,33]. Hungarian scholars have implemented pattern-language "coding engines" for social housing co-design, and Spanish researchers have documented co-design and co-manufacturing approaches in Barcelona's vulnerable urban contexts [36,37].

Digital innovation in participatory housing has also emerged as a significant trend, with researchers developing graphic user interfaces for housing customization, gamified simulations for co-living design, computational systems for mass-housing collaborations, and IoT prototypes for cohousing communities [38–41]. These technological interventions aim to enhance user participation but often focus on tool development rather than comprehensive DT process implementation or outcome measurement.

Social sustainability and community empowerment have been central themes in participatory housing research across contexts. Studies have examined spatial agency in older people's cohousing, co-design toolkits for community-led affordable housing, and activist co-design in contested housing occupations [42–44]. Comparative research has analyzed participatory versus conventional design approaches in social housing regeneration, while other studies have explored regenerative housing that enables resident agency in ecological restoration [45,46].

Despite this global expansion of participatory approaches, critical examination reveals that many of these studies do not explicitly frame their methodologies within canonical DT frameworks (d.school, Double Diamond, IDEO models). Instead, they employ related but distinct terminology: "co-design," "participatory design," "community engagement," or "action research." Furthermore, these international applications often lack systematic documentation of the full DT cycle, particularly the prototyping and testing phases and rarely measure outcomes related to psychological well-being, community dynamics, or governance sustainability. This represents a significant methodological gap: while participatory intentions are increasingly common, rigorous application and evaluation of structured DT methodologies in housing contexts remain limited.

Particularly relevant are emerging applications of DT in housing-specific contexts. Recent studies have developed DT-PAR (Participatory Action Research) frameworks for group housing design, integrated quantitative methods and operations research with DT processes, and applied DT to community-driven crime prevention in urban housing through CPTED (Crime Prevention Through Environmental Design) principles [47–49]. These applications demonstrate DT's potential to address specific housing challenges while highlighting the

methodology's adaptability to architectural and urban contexts.

Complementary research from environmental psychology and user experience design further emphasizes how built environments fundamentally shape cognitive patterns, perceived safety, stress regulation, social interaction, and emotional states [50,51]. DT, with its emphasis on empathetic observation, behavioral mapping, and iterative refinement, offers a robust methodological toolkit for decoding these complex human-environment interactions and translating insights into design decisions grounded in lived experience [52,53].

Despite this theoretical promise and emerging applications, DT remains underexplored within mainstream housing research. A critical review reveals persistent gaps: few empirical studies systematically apply DT methodologies to residential environments, limited incorporation of emotional and cultural needs into design processes, minimal integration of iterative prototyping into housing development workflows, and weak adoption of participatory methodologies in public sector housing programs such as JNNURM and PMAY [54–57]. These deficiencies are particularly pronounced in Indian group housing contexts, where high-density environments exhibit significant mismatches between policy intentions, design assumptions, and lived realities [58].

This dispersion of knowledge across disciplinary silos architecture, design innovation, environmental psychology, housing studies creates a critical research gap: no comprehensive synthesis exists that maps how DT has been conceptualized, applied, and evaluated specifically in relation to group housing design. While systematic reviews have examined DT in innovation management, sustainability, and healthcare, none have focused specifically on housing as a complex socio-spatial system where physical design intersects with psychological experience and social dynamics [16,20,27].

To consolidate this dispersed knowledge and provide a foundation for practical application, this study conducts a PRISMA 2020-guided systematic literature review (SLR) to address the following questions:

(1) How is DT (and related human-centred/participatory frameworks) conceptualized and operationalized in research addressing group housing design?

(2) What are the key thematic focus areas, methodological approaches, and outcomes reported in studies applying DT methodologies to group housing contexts?

(3) What theoretical lenses (e.g., power dynamics, community well-being, resource scarcity, innovation diffusion) are integrated with DT in housing studies, and how are these syntheses achieved?

(4) Based on synthesized evidence, what are the primary research gaps and future directions for employing DT in designing sustainable, human-centric group housing, particularly in Indian urban contexts?

This review adopts the PRISMA 2020 guidelines to ensure methodological rigor, transparency, and reproducibility [59]. By systematically mapping and synthesizing dispersed knowledge at the DT-housing interface, this study aims to establish a comprehensive foundation for repositioning housing design as a human-centred, psychologically informed, and community-responsive domain capable of addressing contemporary urban living challenges. The resulting synthesis will directly inform the subsequent empirical phases of this doctoral research, which seeks to develop and validate a context-sensitive DT framework for group housing in Vijayawada, India.

2. Methodology

2.1. Overview and protocol development

This study employed a SLR methodology, designed and executed in strict accordance with the PRISMA 2020

(Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency, reproducibility, and methodological rigor [59]. Prior to the search, a detailed review protocol was developed to predefine the research aims, eligibility criteria, search strategy, and synthesis plan, aligning with best practices for evidence synthesis.

2.2. Search strategy and information sources

To ensure comprehensive and multidisciplinary coverage, searches were conducted across multiple bibliographic databases and grey-literature sources. Academic databases included as follows:

(1) Scopus and Web of Science (Core Collection) for broad interdisciplinary coverage;
(2) ScienceDirect, JSTOR, and Avery Index to Architectural Periodicals for architecture and social-science literature;
(3) IEEE Xplore for technology- and systems-oriented work;
(4) Publisher platforms (Springer, Taylor & Francis, Wiley, MDPI) for direct journal content;
(5) Google Scholar was used to capture seminal works, conference proceedings, and theses via the first 200 results per query (utilising Publish or Perish software);
(6) Architecture and housing-specific sources (Archnet-IJAR, SPA Vijayawada repository) and relevant conference proceedings (CAADRIA, DMI, eCAADe) were also searched;
(7) Grey literature searches targeted policy and practice documents from Indian housing agencies (HUDCO, DDA) and national missions (PMAY, JNNURM) to capture practice-oriented insights.

2.3. Search string and selection criteria

Search strings were constructed using Boolean logic to capture the intersection of DT and housing-related concepts. The core query structure combined variants of the following:

(1) Design process terms: "design thinking", "human-centred design", "co-design", "participatory design", "participatory action research", "co-creation";
(2) Housing context terms: "housing", "group housing", "multi-family", "social housing", "cohousing", "affordable housing", "public housing", "housing estate";
(3) Context-specific terms: "PMAY", "JNNURM", "HUDCO", "DDA" were used to surface literature on institutional adoption in the Indian context.

Parallel searches combined design-process terms with keywords for psychological and experiential dimensions ("psychological", "well-being", "sense of place", "topophilia"). Syntax was adapted for each database. The publication window was set from 2000 to 2025 to capture contemporary DT scholarship while retaining foundational theoretical works. The search was limited to English-language documents, including peer-reviewed articles, conference papers, book chapters, and substantive grey literature reports.

2.4. Eligibility criteria

Studies were assessed against pre-defined eligibility criteria structured using the PICOS (Population, Intervention, Comparison, Outcomes, Study design) framework (Methley *et al.*, 2014). The criteria, detailed in **Table 1**, were applied during the title/abstract and full-text screening stages to ensure consistency and transparency in study selection.

<div align="center">**Table 1.** Eligibility criteria (PICOS framework)</div>

PICOS element	Inclusion criteria	Exclusion criteria
Population	Studies focusing on the planning, design, or evaluation of group housing (multi-family, collective residential environments, including social housing, co-housing, and private apartment complexes).	Studies on single-family detached homes, non-residential buildings, or institutional housing (e.g., dormitories, hostels) as the primary focus.
Intervention	Application of Design Thinking (explicitly named) or its core methodological phases (empathize, define, ideate, prototype, test). Studies employing participatory design, co-design, or human-centered design frameworks with a clear, structured, and iterative process aligned with DT principles were also included.	Studies mentioning only general "community consultation," "stakeholder engagement," or "post-occupancy evaluation" without a structured, iterative co-design process. Studies on product or digital interface design without direct spatial implications for housing.
Comparison	Not a primary criterion for this descriptive, mapping review. Comparative studies within the included literature were analyzed for their findings.	-
Outcomes	Studies reporting on spatial/architectural, social, psychological, behavioral, or governance outcomes of the design process (e.g., design changes, user satisfaction, community cohesion, perceived safety, well-being, policy uptake).	Studies focused solely on technical, structural, or environmental performance metrics (e.g., energy efficiency, material strength) without a link to user experience, behavior, or participatory process outcomes.
Study design	Empirical studies (qualitative, quantitative, mixed-methods), case studies, theoretical/conceptual frameworks, and systematic reviews. High-quality grey literature (e.g., technical reports, project evaluations) with substantive methodological detail was included.	Purely descriptive project reports without analysis, opinion pieces/editorials, non-peer-reviewed magazine articles, theses/abstracts where the full text was unavailable, and non-English publications.

2.5. Study selection process

The selection process followed the PRISMA 2020 four-phase flow as outlined:

(1) Identification: Records from all sources were imported into Zotero reference management software for deduplication;

(2) Screening: Titles and abstracts were screened against eligibility criteria. To ensure reliability, a random 10–20% subset was screened independently by two reviewers, with disagreements resolved through discussion. The remaining records were screened by the primary reviewer with periodic cross-checks by the supervisor;

(3) Eligibility: Full texts of potentially relevant studies were retrieved and assessed in detail. Reasons for exclusion at this stage (e.g., wrong intervention, insufficient methodological detail) were documented;

(4) Inclusion: Studies meeting all criteria proceeded to data extraction. The process is documented in the PRISMA flow diagram (**Figure 1**), which records the number of records identified, screened, assessed, and included.

2.6. Data extraction and management

A standardized data extraction form was developed in Microsoft Excel to systematically capture information from each included study. Extracted data included as follows:

(1) Bibliographic details: Authors, year, title, source, DOI;

(2) Study characteristics: Geographic context, research aims, study design, methodology;

(3) Housing context: Type (public/private/co-housing), scale, target demographic;

(4) DT/intervention Details: Explicit framework used, phases implemented, participatory methods (e.g.,

workshops, prototyping, CPTED audits);

(5) Outcomes: Reported findings related to spatial design, user satisfaction, community dynamics, psychological well-being, safety, and governance;

(6) Theoretical foundations: Any integrated theoretical lenses (e.g., Flyvbjerg, Rogers, Ibasho);

(7) Limitations & gaps: Author-identified constraints and future research directions.

A subset of studies was double-extracted to ensure consistency; the primary reviewer completed the remainder with supervisor spot-checks.

2.7. Quality assessment (critical appraisal)

To assess the methodological rigor and potential bias of included studies, a quality appraisal was conducted using the following design-appropriate tools:

(1) Qualitative studies were appraised using the Critical Appraisal Skills Programme (CASP) checklist;

(2) Mixed-methods studies were assessed with the Mixed Methods Appraisal Tool (MMAT);

(3) Quantitative descriptive/case studies were evaluated using relevant Joanna Briggs Institute (JBI) checklists.

Each study received a quality judgement. While no studies were excluded based on quality alone, the appraisal informed the synthesis and discussion by highlighting the strength of the evidence.

2.8. Data synthesis method

Given the anticipated heterogeneity in study designs and outcomes, a narrative thematic synthesis was employed. The process involved as listed:

(1) Descriptive mapping: Tabulating studies by year, geography, design, and housing type to identify patterns;

(2) Thematic coding: Using NVivo software for iterative coding of the extracted data to identify recurring concepts (e.g., empathy methods, prototyping tools, governance barriers);

(3) Theme development: Grouping codes into overarching themes and sub-themes that directly addressed the research questions;

(4) Cross-case synthesis: Comparing findings across different contexts (e.g., public vs. private housing, Global North vs. Global South) and mapping the integration of theoretical frameworks.

2.9. Limitations of the review methodology

Several methodological limitations are acknowledged as follows:

(1) Language and database bias: The restriction to English-language publications and selected databases may have omitted relevant studies in other languages or in non-indexed sources;

(2) Grey literature capture: While sought, not all practice-based project documentation may have been retrieved;

(3) Screening constraints: Due to practical resource limitations, the majority of screening was conducted by a single reviewer, albeit with validation checks and a dual-screened subset to mitigate bias;

(4) Conceptual breadth: The inclusive approach to "DT-related" frameworks introduces heterogeneity but was necessary to map the field comprehensively. These limitations are considered when interpreting the findings and their generalisability.

3. Results

3.1. Study selection

The systematic search process identified a total of 156 records from academic databases (n = 124), conference registers (n = 25), and grey literature sources (n = 7). Following the removal of 42 duplicates, 114 unique records underwent title and abstract screening. Of these, 89 records were excluded as they did not meet the eligibility criteria outlined in **Table 1**, primarily due to lack of focus on DT or irrelevance to housing or built-environment contexts. The remaining 25 full-text articles were retrieved and assessed in detail. Of these, 17 were excluded due to: absence of a structured DT or participatory methodology (n = 8), focus on single-family or non-residential architecture (n = 5), insufficient methodological reporting (n = 3), or non-English full text (n = 1). Ultimately, 8 studies satisfied all inclusion criteria and were included in the final qualitative synthesis. The selection process is detailed in the PRISMA 2020 flow diagram (**Figure 1**).
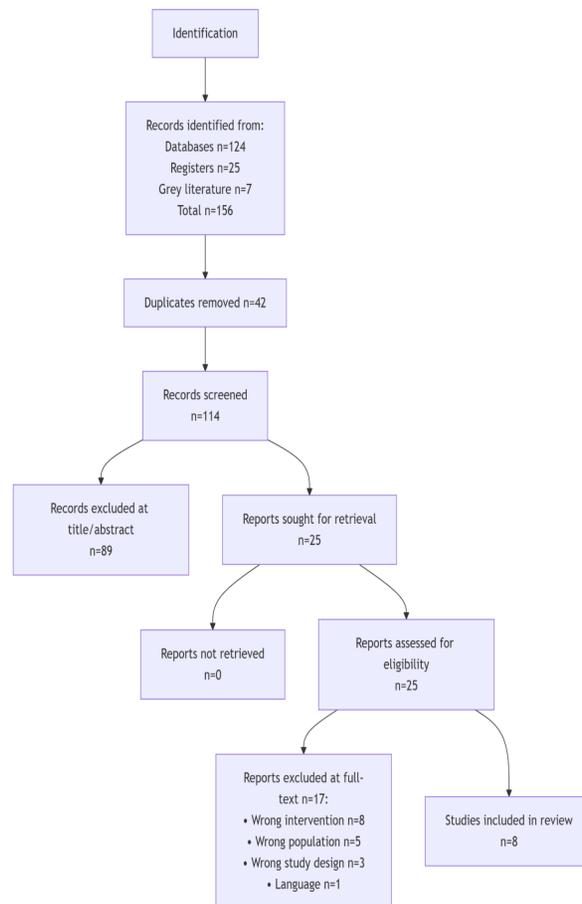

Figure 1. PRISMA 2020 flow diagram of study selection.

3.2. Characteristics of included studies

The characteristics of the eight included studies are summarized in **Table 2**. The studies were published between 2014 and 2025 and originated from diverse geographical contexts: India (n = 3), Poland (n = 1), Australia (n = 1), Egypt (n = 1), Greece (n = 1), and one multinational review. Study designs included empirical case studies, conceptual frameworks, computational design experiments, applied design research, and methodological model

development.

The housing contexts addressed were similarly varied, encompassing urban redevelopment projects, elderly housing, multi-unit housing design, interior residential spaces, and sustainable built environments. All studies explicitly engaged with the core, iterative phases of DT empathy, ideation, prototyping, and testing through the operationalization of these phases ranges from traditional workshop-based co-design to digital and computational methods. Three studies were directly situated in Indian group housing contexts, forming a critical subset for contextual analysis [31,47–49].

Table 2. Characteristics of included studies

Author(s), year, country	Study design & housing context	Design thinking / participatory methods	Key findings	Quality appraisal (CASP/MMAT)
Kumar *et al.* (2016), India [31]	Case study: Urban redevelopment housing project	Mixed-methods DT: stakeholder workshops, iterative prototyping, feedback loops	DT improved multi-stakeholder alignment and design acceptance; highlighted institutional adoption barriers in India.	Moderate-High: Clear aims, appropriate methodology, good reflexivity.
Wilson *et al.* (2014), Australia [60]	Conceptual framework: Sustainable built environments	DT integrated with strategic foresight for sustainable innovation	Proposed DT enhances long-term, adaptive thinking for housing sustainability; lacks empirical validation.	Moderate: Theoretically sound, limited methodological detail.
Wąsowicz *et al.* (2022), Poland [61]	Applied design research: Elderly housing	Human-centered DT with universal design; co-design workshops with elderly users	Empathy-driven DT improved accessibility, safety, and social inclusion outcomes.	Moderate: Strong participant focus; limited sample generalizability.
Vamvakidis (2022), Greece [62]	Methodological research: Multi-unit housing	Computational DT: parametric design, programmatic iteration	Digital DT tools enable rapid customization; technically focused with limited social outcome measures.	Moderate: Innovative methods; narrow focus on computational process.
Rashdan & Ashour (2022), Egypt [63]	Experimental study: Interior residential design	DT for spatial conceptualization; user journey mapping, prototyping	DT improved functional layout and user satisfaction; limited to single-unit scale.	Low-Moderate: Limited methodological transparency and context.
Kumar & Srikonda (2025a), India [9]	Framework development: Group housing	DT + Interaction Design: VR prototyping, empathy mapping, analytics	IxD-enhanced DT reduced iteration cycles (~25%) and improved communal space satisfaction.	High: Robust methodology, clear outcomes, good contextual relevance.
Kumar & Srikonda (2025b), India [47]	Framework development: Group housing	DT + Participatory Action Research (PAR) hybrid model	Framework integrates academic rigor with deep participatory empathy; notes scalability challenges.	High: Strong theoretical integration, transparent methodology.
Tantiyaswasdikul, K. (2023), Thailand [64]	Systematic/narrative review: Sustainable housing innovation	Synthesis of DT in green buildings & eco-housing	DT is key for sustainable innovation but underexplored at residential scale.	Moderate: Depends on review methodology rigor.

3.3. Thematic synthesis

Thematic analysis of the eight studies revealed four interconnected meta-themes that address the review's research questions as follows:

(1) The evolving methodology of DT in housing;

(2) The centrality of empathy and participatory depth;

(3) Outcomes and measurement gaps;

(4) Contextual and scalability challenges.

3.3.1. Meta-theme 1: The evolving methodology of DT in housing

The studies demonstrate a clear trajectory from conceptual DT frameworks toward specialized methodological hybrids [60]. Later studies integrate DT with the following aspects:

(1) Participatory action research (PAR) for scholarly-community co-inquiry [47];

(2) Interaction design (IxD) for digital prototyping and behavioral analytics [9];

(3) Computational design for parametric iteration [62].

This evolution (research question 1) signifies DT's adaptability but also reveals a fragmented methodological landscape where "DT" serves as an umbrella for disparate practices, complicating comparative analysis and replication.

3.3.2. Meta-theme 2: The centrality of empathy and participatory depth

Empathy-building and stakeholder participation were unanimously emphasized as the defining, non-negotiable core of housing-related DT (research questions 1 and 2). Methods ranged from ethnographic interviews and co-design workshops to digitally-mediated empathy mapping [9,31,61]. However, the depth of participation varied significantly. While some studies engaged residents as co-creators throughout the design cycle, others limited participation to initial consultation or feedback on pre-defined prototypes. This variation points to a critical gap between the ethos of "designing with people" and its practical execution, which is often constrained.

3.3.3. Meta-theme 3: Outcomes and measurement gaps

Reported outcomes spanned three domains (research question 2):

(1) Spatial/functional: Improved layouts, accessibility, customization;

(2) Social/psychological: Enhanced user satisfaction, perceived safety, community belonging;

(3) Process-related: Reduced iteration time, improved stakeholder consensus.

A significant finding was the lack of standardized, robust measurement. Outcomes were often described qualitatively or via self-reported satisfaction. Only two studies employed quasi-experimental or pre-post evaluation [9,61]. This inconsistency makes it difficult to assess DT's efficacy empirically and represents a major barrier to its evidence-based adoption in housing policy.

3.3.4. Meta-theme 4: Contextual and scalability challenges

A tension emerged between context-specific success and scalability (research questions 3 and 4). Intensive, empathy-rich processes yielded positive outcomes in specific cases (e.g., elderly housing in Poland, redevelopment in India) but were resource-heavy. Conversely, scalable digital tools (computational, VR) raised concerns about equitable access and digital literacy. Furthermore, studies consistently identified institutional, regulatory, and policy frameworks as the primary barrier to wider DT adoption, especially in public housing sectors. The reviewed literature largely documents pilot-scale success but offers limited pathways for integrating DT into mainstream housing delivery systems.

3.4. Quality appraisal summary

Methodological quality was appraised using design-appropriate tools (CASP for qualitative studies, MMAT for mixed-methods). Overall, the included studies demonstrated adequate to high rigor. Strengths included clear articulation of research aims, appropriateness of study design, and, in most cases, a strong reflexive account of the researcher's role. The frameworks by Kumar & Srikonda scored highest due to their transparent methodology, integration of theory, and clear reporting of limitations [9,47].

Common limitations across several studies were limited generalizability (due to case-study design), incomplete reporting of DT phases (often glossing over prototyping or testing), and partial stakeholder representation. No study was excluded based on quality, but these limitations were factored into the synthesis by weighting findings from more robust studies more heavily in the analysis. The appraisal confirms that while the evidence base is small, it is sufficiently credible to support the thematic synthesis and identification of research gaps.

4. Discussion

The findings of this systematic review demonstrate that DT has emerged as a valuable methodological and conceptual approach across diverse built-environment and design-related domains. Although the final set of eight included studies reflects a modest evidence base, they collectively reveal consistent patterns that have significant implications for understanding and advancing DT within group housing contexts. This discussion synthesizes these insights in relation to the review's research questions and situates them within the broader discourse on housing design, user experience, and methodological innovation.

Across the studies, DT is positioned as an iterative, human-centred, and problem-reframing methodology that enables designers to navigate complexity whether in urban redevelopment, sustainability transitions, or architectural pedagogy [31,60,61]. This emphasis on empathy, ideation, experimentation, and reflective evaluation aligns strongly with the multifaceted nature of group housing, where physical, psychological, cultural, and social dimensions intersect. While none of the included studies applied DT directly to large-scale group housing in the Indian context, their collective insights elucidate why DT is particularly well-suited for such environments. Group housing involves diverse user profiles, competing spatial needs, safety and privacy concerns, and varying cultural practices conditions that inherently require participatory, inclusive, and iterative design approaches.

A key insight emerging from the synthesis is that DT systematically operationalizes empathy, a component traditionally underemphasized in mainstream architectural or planning workflows. Studies focusing on elderly housing and interior spatial ideation demonstrated how empathy-driven inquiry captures residents' psychological needs, emotional triggers, and lived experiences [61,63]. In the context of group housing, this suggests the pressing need to move beyond technical-functional design parameters to incorporate users' emotional attachments, behavioral patterns, perceptions of safety, and aspirations for community belonging. This shift directly addresses the second DRC recommendation to question "why different thinking is needed." DT provides that "different thinking" by foregrounding user voices, lived experience, and social-spatial nuances that conventional housing design tends to overlook.

The review also finds that participation and co-creation are fundamental in DT-informed design processes, offering significant potential for democratizing the housing design landscape. The PAR-integrated DT frameworks proposed by Kumar & Srikonda exemplify how structured collaboration between residents, architects, planners, and policymakers can produce context-sensitive and socially resonant housing solutions [9,47]. These approaches

hold particular value for Indian public sector housing, such as PMAY, JNNURM, or municipal redevelopment schemes, where top-down planning often results in misaligned outcomes, low user satisfaction, and poor long-term adaptability. The findings underline a persistent methodological gap: although participatory concepts are widely discussed in Indian housing policy, they are seldom enacted through structured cycles of empathy, prototyping, and iterative evaluation. DT can fill this gap by offering a replicable, human-centred design protocol.

Furthermore, the synthesis highlights the role of prototyping and iteration, especially in computational and parametric workflows [62]. Digital modelling, programmatic iterations, and rapid scenario testing illustrate how DT principles are being extended into computational environments. For group housing design, which often involves complex spatial configurations, dense regulatory overlays, and multiple stakeholder demands, such iterative digital processes can significantly enhance solution exploration and design precision. However, the review also indicates that prototyping in housing contexts remains largely conceptual or digitally simulated; very few studies reported prototyping through physical mock-ups, pilot units, or real-time feedback loops. This constitutes a notable methodological gap and an opportunity for future research and practice.

Sustainability and foresight emerged as cross-cutting concerns in two studies that integrated DT with anticipatory design approaches [60,64]. These frameworks demonstrate how DT supports long-term environmental, social, and governance-oriented thinking, which is increasingly critical in group housing developments facing climate vulnerabilities, infrastructure strains, and socio-economic inequalities. Yet, despite this potential, sustainability-oriented DT applications remain largely conceptual, underscoring the need for empirical testing within housing projects, especially in Indian contexts where sustainability aspirations often clash with affordability constraints.

A notable contribution of the included studies is the integration of DT with other theoretical and methodological frameworks such as PAR, interaction design, and digital design methodologies. These hybrids illustrate DT's inherent flexibility and its capacity to operate as a transdisciplinary methodological platform. For group housing research, such integrations are especially promising because housing problems are inherently transdisciplinary spanning psychology, sociology, governance, engineering, digital technology, and environmental science. The reviewed studies indicate that DT can serve as a unifying framework across these domains, supporting richer, more contextualized, and more inclusive housing design processes.

Despite these strengths, the review also reveals important limitations in the existing evidence base as follows:

(1) There is a clear lack of empirical DT applications directly within group housing projects, particularly in India. While DT-inspired principles appear in redevelopment and pedagogical projects, the absence of large-scale, real-world DT housing interventions suggests a significant practical and research gap;

(2) The psychological, emotional, and sociocultural dimensions of group housing, although recognized, are not yet systematically incorporated into DT cycles in built-environment research;

(3) Prototyping and iterative testing remain underdeveloped in spatial design, particularly in public sector housing, where bureaucratic constraints and resource limitations hinder experimentation;

(4) The included studies lack longitudinal assessment of outcomes, such as long-term user satisfaction, behavioral adaptation, community dynamics, or post-occupancy changes.

Taken together, the findings strongly indicate that DT holds transformative potential for addressing the limitations of conventional housing design philosophies, which tends to overemphasize physical typologies, regulatory compliance, and cost optimization at the expense of social and psychological dimensions. DT provides the methodological scaffolding needed to incorporate user knowledge, facilitate collaborative decision-making,

support iterative innovation, and integrate digital/parametric tools, all of which are essential for designing humane, resilient, and context-sensitive group housing in contemporary India.

This review, therefore establishes a conceptual and methodological foundation for the next phase of this research: the development of a DT-based framework tailored specifically for group housing in Vijayawada, capable of capturing psychological needs, lived experiences, cultural diversity, and community dynamics alongside spatial and policy constraints. The subsequent chapter will build on these insights to identify research gaps and propose a structured DT model for empirical validation.

5. Research gaps and future directions

The synthesis of the eight included studies reveals several significant research gaps at the intersection of DT and group housing. These gaps highlight conceptual, methodological, and empirical limitations in current scholarship and underscore the need for a more systematic, context-sensitive application of DT within the Indian housing sector, particularly in rapidly urbanizing cities such as Vijayawada. The following subsections outline these gaps and identify specific opportunities for future research.

5.1. Limited empirical applications of DT in real housing contexts

A central finding of this review is the absence of large-scale empirical studies applying DT directly to group housing projects, especially in the Indian context. While individual studies demonstrate DT's utility in urban redevelopment, elderly housing, architectural pedagogy, and computational workflows, none apply DT end-to-end within an actual group housing development. This gap indicates that DT has not yet transitioned from conceptual potential to practical implementation in mainstream housing practice. There is a need for field-based studies that apply the full DT cycle empathy, definition, ideation, prototyping, and testing to real group housing environments. Such studies should document process details, stakeholder roles, iterative refinements, and measurable outcomes, providing scalable models for Indian housing agencies and private developers.

5.2. Underdeveloped integration of psychological and experiential dimensions

Although several included studies acknowledge psychological needs (e.g., dignity in elderly housing, sensory experiences in interior design), none systematically operationalize psychological constructs within the DT process for housing. Critical experiential aspects perceived safety, social belonging, emotional comfort, territoriality, and cultural routines remain insufficiently addressed. Future research should integrate environmental psychology, user-experience design, and behavioral mapping into DT frameworks for housing. Methods such as empathy maps, journey mapping, affective prototyping, and lived-experience audits should be systematically developed and tested to capture psychological dimensions of dwelling in group housing.

5.3. Lack of structured prototyping and testing in housing design

Prototyping and iterative testing core components of DT are weakly represented in existing housing-related literature. Most prototyping occurs digitally (e.g., parametric simulations) rather than through physical mock-ups or real-world pilot interventions. The absence of iterative testing reduces opportunities for user feedback, evaluation, and refinement before final construction. Housing research should explore low-cost, rapid prototyping techniques suitable for spatial design, such as VR/AR models, 1:1 temporary installations, modular mock-ups, participatory scenario simulations, and digital twin testing. Systematic frameworks for capturing and analysing

prototype feedback must be developed.

5.4. Limited integration of DT with public sector housing programs

Indian housing missions PMAY, JNNURM, DDA schemes rarely incorporate structured participatory or iterative processes. The review reveals minimal engagement with DT principles in public sector housing, despite strong evidence that user-centred approaches improve affordability, acceptance, and community outcomes. Research is needed to embed DT within public housing policy frameworks, including guidelines for stakeholder participation, iterative design cycles, and post-occupancy evaluation. Pilot DT-based interventions could be designed in partnership with municipal corporations, housing boards, or urban planning departments.

5.5. Fragmented methodological approaches and weak theoretical integration

While reviewed studies applied PAR, foresight, computational design, and interaction design, theoretical integration varied widely. Many studies relied on DT rhetoric but did not fully articulate or evaluate the complete methodology. Similarly, there is limited synthesis of DT with theories relevant to group housing such as Diffusion of Innovations, social sustainability, or environmental-behaviour frameworks. Future scholarship should develop hybrid models integrating DT with complementary theories of innovation diffusion, environmental psychology, social resilience, participatory governance, and computational design. Such integrative models can support more robust, interdisciplinary approaches to group housing research.

5.6. Insufficient attention to cultural, social, and governance contexts

The included studies are predominantly from non-Indian settings, often focusing on cohousing, universal design, or redevelopment in Western contexts. These models do not directly translate into the socio-cultural realities, informal practices, economic constraints, and governance systems shaping Indian group housing. India-specific frameworks must be developed that reflect local cultural practices, community dynamics, aspirational lifestyles, and governance structures. Comparative studies between Global North participatory models and Indian housing contexts could identify transferable principles and necessary adaptations.

5.7. Limited longitudinal evaluation of DT-based housing interventions

None of the reviewed studies conducted long-term evaluation of DT outcomes such as resident satisfaction, behavioral adaptation, community cohesion, or sustained usability. Without longitudinal data, the long-term benefits of DT in housing remain untested. Future research should implement post-occupancy evaluations (POE) and long-term monitoring of DT-based interventions. This would generate evidence on how DT influences housing performance over time and contributes to resilience, adaptability, and community well-being.

5.8. Underutilization of digital and computational tools in group housing research

One study demonstrated how computational design can support DT iterations, yet such integration remains rare [62]. Digital tools, parametric modelling, VR, AI-driven layout optimization, and digital twins have significant potential for enhancing rapid ideation and stakeholder co-creation. Research should advance hybrid digital-human DT workflows, integrating computational methods with user-centred practices. This includes co-creation platforms, participatory VR simulations, and real-time feedback systems for residents and designers.

5.9. Summary of research gaps

Across all eight themes, the overarching insight is clear. DT is theoretically aligned with the needs of group housing, but practical, empirical, psychological, and policy-level adoption remains extremely limited. This gap justifies this research and the development of a new DT-based framework tailored to Indian group housing, addressing the problems below:

    (1) Psychological needs;

    (2) User aspirations;

    (3) Safety and well-being;

    (4) Community dynamics;

    (5) Participatory governance;

    (6) Spatial adaptability;

    (7) Digital prototyping;

    (8) Iterative refinement.

6. Conclusion

This systematic literature review examined how DT has been conceptualized, operationalized, and evaluated within the built environment, with particular attention to its potential application in group housing. Although only eight studies met the inclusion criteria, their collective insights reveal a coherent and compelling argument for the relevance of DT as a transformative methodology in housing research and practice.

Across the reviewed literature, DT consistently emerged as a human-centred, iterative, and inquiry-driven approach that enables designers to uncover deep user needs, negotiate stakeholder complexity, and generate innovative solutions in uncertain or multifaceted environments. Studies applying DT in urban redevelopment, sustainable built-environment innovation, elderly housing design, interior spatial conceptualization, and computational multi-unit design demonstrated that DT supports empathy-driven understanding, creative ideation, rapid prototyping, and reflective evaluation components that address many longstanding challenges in housing design.

However, the review also revealed that DT remains significantly underutilized in group housing contexts, particularly in India. Existing housing research tends to prioritize physical design, compliance, cost, and efficiency, frequently overlooking psychological, social, and experiential dimensions that are critical to residential satisfaction, community well-being, and long-term adaptability. Furthermore, there is a lack of empirical studies implementing DT end-to-end in real group housing environments. This gap is especially relevant to Indian public housing programs (PMAY, JNNURM, DDA projects), where participatory processes are limited and iterative methods are rarely institutionalized.

The thematic synthesis highlighted eight key domains in which DT offers substantial promise for group housing: conceptual reframing of design problems, participatory engagement, empathy-based user understanding, iterative prototyping, sustainability foresight, experiential quality, computational integration, and theoretical hybridity. Together, these themes demonstrate that DT can expand the traditional boundaries of architectural and housing design by embedding psychological insights, social practices, cultural patterns, digital tools, and long-term strategic thinking into design processes.

Yet, the review also emphasized persistent gaps, including the need for deeper psychological integration,

real-world prototyping, longitudinal outcome studies, context-sensitive frameworks for India, and hybrid methods combining DT with participatory governance, computational modelling, and environmental psychology. These gaps form the foundation for the next phase of this doctoral research.

In conclusion, the evidence synthesized in this SLR strongly supports the proposition that DT has significant, underexplored potential to transform group housing into more human-centred, psychologically attuned, socially cohesive, and contextually responsive living environments. By situating housing design within an empathy-driven and iterative innovation paradigm, DT offers a pathway for addressing the limitations of conventional top-down approaches. The findings of this review directly inform the development of a DT-based framework for group housing in Vijayawada. Such a framework aims to bridge the gap between policy intentions, spatial design practices, and lived experiences ultimately contributing to more resilient, inclusive, and meaningful housing environments for diverse urban communities.

Disclosure statement

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