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Fire resilience in urban settlements: identifying causes of ignition and spread in Quezon city

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Abstract

Purpose – This study examines the perceived drivers of fire ignition and spread in dense urban settlements in Quezon City, the Philippines, comparing how fire professionals and residents account for them.

Design/methodology/approach – This study draws on 24 semi-structured interviews with 5 fire professionals and 19 residents of two high-density informal settlements. Interviews were analyzed thematically, with professional and resident perspectives on the same hazards compared directly.

Findings – Fire professionals and residents agreed on the principal physical drivers: electrical failure from grid overloading and unsafe cooking were the main sources of ignition, and combustible materials and restricted emergency access the main drivers of spread. The two groups diverged on cause. Professionals attributed hazardous practices to individual inattentiveness, whereas residents construed them as adaptations forced by poverty and confined space, a divergence that helps explain the limited effect of conventional, negligence-based safety education. Residents also contested the assumed link between dwelling density and spread, attributing it instead to material composition and spatial configuration.

Practical implications – The spatial conditions that foreclose municipal suppression cannot easily be reversed, so resilience strategy should pivot toward decentralized "soft" infrastructure: behaviorally targeted education, localized early warning and community-held suppression, financed and governed through existing barangay disaster-risk structures. Framing hazardous practice as forced adaptation rather than negligence also favors harm-reduction approaches, which work with residents' material realities, over punitive enforcement that tends to drive unsafe practices underground.

Originality/value – This study reframes well-documented fire-risk factors through a "space–risk nexus" in which the spatial saturation of the built environment forces the socio-economic adaptations that become physical fire hazards. The framework shows that this saturation makes standard infrastructure-based fire-safety codes structurally inapplicable, not merely difficult to enforce. Informality, therefore, emerges as a physical condition as much as a legal one, and the analysis indicates that resilience is better served by community-based

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"soft" infrastructure than by hard-infrastructure retrofits, which would require large-scale displacement in already-saturated settlements.

Keywords Philippines, Spread, Informal settlements, Ignition, Urban fire resilience, Urban planning and development

Paper type Research paper

1. Introduction

Fires remain one of the leading causes of disaster loss globally, erasing an estimated 1% of global gross domestic product each year (The Geneva Association, 2014). This burden falls unevenly, with conditions for fire spread more severe and fire events more frequent, in low- and middle-income countries (Rush *et al.*, 2020). Although settlement fires, those that ignite and spread through large areas of dense urban development, are overwhelmingly caused by human activity and are, therefore, mitigable, socio-economic disparity drives a deep wedge in fire resilience. The roughly 20% of the global population living in lower-income countries bears nearly half of all global fire casualties, and residents of lower socio-economic status face disproportionate exposure and vulnerability to fire hazards (Arup, 2018).

The drivers of these fires are complex, and the literature often reports contradictory findings on the primary causes of ignition and spread (Filkov *et al.*, 2023). Ignition is shaped by an array of developmental factors, including population density, planning irregularities and settlement location, while the subsequent spread of fire is dictated by built-environment factors (combustible materials and weak adherence to fire-safety standards) and by governance factors such as inadequate access to fire-safety resources. The cumulative effect is that dense urban settlements behave as fuel for rapid, intense fire spread (Stevens and Rush, 2025).

This study examines these dynamics in Quezon City, the largest city in the National Capital Region (NCR) of the Philippines. Fire is a persistent and unevenly distributed hazard in the country: an average of 15,733 fire incidents were recorded nationwide each year between 2013 and 2018, and the NCR alone accounted for more than a quarter of these, 27,011 incidents over the period, more than two and a half times the total of the next-highest region (CPBRD, 2020). The NCR's disproportionate share has persisted, leaving it among the most fire-affected regions through the first half of 2024 (BFP, 2024). Residential structures consistently account for the largest share of incidents, 5,315 of 7,063 structural fires nationwide in the first half of 2024 (BFP, 2024). Such fires fall most heavily on the dense, low-income residential settlements that form the focus of this study, underscoring the need to understand how spatial and socio-economic drivers interact to produce fire risk. Accordingly, this research addresses two questions:

RQ1. What are the primary sources of fire ignition in these urban settlements?

RQ2. What are the primary mechanisms driving fire spread?

In answering them, this study aims to inform targeted resilience strategies for Quezon City that are adaptable to comparable dense urban environments globally.

2. Background

Rapid urbanization has reshaped global demographics, driving the proliferation of dense informal settlements; by 2050, an estimated three billion people will live in such settlements worldwide (Agyabeng *et al.*, 2022). These settlements are generally characterized by limited governmental oversight, unplanned development and insecure legal status (Atkinson, 2024), conditions that produce acute inequalities. Because such settlements are frequently

embedded within or adjacent to the formal city, the hazards they concentrate, fire among them, are rarely contained within their boundaries.

Settlement fires cause significant physical and psychological harm, loss of livelihoods and displacement, and recent estimates suggest that more than 120,000 people die annually from fire- and burn-related injuries worldwide, with approximately 90% of them in low- and middle-income countries (WHO, 2024). Scholarship addressing this problem has, however, developed along two only partially connected trajectories. The dominant trajectory is technical and experimental and has produced substantial advances in understanding how settlement fires ignite and spread: full-scale and numerical studies have quantified the role of inter-dwelling separation distance (Cicione *et al.*, 2021), the combustibility of typical dwelling materials (Wang *et al.*, 2020) and the influence of wind and settlement geometry on conflagration-scale spread (de Koker *et al.*, 2020). This body of work has been pivotal in establishing an evidence base where little previously existed, yet by its nature it tends to abstract fire behavior from the social and economic conditions that produce it. A second, more recent trajectory reframes settlement fire risk as fundamentally socio-political, arguing that its distribution reflects structural patterns of poverty and marginalization and that durable risk reduction is, therefore, as much a question of governance, tenure and service provision as of fire engineering (Jennings, 2013; Rush *et al.*, 2020). Recent contributions have extended this view by interrogating the social dimensions that technical solutions tend to neglect (Kurata *et al.*, 2023), including the gendered distribution of fire risk and responsibility (Hirst and Underhill, 2025). A persistent obstacle across both trajectories is the poverty of incidence data. A substantial share of settlement fires, approximately 40% in South Africa for example, are recorded with undetermined causes, constraining both modeling and policy (Flores Quiroz *et al.*, 2021).

Our study is positioned within, and seeks to bridge, these two trajectories. Where much of the technical literature documents risk factors from an external, expert vantage point and where the socio-political literature has established the structural framing largely at the level of policy and political economy, we contribute a perception-based account that places professional and resident interpretations of risk in direct comparison. We foreground this comparison because effective fire-risk mitigation is widely held to depend on the active participation of built-environment and governance stakeholders, yet professionals are not always engaged in practice even where guidance exists (Alabi *et al.*, 2017). In foregrounding how professionals and residents themselves construe risk, we respond to calls within this literature for approaches that ground technical and experimental knowledge in the lived political, social and economic realities of settlement residents (Rush *et al.*, 2020), and our findings bear directly on at least one unresolved empirical question within the technical strand, the extent to which dwelling density, as distinct from material and configurational factors, governs fire spread (Gibson *et al.*, 2022; Stevens *et al.*, 2020).

2.1 Ignition sources in the built environment

Fire ignition in urban settlements is driven by a complex interaction of physical and social factors, with literature consistently identifying electrical failure and unsafe cooking behaviors as primary sources. Electrical faults, including arcing, loose connections and overloading, are globally recognized as leading causes of fire (da Rocha *et al.*, 2023), including in the Philippines (Bringula and Balahadia, 2018). In densely populated settlements, the demand for electricity often outpaces safe infrastructure, leading to grid complications and overload (Walls *et al.*, 2019). This overloading, in turn, is among the most frequently identified electrical ignition sources in informal settlements (Walls *et al.*, 2017). Socio-economic factors compound the danger, with poorer living standards correlated with a

higher likelihood of fires caused by electrical faults (Palazzi *et al.*, 2023). For example, research in informal settlements in China identified electrical failure as the cause in the majority of significant fire events analyzed (Hu *et al.*, 2022).

Inadequate cooking equipment and unsafe fuel sources further contribute to ignition risk. The use of paraffin and kerosene is widespread in many settlements; however, faulty stoves and the high flammability of these fuels present severe dangers (Kimemia *et al.*, 2018). Previous work has found that a third of kerosene stoves fail after a year of usage yet often remain in operation because of economic necessity (Kimemia *et al.*, 2018). While distinct from urban settlements, studies of temporary camps show similar vulnerabilities regarding unsafe cooking methods (Kazerooni *et al.*, 2016). The location of cooking activities is also critical; cooking within dedicated kitchen areas significantly reduces ignition probability compared to multipurpose spaces (Mtani and Mbuya, 2018). Cooking is not the only domestic ignition source. Although smoking accounts for a smaller share of structural fires, the fires it causes are disproportionately deadly (Zhang, 2023). Whatever the ignition source, the absence of early detection compounds the danger, because flashover in an informal dwelling can occur rapidly, fires that might otherwise be survivable can quickly become fatal, and smoke-alarm interventions have accordingly been shown to save lives in these settings, though they must be adapted to settlement conditions (Pharoah *et al.*, 2022).

2.2 Mechanisms of fire spread

Once ignited, the severity of a fire event in an urban settlement is dictated by the speed and extent of spread, primarily influenced by dwelling density, material composition and emergency access. High dwelling density is frequently cited as a key factor in disaster and fire severity and frequency (Twigg *et al.*, 2017). The spacing between structures acts as a buffer; research suggests that increasing dwelling spacing can significantly reduce heat flux (Wang *et al.*, 2020) and impede spread (Stevens *et al.*, 2020). Experimental studies indicate that at specific distances (e.g. 3–5 m), the survival rate of adjacent dwellings increases dramatically (Wang *et al.*, 2020). However, there is debate regarding density as a sole predictor; some studies suggest that density must be analyzed alongside wind conditions and spatial layout, as high-spread events have occurred in areas with varying densities (Gibson *et al.*, 2022).

The combustibility of construction materials fundamentally alters fire dynamics. Common materials in informal settlements, such as timber, plastic, foam and cardboard, facilitate rapid flame propagation (Thevega *et al.*, 2022; Wang *et al.*, 2020). Comparative studies show that timber-clad dwellings allow for significantly faster spread times than steel-clad alternatives (Cicione *et al.*, 2019). This risk is compounded by the accumulation of combustible material between dwellings. In the absence of municipal waste services, the open spaces between homes often become dumping grounds for debris and litter, creating "fuel bridges" that allow fire to jump between structures (Walls *et al.*, 2017).

Finally, the capacity of emergency services to respond is often severely compromised. Narrow or blocked roads, steep topography and pathways that cannot bear the weight of fire apparatus prevent responders from reaching ignition sites (Flores Quiroz *et al.*, 2021; Guevara Arce *et al.*, 2021), and the ideal response times cited in the literature are rarely achievable under these physical constraints (Erden and Coşkun, 2010). The 2017 Imizamo Yethu fire in South Africa illustrated the consequences, as inaccessible routes, compounded by residents returning to retrieve belongings, severely hampered containment (Kahanji *et al.*, 2019).

3. Methods

This study used a qualitative, interpretivist research design based on semi-structured interviews, selected to access the situated meanings that fire professionals and residents

attach to the causes of fire ignition and spread. A qualitative approach is appropriate where the research objective is to understand how risk is perceived, experienced and acted upon, rather than to measure the incidence of predefined variables.

3.1 Study setting

This study was conducted in Quezon City, the largest and most populous city in Metro Manila. The city was selected purposively on the basis of two criteria: the prevalence of dense, mixed formal–informal urban settlements and a documented history of frequent and severe fire incidents compounded by limited fire-emergency infrastructure. Within Quezon City, fieldwork targeted the barangays (the smallest local-governance units in the Philippines) of Pansol and Daan Tubo (Figure 1), both characterized by high-density settlement and a combination of formal and informal dwelling typologies. Both barangays had experienced significant settlement fire events approximately four months before data collection; interviews in Pansol were conducted in community halls then housing displaced households. The recency of participants' experiences was methodologically salient, situating the study among those with direct and immediate experience of fire, which enhanced the information richness of the sample, while also requiring particular ethical care, as discussed below.

3.2 Research design and sampling

Participants were recruited using purposive sampling, supplemented by community-facilitated recruitment through Barangay Captains and community representatives who assisted in identifying eligible residents. The final sample comprised 24 participants drawn from two complementary respondent groups: fire professionals (n = 5) and residents (n = 19).

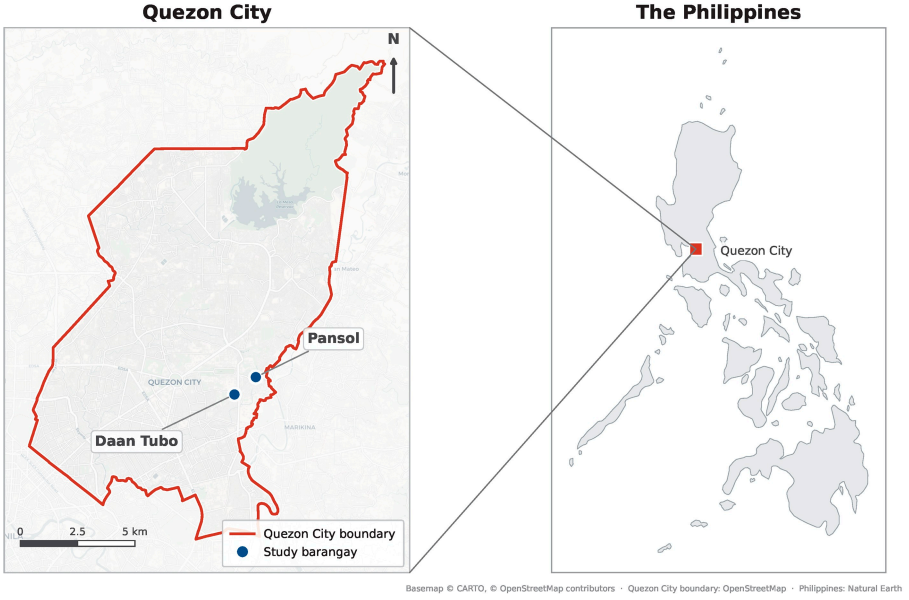

Figure 1. Selected case sites of Pansol and Daan Tubo located in Quezon City

Source: Authors' own work

The two-group design was a deliberate triangulation strategy, enabling systematic comparison of expert and experiential accounts of the same phenomena. Fire professionals comprised four firefighters serving the Krus Na Ligas, Holy Spirit and Quezon Fire District stations and one official from the Quezon City Disaster Risk Reduction and Management Office (QCDRRMO), selected for their operational knowledge of fire response and the built-environment conditions of the study sites. Residents were eligible for inclusion if they were aged 18 years or older and a resident in the study barangays; 63% of resident participants had directly experienced a fire event, the majority in the months preceding data collection.

Sample size was determined by the principle of information power rather than by a predetermined target or the logic of statistical representativeness (Malterud *et al.*, 2016). Several features of the study indicated that a relatively modest sample would carry sufficient information power: the research aim was narrowly specified (the perceived drivers of ignition and spread); the sample was highly specific, comprising participants with direct professional or lived experience of settlement fire; and the analysis was supported by an established body of theory on fire risk against which accounts could be interpreted. These conditions correspond to those under which the empirical methodological literature reports that saturation is reliably achieved within 12 interviews (Guest *et al.*, 2006). Data collection and preliminary analysis proceeded concurrently, and recruitment continued until the research team judged that additional interviews were no longer generating new codes or themes in relation to the research questions, indicating that thematic saturation had been reached.

Ethics approval was obtained from the University of Sydney Human Research Ethics Committee (HE000632). Informed consent was obtained from all participants before interview, and participation was voluntary, with participants free to withdraw at any point. Given that a substantial proportion of resident participants had recently experienced a fire event and, in some cases, displacement, interviews were conducted with sensitivity to participants' circumstances, and care was taken to avoid distress. All data were anonymized, and identifying information was removed from transcripts before analysis to protect participant confidentiality.

3.3 Data collection

Data were collected through semi-structured, in-person interviews lasting approximately 30–45 min, each audio-recorded with participant consent and accompanied by contemporaneous field notes. Interviews were conducted in-person in June and July 2025. Two interview guides were developed, one for each respondent group, with questions grounded in the risk factors identified in the fire-risk literature to ensure that the protocol engaged directly with established knowledge while leaving space for participants to raise issues in their own terms.

Interviews with fire professionals were conducted primarily in English and focused on operational expertise regarding emergency access, infrastructure and modes of fire spread. Indicative questions included:

Q1. "How do you believe access to fire events could be increased? What improvements to fire safety could be made? Are there specific modes of fire spread or ignition that could be targeted? What do you see as the main reason for fire ignition and spread?"

Resident interviews were conducted in Tagalog by a research assistant fluent in the language to ensure comprehension and to allow participants to articulate their experiences without language barriers; indicative questions included:

Q2. "What do you know about fires and fire safety? Do you have any strategies to deal with fires? Have you experienced a fire event? What do you see as the main reason for fire ignition and spread?"

Conducting resident interviews in the participants' first language was a deliberate measure to enhance the validity and depth of the accounts obtained.

To triangulate volunteered perceptions against established risk factors, each interview guide also incorporated a structured checklist. Participants were asked to indicate whether specific factors documented in the literature (e.g. electrical failure or dwelling density) had, in their experience, been primary causes of ignition or spread. This component allowed the assessment of factors that participants might not have nominated spontaneously during open-ended questioning and provided a structured point of comparison between the two respondent groups and between participant accounts and the existing evidence base. Audio recordings were transcribed *verbatim*, and Tagalog-language interviews were translated into English for analysis.

3.4 Data analysis

Interview transcripts and field notes were analyzed using thematic analysis (Fereday and Muir-Cochrane, 2006), supported by NVivo qualitative data-analysis software. The analysis followed a hybrid deductive–inductive logic. A deductive framework of three *a priori* parent codes (*Fire Ignition, Fire Spread and Fire Knowledge*) was established at the outset, derived directly from the study's research questions and the structure of the interview guides. Within this framework, sub-codes were developed inductively from the data to capture more granular and emergent themes; for example, the *Fire Ignition* parent code encompassed sub-codes such as electrical failure and cooking-related practices, while the *Fire Spread* parent code encompassed sub-codes such as combustible materials, dwelling density and restricted emergency access. This hierarchical structure preserved analytical alignment with the research questions while allowing themes that participants themselves emphasized to surface.

Analysis proceeded through the established phases of thematic analysis: familiarization with the transcripts and field notes through repeated reading; generation of initial codes by systematically coding data extracts against the framework; collation of codes into the parent themes and emergent sub-themes; and review and refinement of these themes against the coded extracts and the full data set to ensure internal coherence and distinctiveness. Coding was conducted by the first author with the code structure being reviewed in discussion with the wider research team to challenge interpretations and confirm the credibility of the emerging themes.

4. Results

The thematic analysis revealed a distinct hierarchy of perceived fire risks, which we organize here through a "space-risk nexus" framework (Figure 2) describing how spatial saturation, socio-economic drivers and physical hazards interact to produce elevated ignition risk, accelerated fire spread and constrained emergency response. We define the space–risk nexus as the mutually reinforcing relationship through which the spatial saturation of the built environment forces socio-economically conditioned adaptations (such as illegal electrical connection and indoor use of outdoor liquefied petroleum gas [LPG]) that are in turn expressed as physical fire hazards, jointly producing the three outcomes named above. This framework represents the empirical articulation of the socio-political account of settlement fire risk set out in the preceding review (Rush *et al.*, 2020), grounding that account's

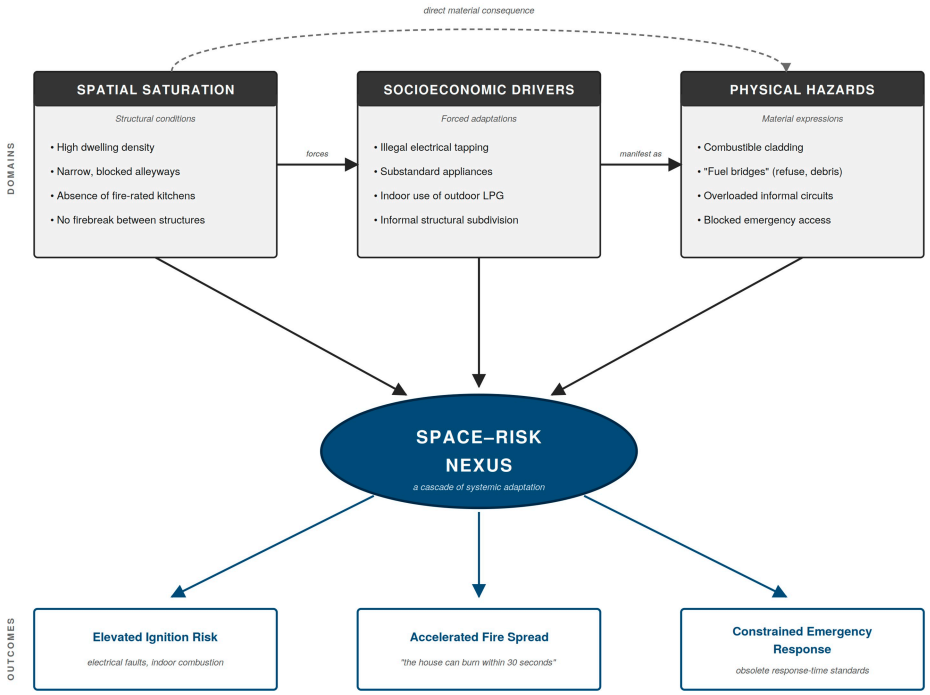

Figure 2. The space–risk nexus framework, showing the directional interactions between spatial saturation, socio-economic drivers and physical hazards that produce elevated ignition risk, accelerated fire spread and constrained emergency response in dense urban settlements

Source: Authors' own work

structural claims in the situated perceptions of those who produce and experience the risk. Reflecting the two-cohort design, the analysis is structured throughout as a systematic comparison of professional and resident accounts of the same phenomena, a juxtaposition that constitutes the study's central analytic strategy. The comparison revealed both convergence and divergence. There was unanimous agreement across both cohorts regarding the most critical physical drivers, with electrical failure identified as the primary source of ignition and combustible materials and restricted access cited as the definitive mechanisms of spread. In contrast, behavioral and spatial factors (notably smoking, fireworks and dwelling density) generated marked divergence, with residents in particular questioning the assumed correlation between spatial proximity and fire spread. The following sections interrogate these points of consensus and divergence in turn and place each within the framework's three interacting domains.

4.1 The socio-economic architecture of fire ignition

Where the technical literature commonly frames ignition as a matter of "human error," participants in Quezon City located it in the interaction between the built environment and the economic constraints of daily life, in the terms of the framework above, the meeting point of its socioeconomic-driver and spatial-saturation domains. Professionals and residents

largely agreed on which sources mattered most (electrical failure and cooking foremost, with smoking a more contested third) but diverged in how they explained them. Where professionals tended to attribute hazardous practice to individual inattentiveness, residents construed the same practices as adaptations forced by poverty and confined space. We present these perceptions here and reserve the fuller structural argument for the Discussion.

4.1.1 Electrical failure as a systemic adaptation. Electrical failure was identified by every participant as a leading cause of ignition. In their accounts, however, these "failures" were rarely described as simple accidents; participants framed them instead as the predictable product of a mismatch between formal energy infrastructure and the informal fabric of the settlement. Residents and professionals alike described a tangle of improvised connections – "octopus connections" and "spaghetti wiring" (the dense criss-crossing of wires) and "jumpers" (illegal taps onto the grid) – that overload the system, which they attributed to high population density and the inability to afford safe appliances. One resident tied electrical risk directly to economic constraint, noting that the market for cheap goods drives the problem: "Usually they buy the substandard appliances. […] These substandard appliances get burnt." On this view, ignition risk is embedded in the very appliances residents can afford, a hazard of poverty rather than of carelessness.

A fire professional corroborated the prevalence of these failures but located their cause differently, pointing to a behavioral element: "I think it's 70–80% [of fires are started by] electrical failures. It's because of the substandard electrical connections and sometimes inattentiveness of the person." Where professionals read the same evidence as partly a matter of "inattentiveness," residents read it as structural inevitability. In residents' accounts, the density of the settlement left little choice but to improvise access to the grid, bypassing safety margins to secure a basic necessity: "Because of population, some would go to illegal tapping connection to the electricity that would start the fire." For residents, these "dangling wires" were more than a local hazard. They reflected a broader failure to extend safe, affordable energy infrastructure to high-density populations.

4.1.2 Cooking and the "Space-Risk" nexus. Cooking was almost universally identified as a primary ignition source, and here, the danger was bound up with spatial constraint, the point at which, in the framework's terms, socio-economic drivers meet spatial saturation. Unlike formal housing with its fire-rated kitchens, dwellings in these settlements often lack a dedicated cooking space, so cooking takes place within multipurpose living areas using portable gas. Participants repeatedly raised the indoor use of the small LPG canisters known as "Gasulito," containers intended for outdoor use that are brought inside for want of space or awareness of the risk. As one resident put it, "Sometimes the canister (of LPG) that must be used outside, they are using it inside." The practice reflects less a disregard for safety than a collision between economic necessity and the physical limits of the dwelling.

That residents are acutely conscious of this danger cuts against any reading of these fires as simple negligence. Participants described sustained vigilance around cooking: "No… We don't leave… We're being careful. We don't leave (when cooking) because we're afraid (of starting fires)." The fear is itself telling, an awareness that, in so fragile a built environment, a single unattended flame can escalate into community-wide loss.

4.1.3 The "invisible" risk of smoking. Smoking presented a different pattern and was named as a primary cause by fewer participants than electrical failure or cooking, suggesting that residents may underestimate it, whether because its hazard is less visible or because indoor smoking has become less common. Yet its danger is less intrinsic to the act than relational. It becomes acute where an ignition source meets the high fuel loads characteristic of these settlements, the framework's physical-hazard domain. The "light materials" that pervade the built environment mean that even a minor source can escalate quickly. One

resident recounted just such an event: "One kid smoked cigarettes in a warehouse, in a storage, that is filled with clothes, flammable materials." Smoking, on this account, is hazardous not in isolation but in combination with the storage of combustible goods in non-fire-rated structures. The comparatively low salience it holds for residents may itself mark a blind spot in community resilience.

4.2 Fire spread and the saturation of the built environment

The second objective was to identify the primary mechanisms driving fire spread. Participants' accounts converge on a built environment so saturated, physically and materially, that it both accelerates spread and outpaces the reach of formal emergency services, the two spread-side outcomes in the framework above. As with ignition, professionals and residents agreed on the broad mechanisms but parted company on one of them, the role of density, in ways that bear directly on how spread should be addressed.

4.2.1 Density, materials and the "fuel bridge" effect. Fire professionals unanimously identified dwelling density as a primary driver of spread. Residents' accounts were more divided. Many accepted density as a critical factor, but several located the danger less in proximity than in what the dwellings are made of and how they are arranged. At least one questioned the separation-distance logic directly: "houses that are separated from each other [often] are the ones that catch fire." Read as fatalism, a sense that spread is inevitable whatever the spacing, this skepticism would be easy to discount. However, it resonates with an unresolved tension in the experimental literature itself, where the standing of density as a primary determinant of spread (as distinct from material composition, wind and spatial configuration) remains contested. What reads as mere divergence from professional consensus, therefore, tracks a real point of uncertainty in the technical evidence base, lending the resident accounts a credibility that a behavioral reading would miss.

On the materials themselves, the accounts converged. Residents widely recognized the hazard of their building fabric and of plywood in particular: "the walls are all old plywood […] so the speed of burning (increases)." Field observations added that the gaps between dwellings are routinely filled with cladding of tarpaulins, advertising sheeting and litter pressed into service as makeshift walls and curtains. Together, combustible construction and these in-fill materials form continuous "fuel bridges" between homes, erasing what little firebreak the spacing might otherwise provide and carrying flame rapidly from one structure to the next.

The danger is compounded when structures are informally repurposed in ways that breach the Fire Code of the Philippines (Republic Act Number 9514), most consequentially its provisions on construction, protective measures and the obstruction of emergency access and egress. A fire professional described an approved dwelling internally partitioned with combustible materials to raise its occupancy, with fatal results:

> So one event recently is that a house was turned into an apartment complex, divided by plywood. It was partitioned by plywood, and they have no fire exit from the second floor. There are instances like that. Also, there was an incident last year – a T-shirt printing shop. […] when the incident occurred, they have a lot of personnel inside who are sleeping because it's a house-business combined. […] So it became more vulnerable to fire. So that's why many casualties occurred.

This points to a second axis of saturation. The external crowding of dwellings is compounded by densification within individual buildings, which become packed with occupants and flammable "light materials." One resident captured the speed this produces, and why conventional response standards cannot keep pace:

> […] the house can burn within 30s. That is why five minutes is not enough. […] But, you know, that is the reality due to the congestion in population, in urban areas. Yeah, that is the problem.

4.2.2 The failure of hard infrastructure solutions. On the final mechanism, there was no disagreement. Every participant identified restricted access as a definitive cause of spread, the framework's constrained-emergency-response outcome made concrete. The narrow, winding alleyways and chronic traffic of these settlements strip standard firefighting protocols of their force. Professionals put the official benchmark at a response time "below seven minutes," but described a built environment that makes it unattainable; as one firefighter put it, even the siren is no help against a blocked road: "You know, here in the Philippines, even if you raise your wham, wham, your siren, you can't do anything about it. So you can just, you know, it's traffic."

Restricted access also defeats the department's escalation protocol. A professional set out the theoretical capacity to "tap" successive alarm levels to summon more resources:

> If the fire is uncontrolled, some officer of the our firefighter will proceed to the area. They will tap the second alarm. […] First. Second. Third. Fourth. Fifth. Task force. Alpha. Bravo. Charlie. Delta. Then the general alert. […] In every alarm, an additional 4 or 5 trucks.

In a saturated settlement, however, the protocol stalls, because there is no physical space for the additional units to deploy. Residents named the same culprit, the geometry of the settlement itself: "the narrowness of the road or the alleyways are one of the main causes of fire spread."

Asked about remedies, professionals conceded that the "ideal" engineering fixes (dedicated emergency lanes and widened roads) are unrealistic at current densities. One described fire lanes as the "perfect" solution while acknowledging the displacement and time they would demand:

> Currently you don't have fire lanes along the highway. That is the perfect one, because only an ambulance or any emergency vehicle will be able to use them. You know, you can be ten years, ten years down the road.

The implication, which we develop in the Discussion, is that the settlement is now too densely built for "hard" resilience infrastructure to be retrofitted without large-scale displacement and that a suppression strategy premised on municipal trucks reaching the fire rests on a physical access that, in these settings, no longer exists.

5. Discussion

Taken together, the findings support that fire risk in these settlements is best understood through a space–risk nexus, in which spatial saturation forces the economic adaptations that produce ignition, accelerates spread once fire begins and forecloses the access on which conventional suppression depends. Read this way, the familiar risk factors are not independent failings but expressions of a single underlying condition. The sections that follow develop this argument and its consequences: first, why the gap between professional and resident understandings of risk undermines conventional fire-safety education; second, how the same saturation renders national engineering standards structurally inapplicable; third, where responsibility for the resulting pivot to "soft" infrastructure should sit; and finally, what the nexus implies for comparable settlements and for future research.

5.1 Bridging the gap in fire safety knowledge and preparedness

A central implication concerns the gap between how residents and professionals understand fire risk and what that gap does to fire-safety education. As the Results showed, professionals

tended to read hazardous practice as inattentiveness, whereas residents experienced the same practices as adaptations forced upon them. That divergence carries practical weight, because conventional safety education is built implicitly on the professional framing. It assumes that informing people of risks will change behavior. Where residents already perceive the risks but see no affordable alternative, such education gains little purchase, and our data suggest this is the situation in Pansol and Daan Tubo.

The pattern is visible in residents' own accounts of preparedness. Many expressed a general sense of safety awareness, yet relatively few reported specific preventative strategies. Over a quarter described having limited or no strategy for a fire event, and among those who did, close to half emphasized reactive measures such as evacuation rather than prevention. The orientation, in other words, is toward surviving fires more than forestalling them. The pattern reflects a structural constraint on knowledge transfer, not indifference. Fire-safety education competes with other disaster priorities, and most residents reported no access to fire-specific seminars, noting that community drills concentrate on earthquake response. The unintended effect is that seismic preparedness has crowded out attention to the more frequent daily threat of settlement fire, leaving residents to manage complex electrical and spatial hazards without formal training, which is why high self-assessments of knowledge coexist with thin preventative repertoires. Closing this gap calls less for awareness campaigns than for actionable, settlement-specific fire curricula that work with residents' material constraints and sit alongside existing earthquake preparedness.

5.2 Systemic constraints: Infrastructure access and socio-economic risk

The dialogue between fire professionals and residents reveals that standard engineering solutions are often incompatible with the spatial and economic fabric of informal settlements. Professionals consistently identified restricted access, because of narrow roads and traffic, as a primary barrier to deploying standard apparatus. This incompatibility is regulatory as well as operational. The quantitative thresholds embedded in national standards presuppose a spatial order that informal settlements do not possess. The Fire Code of the Philippines (Republic Act Number 9514) and its Revised Implementing Rules require fire department access roads to maintain an unobstructed width sufficient for two-way apparatus movement and aerial operations, an internationally standard minimum of 6.1 m (20 ft). In Pansol and Daan Tubo, however, primary circulation occurs through alleyways frequently narrower than one meter, rendering compliance physically impossible short of demolition. The Code's hydrant provisions similarly assume a residential service radius of approximately 250 m; yet even where a hydrant falls within this nominal range, the winding and obstructed geometry of settlement pathways inflates the effective hose-lay distance well beyond the straight-line radius, while the chronic low water pressure reported by both residents and professionals further negates nominal coverage. These access standards are compounded by the firewall and minimum-setback provisions of the National Building Code of the Philippines (Presidential Decree Number 1096), which presuppose defensible space between adjacent structures, clearances that are unattainable where dwellings of combustible "light materials" abut one another directly. The cumulative effect is a regulatory architecture whose safety thresholds are systematically unmeetable under conditions of informality, such that formal compliance functions less as an attainable benchmark than as a marker of these communities' exclusion from the formal urban order. Context-specific, or "bespoke," fire safety standards are, therefore, needed, calibrated to the spatial realities of dense settlements and in place of codes imported wholesale from contexts that assume regular street grids, vehicular access and inter-structural spacing.

The socio-economic drivers of ignition compound these physical constraints. The primary ignition sources identified (electrical failure and cooking) must be read as adaptations to economic conditions. Electrical overloading stems largely from the need to access energy within a constrained infrastructure that lacks accessible metering for all households; likewise, the use of LPG in multipurpose living spaces follows from the absence of fire-rated kitchens. Framing these risks as systemic adaptations rather than negligence points toward more supportive policy. Rather than punitive measures, which may drive practices underground, the emphasis should fall on harm reduction, working with residents' material reality to widen safety margins through load-management education and safer cooking protocols.

In contrast to "hard" infrastructure (the physical assets of fire safety such as access roads, hydrants and fire stations), we use "soft" infrastructure to denote the non-physical, social and institutional capacities that reduce risk and enable response: community fire-safety knowledge and education, local organization and social networks, early-warning and communication systems and community-held suppression capability. The distinction is consequential because, where hard infrastructure presupposes the spatial and fiscal conditions that saturated settlements cannot meet, soft infrastructure can be developed within those constraints. The contrast is, at root, also an economic one. Retrofitting hard infrastructure (road widening or dedicated fire lanes) in an already-saturated settlement entails more than construction costs; it also imposes the substantial and often prohibitive social and economic costs of displacement, on a timescale participants themselves characterized as a decade or more. The decentralized measures advanced here, by contrast, are low in unit cost, require no displacement and can be financed through existing local appropriations. While a formal cost-effectiveness comparison lies beyond the scope of this qualitative study, the asymmetry is substantial enough to suggest that, under the binding spatial and fiscal constraints these communities face, soft-infrastructure investment is likely to yield greater marginal risk reduction per unit of expenditure than the hard-infrastructure alternative, a proposition we flag for formal cost–benefit analysis in future work.

5.3 Pathways to resilience: enhancing "soft" infrastructure

If suppression cannot be guaranteed by municipal apparatus, then resilience must be built into the community itself. The soft-infrastructure measures the findings point toward are concrete: settlement-specific education targeting the highest-salience risks, particularly electrical load management and indoor LPG use; localized early-warning and alerting routed through barangay structures; and pre-positioned communal suppression equipment that residents are trained to use in the critical first minutes, before professional units could arrive even under ideal conditions. Their value, however, depends less on initial provision than on the clarity with which responsibility for their governance and upkeep is assigned.

We argue that this responsibility is best located within the existing decentralized Disaster Risk Reduction and Management (DRRM) architecture rather than delegated to *ad hoc* volunteerism, which tends to erode once initial enthusiasm or external project funding lapses. Under the Philippine Disaster Risk Reduction and Management Act (Republic Act Number 10121), every barangay is mandated to maintain a Barangay Disaster Risk Reduction and Management Committee (BDRRMC) headed by the Punong Barangay, providing a ready institutional owner for communal fire points, alarm systems and the periodic inspection and replacement of suppression equipment. Critically, the same legislation supplies a dedicated and recurring financing mechanism. Local government units must set aside not less than five percent of estimated revenue from regular sources as a Local Disaster Risk Reduction and Management Fund (LDRRMF), of which up to 70% may be

directed toward pre-disaster risk reduction, a category that explicitly encompasses the procurement and maintenance of life-saving equipment. Embedding communal suppression assets within the BDRRMC's mandate and the LDRRMF's appropriations cycle, therefore, offers a route to sustainability that does not depend on the uncertain continuity of external donors. Within this structure, the role of the Bureau of Fire Protection shifts from sole suppression provider to technical authority (certifying equipment, training resident first-responders and integrating barangay-level alarm systems into formal dispatch protocols), while non-governmental organizations and the private sector are best positioned to absorb capital and start-up costs and to support the community organizing required to embed these practices. Anchored in statutory mandates, this distribution of responsibility aligns the maintenance of micro-suppression infrastructure with the funding and accountability cycles already governing disaster risk reduction at the local level.

5.4 Implications for global urban resilience

While grounded in Quezon City, these findings speak to the wider predicament of rapidly urbanizing settlements everywhere. Spatial saturation (the condition in which density, combustible construction and the absence of defensible space compound one another) is a shared feature of informal settlements worldwide, even as our evidence cautions against treating raw density as a sufficient explanation of spread in its own right. The broader lesson is that resilience in these contexts depends on adapting safety strategy to the settlement's actual constraints, as planning standards the local fabric cannot satisfy will never be met in practice. A shift toward soft solutions (education, early warning and micro-suppression) offers an immediate and attainable layer of community resilience alongside formal emergency services.

The space–risk nexus is intended not as a static description but as a framework that can be operationalized and tested. It yields several propositions amenable to empirical examination: first, that the degree of spatial saturation in a settlement is positively associated with reliance on hazardous adaptive practices, independent of residents' risk awareness; second, that the magnitude of the attribution gap, the divergence between professional and resident framings of the causes of risk, predicts the failure of behavior-change interventions premised on an assumption of negligence; and third, that in saturated settlements, marginal investment in soft infrastructure achieves greater risk reduction than equivalent investment in hard infrastructure. Articulating these as testable relationships distinguishes the nexus from a purely descriptive account and provides a structure for the mixed-methods and comparative research we identify as priorities.

5.5 Limitations

Several limitations qualify these findings. This study is purposive and place-specific, two settlements in Quezon City, and although the sampling was designed for information power and the analysis reached thematic saturation, the transferability of specific findings to other settlements remains to be tested empirically. The account is also perception-based by design; as noted, the chronic unavailability of disaggregated incidence data for these settlements currently precludes triangulating perceived against recorded risk, and integrating the two through mixed-methods and comparative designs is the priority we identify for future work. Finally, the engineering and economic questions the findings raise (practical means of improving access and response and formal cost-effectiveness analysis of soft-infrastructure interventions) lie beyond a qualitative study's scope and warrant dedicated investigation.

6. Conclusion

This study investigated the perceived drivers of fire ignition and spread in dense urban settlements in Quezon City, through semi-structured interviews with fire professionals and residents analyzed thematically. Across both groups, there was broad consensus on the physical mechanisms of risk: electrical failure from grid overloading and unsafe cooking were identified as the primary sources of ignition and combustible construction materials and restricted emergency access as the principal drivers of spread. The contribution of this study, however, lies not in enumerating these factors, which are well documented globally, but in reinterpreting them. Three findings follow from its perception-based, dual-perspective design. First, professionals and residents diverged not over *which* hazards matter but over their *cause* – professionals locating risk in individual inattentiveness, residents in structural constraint – and this attribution gap is itself the mechanism through which conventional, negligence-based safety education fails. Second, the analysis complicates the density-centered account of spread prevalent in the technical literature, as residents attributed spread less to proximity than to material composition and spatial configuration. Third, because the spatial saturation that forecloses municipal suppression cannot readily be reversed, the case is made for decentralized rather than infrastructure-led intervention.

The principal theoretical contribution is, therefore, to reframe these findings rather than merely to enumerate them. This study moves settlement fire away from the conventional category of isolated "human error." Ignition sources such as illegal electrical tapping and the indoor use of hazardous fuels are better understood as adaptations forced by economic poverty and spatial confinement. The space–risk nexus we advance situates these adaptations within a single condition, the physical saturation of the built environment, that renders conventional fire-safety standards structurally inapplicable. On this view, informality is more than a legal status; it is a distinct physical condition, one that calls for bespoke disaster-management frameworks rather than the wholesale import of standards designed for the formal city.

Practically, the implications follow directly from the nexus and span policy, practice and society. For policy, fire-safety regulation calibrated to formal urban form (prescribing access-road widths, hydrant spacing and inter-structural setbacks that saturated settlements cannot physically meet) marks these communities as outside the formal order, so context-specific provisions are required. For practice, because the conditions that foreclose municipal suppression are not readily reversible, resilience strategy must pivot toward decentralized "soft" infrastructure: community-embedded education addressing specific behavioral risks such as electrical load management and indoor LPG use; localized early-warning routed through barangay structures; and the strategic placement of communal suppression tools, whose durability depends on locating their governance and financing within existing statutory mechanisms, the BDRRMC and the LDRRMF. For society, reframing hazardous practice as forced adaptation instead of negligence implies that harm-reduction approaches, which work with residents' material realities, are more likely to reduce risk than punitive enforcement that drives unsafe practices underground.

In sum, this study reinterprets familiar fire risks, shifting the analytical object from the factors themselves to the divergent ways professionals and residents make sense of them and from individual culpability to the spatial and economic structures that make hazardous practice unavoidable. On this basis, the findings offer a scalable and economically realistic blueprint for fire resilience in Quezon City that is adaptable to comparable resource-constrained settlements elsewhere; and the space–risk nexus, articulated here as a set of testable propositions, provides a framework through which that adaptability can be examined in future comparative and mixed-methods research.

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