

Fatal Fire Incidents in Iceland, 1968–2025: A National Registry Study of Building Construction Period and Fire Mortality

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Additional Declarations: Competing interest reported. M.S.S. is a former firefighter and emergency medical technician with Akureyri Fire and Rescue (2007–2022), a former employee of the Housing and Construction Authority (Húsnæðis- og mannvirkjastofnun, HMS), the regulatory body examined in this study, and a former chair of the national firefighter and paramedic union (LSS). This professional background informs interpretation but did not drive data inclusion or classification, as evidenced by the blinded coding-reproducibility check reported in the manuscript. M.S.S. holds no current financial or employment relationship with Akureyri Fire and Rescue, HMS, or LSS. T.B. declares no competing interests.

Abstract

This observational study presents a 58-year national registry of all identified fatal fire incidents in Iceland (1968–2025). The Gjöll registry contains 113 fatal incidents and 145 deaths, of which 93 incidents (116 deaths) are structure fires. Decade-aggregated fire mortality peaked in the 1970s (21.9 deaths per million per year) and fell by approximately 80% to 4–7 per million from the 1990s onward. Fatal fires concentrate in older building stock. Among incidents from 1996 onward, when construction-year data are complete, the pre-1998 structure-fire cohort records 38 deaths (36 in dwellings; 0.55 per 100,000 person-years; 95% CI 0.39–0.76), against zero to two deaths in post-1998 buildings depending on classification convention. Reported as exact post-versus-pre Poisson rate ratios, the reduction holds under every convention for classifying a fatal fire in a building: 0.10 (95% CI 0.002–0.58) under the standard convention, 0 (0–0.38) under a stricter definition, and 0.19 (0.02–0.75) in an adversarial worst case, every interval excluding 1 at the modeled denominator. Interrupted time series analysis shows a consistent pre-1999 decline (IRR 0.95/year, $p < 0.001$) and no significant discrete change at 1999; the decline flattens rather than stepping down. The findings are compatible with a safety advantage in newer, code-era buildings but do not identify the independent effect of Iceland’s 1998 building regulation, since construction period bundles building age, materials, occupancy, and concurrent secular change.

1. Introduction

Effective fire safety regulation depends on reliable, long-term data. Yet national fire fatality statistics are typically published as aggregate counts without incident-level traceability, which limits their value for trend analysis and policy evaluation [1, 2]. This is particularly true for small states, where annual counts are low and vary widely from year to year. National fire-mortality trends have been analyzed from cause-of-death registers in the Nordic region (for example, Sweden’s 1952–2013 series [3]), and the fragmented state of European fire statistics has itself been the subject of study [4]. Yet these analyses draw on cause-of-death coding or aggregated national returns; to the authors’ knowledge, no published national registry combines complete *incident-level* coverage across nearly six decades with per-incident source traceability spanning multiple regulatory eras. Existing aggregate statistics also contain documented errors. Icelandic official records reported zero fire deaths in 2009 despite a confirmed fatal fire at Kljáströnd in Eyjafjörður that year [5].

This paper uses Iceland as a case study of how fatal fire risk is distributed across building construction periods and asks how large and how robust the difference between older and newer (code-era) building stock is. This study separates what the design can and cannot deliver: it can *describe* the concentration of fatal fires by construction period; it can *suggest* mechanisms; but it cannot *identify* the independent causal effect of any single regulation, because construction period bundles building age, materials, electrical systems, occupancy, renovation history, and calendar-period secular change. Iceland is well suited to the descriptive task. Its small population (approximately 200,000 in 1968, growing to 388,000 in 2025) allows every identified fatal fire incident over nearly six decades to be compiled, a completeness rarely achievable in larger states; its centralized framework applies uniformly nationwide; and its building

stock is among the youngest in Europe, with a mean construction year of approximately 1992 [6]. The 1998 building regulation (below) provides a salient construction-period marker against which to describe the cohort contrast, not a treatment whose effect this design estimates.

Iceland's fire safety framework rests on two distinct legal instruments. Fire prevention and fire services are governed by primary legislation: a succession of parliamentary fire prevention acts (Lög nr. 55/1969, which established the first national fire authority; nr. 74/1982; nr. 41/1992; and the current nr. 75/2000). Each act is a consolidated statute that superseded its predecessor [7–10]. Construction fire safety requirements, by contrast, are set by secondary legislation: a building regulation (byggingarreglugerð) issued by the responsible minister under the Planning and Building Act, Skipulags- og byggingarlög nr. 73/1997 [11]. The construction-period marker examined in this study is that building regulation, Byggingarreglugerð nr. 441/1998, effective for buildings of construction year 1999 or later. It introduced mandatory smoke detectors and approved portable fire extinguishers in all new dwelling units, alongside the passive requirements of the building regulation (compartmentation, protected egress, and reaction-to-fire requirements on linings), marking the transition to modern prescriptive residential fire safety requirements [12]. Earlier building regulations already contained passive structural fire provisions, but active detection and first-aid firefighting equipment were not universally mandated in new dwellings before 1999; the 1998 revision is therefore best read as making residential detection and suppression provisions universal and prescriptive rather than creating fire regulation where none existed.

To realize this analytical potential, a comprehensive national registry was created. The Gjöll¹ registry is the first national incident-level fatal fire registry for Iceland. It was compiled through systematic review of newspaper archives, institutional yearbooks, and official government reports, and source references are documented for each record [13, 14]. It is used to (i) describe long-term trends in fatal fire incidents, (ii) compare fatality distributions by building construction year, and (iii) characterize the time-series behavior of fire mortality around the 1999 regulatory milestone using interrupted time series analysis as a descriptive device rather than a causal test.

2. Data and Methods

The Gjöll registry was compiled through systematic review of newspaper archives (notably Tímarit.is), institutional yearbooks (Árbók Þjóðvinafélagsins; Árbók Slysavarnafélags Íslands, later Landsbjörg), government investigation reports, and court records. All 113 fatal fire incidents were verified against at least two independent sources where available [13, 14]. Two exported tables from the registry were analyzed: fatal structure fires ($n = 93$ incidents) and other fatal fire-related incidents ($n = 20$ incidents). The unit of analysis is the fatal incident; all fatal fire incidents for 1968–2025 were included, with no sampling. The registry was finalized on 31 December 2025, so 2025 is a fully observed calendar year and the analysis window matches the exposure window. During compilation the registry's annual death counts were cross-checked against the official national fatal-fire tallies maintained by the fire authority (Brunamálastofnun, later HMS), which span 1968–2018; the underlying year-by-year comparison is available on request. The two series broadly track one another but diverge in several of the earliest years,

where the official tallies record more deaths than the registry, consistent with archival under-ascertainment in the registry's early decades; in other years the registry documents deaths the official tallies omit or misclassify. Because neither source classifies deaths by construction year and both are incomplete or fallible, this cross-check bounds rather than fully quantifies completeness of ascertainment, which remains uncertain for the earliest decades; under-ascertainment is plausible, particularly before the mid-1990s. For the 1999–2025 window on which the post-1998 finding depends, near-complete ascertainment is expected: every post-1999 registry incident carries both a media and an official-investigation source reference, and the small population makes an unrecorded fatal dwelling fire in a newer building highly unlikely, so a missed post-1998 fatality is improbable. As a completeness check, the registry's annual death counts were reconciled against Statistics Iceland's cause-of-death series (ICD-10 X00–X09, exposure to smoke, fire and flames, available from 1996 [15]), which requires no individual-level linkage. Over 1996–2024 the registry documents 50 fire deaths against 36 in the official X00–X09 series: the registry is the more complete record, additionally capturing intentional fire deaths (arson and homicide, coded outside X00–X09), non-building fire deaths, and at least one death the official series omits (the 2009 record above). In four early single-death years the official series records a death the registry did not ascertain, consistent with the residual early-decade under-ascertainment noted below. The full year-by-year reconciliation is reported in the Supplementary Material. The one- and two-death sensitivity cells already bound the effect of a single missed case at the modeled denominator. The 1999 threshold (effective year of Byggingarreglugerð nr. 441/1998) serves as the measurable proxy for the broader modernization of fire safety regulation enacted between 1994 and 2000. The study design cannot causally disentangle this regulatory bundle from concurrent technological, socioeconomic, and behavioral confounders.

Incidents were classified into two groups. Fatal structure fires (93 incidents, 116 deaths) are incidents in which the fire originated in or spread through the building structure, so that building-integrated fire safety features (egress, compartmentation, detection, suppression) were relevant to the fatality outcome. Other fire-related deaths comprise non-building settings (ships, vehicles) together with the small number of in-building fires in which building-integrated fire protection was not materially engaged in the fatality (20 incidents, 29 deaths; the three in-building “other” cases are itemized in the Supplementary Material). This relevance-based rule is deliberately narrower than the standard international convention, under which any fatal fire inside a building counts as a structure fire (the US National Fire Protection Association [NFPA], the US Fire Administration [USFA], and the Swedish Civil Contingencies Agency [MSB] [16–18]). It is adopted here because the paper's question concerns whether building-level fire protection was engaged. The resulting circularity risk is flagged explicitly: a fatality in a newer building whose protection performed as designed can be routed to “other,” which could keep the structure-fire cohort artificially clean. To guard against this, two cases fall near the boundary in a manner relevant to the post-1998 cohort: a 2014 death in a nursing home constructed in 2001, classified “other” because the death arose from a localized bedding ignition rather than structural fire spread; and the 2024 Stuðlar/Fossaleyni case, where an unauthorized extension operated for roughly 20 years outside the legal building-permit framework. Both are counted as post-1998 structure-fire deaths in a worst-case sensitivity analysis

(Section 3), so that no headline conclusion depends on this classification rule. The original classification was performed against the predefined rule and was not blinded to construction year; its reproducibility was subsequently validated by an independent blinded re-code (below), and the residual reliance on a single primary coder for the full registry is disclosed as a limitation that the worst-case sensitivity further bounds. Buildings are classified by recorded construction year in the national property registry (the completion year recorded by Registers Iceland, which may lag behind design and permitting): the pre-1998 cohort is construction year ≤ 1998 and the post-1998 cohort is ≥ 1999 ; “pre-1998” and “post-1998” are used as shorthand for these throughout. Because 1999–2001 completions may have been designed under earlier rules, the earliest post-1998 cohort years are conservatively contaminated toward the pre-1998 regime. Construction year is missing for 48 of 93 structure-fire incidents; all missing cases predate 1996 and therefore do not affect the post-1998 finding (Section 3).

Annual population on 1 January was obtained from Statistics Iceland for 1968–2025 [19], and crude annualized deaths per million population are reported by decade. No census-based housing-stock denominator stratified by construction period is available. Person-years of exposure in pre-1998 versus post-1998 dwellings for 1999–2025 were therefore derived from the observed annual dwelling-completions series (Statistics Iceland, completed dwellings 1970–2021, extrapolated to 2025 from the 2019–2021 mean). This series was anchored to the documented ~ 2021 dwelling stock of approximately 148,000 units (Registers Iceland) and allocated to population by the post-1998 stock fraction [6, 20]. An earlier stepped completion-rate model gave similar but slightly more generous post-1998 exposure (2.08 versus 1.86 million person-years, i.e. mildly anti-conservative). The full derivation, the residual biases, and sensitivity tests (halved denominator; anchor varied 140,000–155,000) are provided in the Supplementary Material.

For the interrupted time series analysis (ITSA), because the 1998 measure is a dwelling-construction regulation, the ITSA on **structure-fire** outcomes (deaths and, separately, incidents) was taken as the primary analysis, and the combined structure-plus-non-structure series as a secondary descriptive comparison only. Non-structure deaths (ship, vehicle, and explosion fatalities, concentrated before 1990) are subject to unrelated safety regimes and would otherwise add an early unrelated decline onto the pre-intervention baseline. A Poisson generalized linear model with log-link and the natural logarithm of annual population as an offset was used [21, 22]. The model used the standard segmented parameterization, coding the post-intervention trend as years since 1999 (zero before 1999) so that the step coefficient is the level change at the 1999 breakpoint, alongside the secular trend and slope-change terms. Because building regulations affect fire mortality through gradual stock turnover rather than instantaneously, the level-change term cannot represent a causal effect of the 1998 regulation (the post-1998 stock share was near zero in 1999) and is interpreted purely descriptively. Overdispersion was assessed by the Pearson chi-squared dispersion ratio. As robustness checks, a negative binomial model with the dispersion parameter estimated by maximum likelihood was fitted, and a quasi-Poisson model with standard errors scaled by the square root of the Pearson dispersion; residual autocorrelation was assessed by the Durbin–Watson statistic. A secondary model with an additional 1982 intervention was compared by Akaike’s Information Criterion (full specifications and results in Supplementary Material).

Analyses were performed in Python 3 using statsmodels [23]. Reporting follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines, with the REporting of studies Conducted using Observational Routinely-collected Data (RECORD) extension and the caveats appropriate to an ecological registry design [24, 25]; a completed checklist accompanies the submission.

One author has prior professional experience in fire and rescue services and, previously, in the national fire-safety oversight body examined in this study; this potential conflict of interest is disclosed in full via the submission system. This experience informs interpretation but did not drive the classification. To test for construction-year-related bias, all 45 fatal incidents of any classification in the complete-data 1996–2025 window (35 structure and 10 other) were independently re-coded by two large language models, blinded to construction year, each applying the predefined rule to the fire-mechanism description alone as an automated reproducibility check. This all-classification set of 45 is distinct from the 45 structure fires with recorded construction year across all decades, which happen to share the same count. The two models were Anthropic Claude Sonnet 5 and OpenAI GPT-5.5; their exact versions, the prompts, and the raw per-incident model outputs are archived in the reproducibility repository. Agreement with the original coding was 97.8% for each (44/45; Cohen’s $\kappa = 0.93$), the single discrepancy being the 2010 Grundartangi industrial fire, whose reclassification would if anything raise the pre-1998 count. The per-incident codings from this run are deposited with the reproducibility package as a frozen snapshot, so the agreement and κ are recomputable offline from the deposited table without re-querying either model, and run-to-run variation in the models cannot affect the reported figures. This indicates the predefined rule can be applied consistently from the incident description alone (a check on rule reproducibility rather than independent human double-coding; the reliance on a single primary coder is disclosed as a limitation, and its effect on the headline result is bounded by the worst-case reclassification sensitivity, in which both borderline post-1998 cases are counted against the cohort).

3. Results

Across 1968–2025 (58 calendar years), the Gjöll registry documents 113 fatal incidents resulting in 145 deaths (mean 1.28 deaths per incident); most incidents involve a single fatality (93/113, 82%). Structure fires account for 93 incidents and 116 deaths (80% of deaths); non-structure incidents contribute 29 deaths across 20 incidents, prominently ship fires (15 deaths across seven incidents), concentrated in the earlier decades of the study period.

Decade aggregation shows the highest burden in the 1970s (35 incidents, 47 deaths), followed by a sustained lower level from the 1990s onward (Table 1; Fig. 2). Crude annualized deaths per million population peak in the 1970s (21.9) and fall by approximately 80% to the range of 4–7 from the 1990s onward. Eight calendar years record zero deaths (1984, 1987, 1992, 2000, 2003, 2007, 2011, 2015). The apparent uptick in 2020–2025 reflects a six-year observation window and rare-event variability. The exact Poisson 95% confidence interval for the 2020–2025 crude rate (approximately 3.8–11.1 deaths

per million per year) overlaps that of the 2010s (approximately 2.6–7.6). The period nonetheless coincides with repeated organizational restructuring of the responsible fire safety authorities and warrants continued monitoring. Fatal incidents concentrate in the October–March period: October–March accounts for 66 of 113 incidents (58%) and 84 of 145 deaths (58%). A binary comparison of October–March versus April–September incidence (against the 49.9% of days falling in the October–March window) is directionally consistent (58.4% of incidents October–March versus 49.9% of days, a difference of 8.5 percentage points, 95% CI -0.7 to 17.2; details in Supplementary Material).

Table 1: Period totals and crude mortality rates for fatal fire incidents in Iceland. Source: Statistics Iceland (table MAN00000). ^aThe 1968–1969 bin covers only 2 years (13 deaths, 6 incidents); its rate (32.3) is unstable and is not the baseline for the decline claim. The 2020–2025 bin covers only 6 years.

Period	Incidents (<i>n</i>)	Deaths (<i>n</i>)	Mean pop. (1 Jan)	Deaths/million/yr
1968–1969 ^a	6	13	201,488	32.3
1970–1979	35	47	214,495	21.9
1980–1989	19	24	238,886	10.1
1990–1999	13	14	264,973	5.3
2000–2009	14	17	296,399	5.7
2010–2019	14	15	325,140	4.6
2020–2025	12	15	370,941	6.7

Construction year is recorded for 45 of 93 structure-fire incidents (48%). Missingness is concentrated in earlier decades. Among structure-fire incidents from 1996 onward, construction year is complete (0 missing). Among incidents with known construction year, no observed fatal structure-fire incidents under the study’s classification rule occurred in buildings constructed after 1998 (Fig. 3; one in-building fatality arises under the standard convention, Table 2). In the 1996–2025 window, the mean construction year of buildings involved in fatal structure fires is 1957, whereas the mean construction year of the Icelandic building stock overall is 1992 [6]; this contrast is illustrative rather than exposure-matched, since the fatal-fire buildings span three decades of incidents while the stock mean is a present-day snapshot. All 48 incidents with missing construction year occurred between 1970 and 1995, and a building that burned before 1999 cannot have been constructed after 1998. The missing data are therefore irrelevant to the post-1998 finding.

Using the observed-completions dwelling person-years as an approximate exposure measure, the 1999–2025 period yields approximately 6.86 million pre-1998 and 1.86 million post-1998 person-years. The pre-1998 cohort records 38 fatal structure-fire deaths (construction year complete for this window; rate 0.55 per 100,000 person-years, 95% CI 0.39–0.76), of which 36 were in ordinary dwellings and 2 in

converted commercial premises (restricting to dwellings gives 0.52, essentially unchanged). Because the post-1998 count is small, the comparison is reported as an exact Poisson rate ratio (post-1998 versus pre-1998) with an exact conditional 95% confidence interval, which is the appropriate inferential statement (Table 2). Under the standard international convention (any fatal fire inside a building), the post-1998 cohort contains one fatality, a 2014 nursing-home death in a building constructed in 2001: rate ratio 0.10 (95% CI 0.002–0.58). Under the stricter building-system-relevance definition, that case is routed to “other” and the cohort records zero deaths (rate ratio 0, 95% CI 0–0.38). A deliberately adversarial worst case additionally counting the 2024 Stuðlar/Fossaleyni fatality (registered construction year 1996, unregistered 2004 extension) gives two deaths (rate ratio 0.19, 95% CI 0.02–0.75); because that death carries a recorded construction year of 1996, moving it into the post-1998 cohort also removes it from the pre-1998 numerator (37 rather than 38 deaths, 0.54 per 100,000), a negligible change reported in full in the Supplementary Material. In every convention the 95% confidence interval for the rate ratio excludes 1 at the modeled (primary) denominator, so the post-1998 fatal-fire rate is significantly lower than the pre-1998 rate even under the worst-case classification; incident-level rate ratios are similar (upper limits 0.45, 0.69, and 0.91). Applied symmetrically, the standard convention adds in-building “other” deaths to the comparison, but the only such death in a post-1998 building is the 2014 nursing-home case already counted (the other in-building “other” deaths are pre-1998 or non-residential, and no residential in-building fatality in the post-1998 window has an unrecorded construction year; §S2). The two adjudicated post-1998 borderline cases are institutional or unauthorized occupancies, so a strictly dwelling-restricted comparison records zero post-1998 against 36 pre-1998 dwelling deaths.

Table 2: Post-1998 versus pre-1998 fatal-fire rate under three conventions. Pre-1998 reference 0.55 per 100,000 (95% CI 0.39–0.76); rate ratio is post/pre with a two-sided exact conditional-Poisson 95% CI (distinct from the one-sided rate upper bounds in the joint sensitivity, Supplementary Material), every CI excluding 1 at the modeled (primary) denominator.

Convention	Post deaths	Post rate/100k	Rate ratio (95% CI)
Standard (any fatal fire in a building)	1	0.054	0.10 (0.002–0.58)
Strict (building-system-relevant spread)	0	0.000	0 (0–0.38)
Worst case (+ unregistered 2004 extension)	2	0.108	0.19 (0.02–0.75)

At the modeled exposure the finding is significant under every classification convention. Under an adversarial halving of the post-1998 denominator, applied coherently so that the freed person-years accrue to the pre-1998 cohort (raising its person-years to approximately 7.79 million and lowering its point estimate to 0.49 per 100,000), the two-sided exact conditional rate-ratio CI (the same statistic as Table 2) excludes 1 only in the strict zero-death cell (RR 0, 95% CI 0–0.85); in the standard (RR 0.22, 95% CI 0.005–1.3) and worst-case (RR 0.45, 95% CI 0.05–1.8) cells it includes 1, so significance is not

retained under this compounded perturbation. The point estimates nonetheless remain 2- to 5-fold apart throughout. The plausible direction of denominator error, the occupancy-density gradient by which older stock is more often subdivided into higher-occupancy units, operates in the same direction as this adversarial halving (both inflate the reported gap), so the modeled-denominator result should be read as the optimistic case rather than a conservative one. This is partly offset by family-formation sorting into newer stock, which raises occupancy in post-1998 dwellings and hence their modeled person-years, so the net direction of the occupancy bias is not fully identified. The residue that survives an adversarial denominator is the 2- to 5-fold point-estimate separation, together with rate-ratio significance in the strict zero-death cell (joint sensitivity matrix and derivation in Supplementary Material). One further recent case, a fatal residential fire in Reykjavík (May 2025, 2 deaths, construction year 1967, under criminal investigation for suspected arson), lies in the pre-1998 cohort and is consistent with the finding.

The segmented Poisson model is used here only as a descriptive device, and it gives a consistent picture. Fire mortality was already declining before 1999 (structure-fire deaths IRR ≈ 0.95 per year, $p < 0.001$), and there is no statistically significant discrete change at the 1999 threshold under any outcome definition or distributional treatment. The decline flattens after 1999 rather than reversing. What the series shows is a pre-existing decline, not a datable break, consistent with the cohort contrast being a property of the building stock rather than the signature of a single regulation. The mechanism-aligned evidence is therefore the construction-period cohort comparison (Table 2), not the interrupted time series. Full model specifications, the negative binomial and quasi-Poisson robustness checks, the Durbin–Watson diagnostic, the 1982-breakpoint comparison, and the complete coefficient table are provided in the Supplementary Material.

4. Discussion

The Gjöll registry documents an approximately 80% decline in fire mortality rates from the 1970s peak (21.9 deaths per million) to the 2010s (4.6 per million), with the rate settling in the 4–7 per million range from the 1990s onward. This decline occurred despite substantial population aging over the period; because fire-fatality risk rises steeply with age, an aging population would, all else equal, push crude mortality upward, so the observed reduction is if anything conservative. It also documents a structural separation between building cohorts: the fatal-fire rate in buildings of recorded construction year 1999 or later is several-fold lower than in pre-1998 dwellings, with the post-1998 upper confidence bound below the pre-1998 point estimate at the modeled denominator, under every classification of the two borderline post-1998 cases (Table 2). This is a description of where fatal fire risk now concentrates by construction period; it is compatible with, but does not identify, a safety benefit of code-era construction, since construction period is a proxy for a bundle of correlated features and concurrent secular change.

The decline cannot be attributed to a single regulatory instrument. The 1998 building regulation is better understood as codifying rather than causing the decline: it plausibly consolidated a broader safety transition that unfolded across the 1990s, although the data cannot establish that it played any independent causal role. The share of Iceland’s space heating supplied by geothermal district heating

rose from roughly 43% of homes in 1970 to close to 90% by the end of the study period, removing a major category of ignition sources from homes [26]. Daily smoking prevalence declined from 34.2% in 1989 to 11.5% by 2015 [27], and smoking materials are among the leading ignition sources in fatal dwelling fires internationally [28, 29]. Emergency medical and prehospital services also developed substantially over the same period, with Iceland becoming the first Nordic country to nationally establish emergency medicine as a specialty [30]. The regulation then arrived when building stock renewal was at its most rapid, so that a growing share of dwellings embodies modern standards: mandatory smoke detection, portable fire extinguishers, compartmentation, and improved construction materials [12, 28, 31]. In this sense, buildings embody regulatory regimes, allowing institutional change to be observed through cohort comparisons of the existing stock. The ITSA is consistent with this interpretation. Mortality was already falling before 1999 (structure-fire IRR = 0.95/year, combined-series 0.93/year, both $p < 0.001$), no significant discrete change occurs at the 1999 breakpoint, and the specific contribution of the 1998 regulation cannot be isolated from the concurrent improvements. This caution mirrors a recognized difficulty in the field: changes in fire-statistics trends are hard to attribute to specific fire-safety measures without comprehensive underlying data [4], and studies that do estimate a regulatory effect on fire outcomes do so with explicit effect sizes, confidence intervals, and enumerated confounders [32]. On the harmonized residential-fire basis reported by the MSB, Iceland's 2010–2019 rate is the lowest among the Nordic countries (approximately 5.5 deaths per million, versus 8.8–12.6 for Norway, Sweden, Denmark, and Finland); this residential-fire basis is defined differently from the all-fatal-fire rate in Table 1 and is contextual rather than central to the cohort analysis [5, 18, 33].

This study is an observational, registry-based cohort description: it documents the association between recorded construction period and fatal-fire outcomes, and it does not, and cannot, estimate the independent causal effect of Byggingarreglugerð nr. 441/1998 net of the concurrent technological, behavioral, and demographic changes. The cohort comparison is accordingly interpreted as compatible with, but not proof of, a safety advantage of newer, code-era construction. Post-1998 buildings have had less time to accumulate age-related risk factors, and occupants of newer housing differ systematically from those in older stock [2, 29, 34]. Building age is unlikely to be the whole story: within the 1996–2025 window four fatal structure fires (six deaths) occurred in buildings under 27 years old at the time of fire (the youngest 14 years old), all of pre-1998 construction, so young pre-code buildings were not fatality-free. An exposure-adjusted comparison of fatal-fire rates by building age is not possible with the current denominators, however, so this observation qualifies but cannot by itself exclude a building-age contribution to the post-1998 zero; the survivorship confound is retained as a limitation. Aggregate associations cannot establish individual-level causal effects [35]. Smoke alarm operability, a stronger predictor of survival than building age [31], cannot be inferred from construction-year data.

The residual burden now concentrates among populations least served by the regulatory apparatus (older housing, unauthorized commercial-to-residential conversions, and arson affecting vulnerable people), and enforcement can nullify code protections even in newer stock, as in the 2024 Stuðlar/Fossaleyni case where an unauthorized extension operated for 20 years outside the legal

building framework [36]. Sustaining the documented gains therefore depends on institutional capacity, not legislation alone (extended analysis in Supplementary Material).

Iceland's small population, centralized governance, young and predominantly concrete building stock, and near-universal geothermal heating limit direct generalization. Specific rates may not transfer to jurisdictions that rely on combustible-fuel heating or timber-framed housing. The methodological approach, a complete national incident-level registry linked to building characteristics and regulatory milestones, is transferable. The construction-year threshold separating regulated from unregulated cohorts is relevant to other high-income countries with prescriptive fire safety frameworks. Three practical directions follow: (1) targeted retrofit and inspection of pre-1998 housing stock, where fatalities concentrate (mean construction year 1957); (2) sustained enforcement capacity and institutional continuity, since regulation without inspection is insufficient; and (3) socioeconomically targeted interventions for populations structurally excluded from prescriptive-code protections.

5. Limitations

The following six limitations are the most material (an extended discussion is provided in the Supplementary Material). First, the registry is small by epidemiological standards (145 deaths across 58 years), and decade-level estimates are sensitive to individual high-casualty incidents. Second, the registry covers fatal incidents only; although annual counts were cross-checked against the official national fatal-fire series, the two diverge in the earliest years, and completeness of ascertainment before the mid-1990s cannot be fully quantified, with under-ascertainment plausible in those years. Third, the post-1998 denominator is built from the observed national dwelling-completions series anchored to the recorded dwelling stock rather than a construction-year-stratified census of occupied dwellings, so the person-years remain an approximation. Fourth, and most consequentially for a fire-mortality study, the analysis is not age-standardized and lacks a cause-of-death breakdown (for example burns versus smoke inhalation), because Iceland's official fire records (unlike the Nordic cause-of-death registers that permit age-adjusted fire-mortality analysis [3]) do not capture victim age or fatality mechanism at the incident level. This absence is not merely a limitation of the present study but is itself a finding about the fragmentation of Icelandic fire-data governance: the same gap that produced documented errors in the official statistics (the 2009 zero-deaths record) and that the Gjöll registry was created to begin to close. Linking future registry records to the national cause-of-death and population-age registers is the clear next step. Fifth, construction year is a proxy for a bundle of correlated features (materials, electrical systems, safety equipment, occupant demographics) rather than a direct causal mechanism. Sixth, the decline coincided with concurrent secular trends (smoking, heating technology, emergency medical services, sociodemographic change) that the interrupted time series cannot separate from regulatory effects.

6. Conclusions

Iceland's fire mortality declined by approximately 80% from its 1970s peak (21.9 deaths per million) to the 2010s (4.6 per million), settling in the 4–7 per million range from the 1990s onward. This decline unfolded within a broader safety transition (geothermal heating, falling smoking prevalence, improved prehospital care) alongside which the 1998 building regulation is one salient construction-period marker; the design does not identify its independent effect. Within the registry's 1999–2025 exposure window, the fatal-fire rate in buildings of recorded construction year 1999 or later is several-fold lower than the pre-1998 rate of 0.55 per 100,000 person-years (95% CI 0.39–0.76), and the finding is robust to fire classification: under the standard “any fatal fire in a building” convention one post-1998 fatality (≈ 0.05 per 100,000, ≈ 10 -fold below the point estimate), zero under a stricter definition, and two in an adversarial worst case (≈ 0.10), with the post-1998 upper bound below the pre-1998 point estimate throughout at the primary denominator, which sensitivity analysis identifies as the optimistic rather than the conservative case; the denominator-robust residue is the 2- to 5-fold point-estimate separation and the strict-classification zero. The remaining burden concentrates in older housing and among vulnerable populations, supporting targeted retrofit, sustained enforcement capacity, and socioeconomically targeted prevention. The Gjöll registry is publicly deposited as updatable research infrastructure [13], with browseable public access. Future research should pursue individual-level data linking building characteristics, occupant demographics, and fire safety equipment status to enable causal inference beyond the aggregate associations documented here.

Declarations

Competing Interests

M.S.S. is a former firefighter and emergency medical technician with Akureyri Fire and Rescue (2007–2022), a former employee of the Housing and Construction Authority (Húsnæðis- og mannvirkjastofnun, HMS), the regulatory body examined in this study, and a former chair of the national firefighter and paramedic union (LSS). This professional background informs interpretation but did not drive data inclusion or classification, as evidenced by the blinded coding-reproducibility check reported in the manuscript. M.S.S. holds no current financial or employment relationship with Akureyri Fire and Rescue, HMS, or LSS. T.B. declares no competing interests.

Author Contribution

M.S.S. conceived the study, compiled the Gjöll registry, performed the statistical analysis, and wrote the manuscript. T.B. contributed governance and institutional context and reviewed and revised the manuscript. All authors read and approved the final manuscript.

Data Availability

The Gjöll registry analyzed in this study is publicly deposited at DATICE (<https://doi.org/10.34881/I5WGJU>) and is browseable at <https://www.gjoll.is>. All analysis code, including a verification script that recomputes every statistic reported in the manuscript, is openly available at <https://github.com/Magnussmari/gjoll-fire-technology>. Supporting population and dwelling-completions series were obtained from Statistics Iceland (tables MAN00000, IDN03001, MAN05302; <https://px.hagstofa.is>). The blinded second-coding outputs reported in the Methods are deposited as a frozen snapshot within the same repository, so the reported agreement and Cohen's κ are recomputable without re-querying any model.

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Footnotes

1. Gjöll (Old Norse *Gjǫll*) is the river in Norse mythology that flows closest to the gates of Hel, the realm of the dead, and is spanned by the bridge Gjallarbrú; the registry is named for it.

Figures

Study design and analytical pipeline

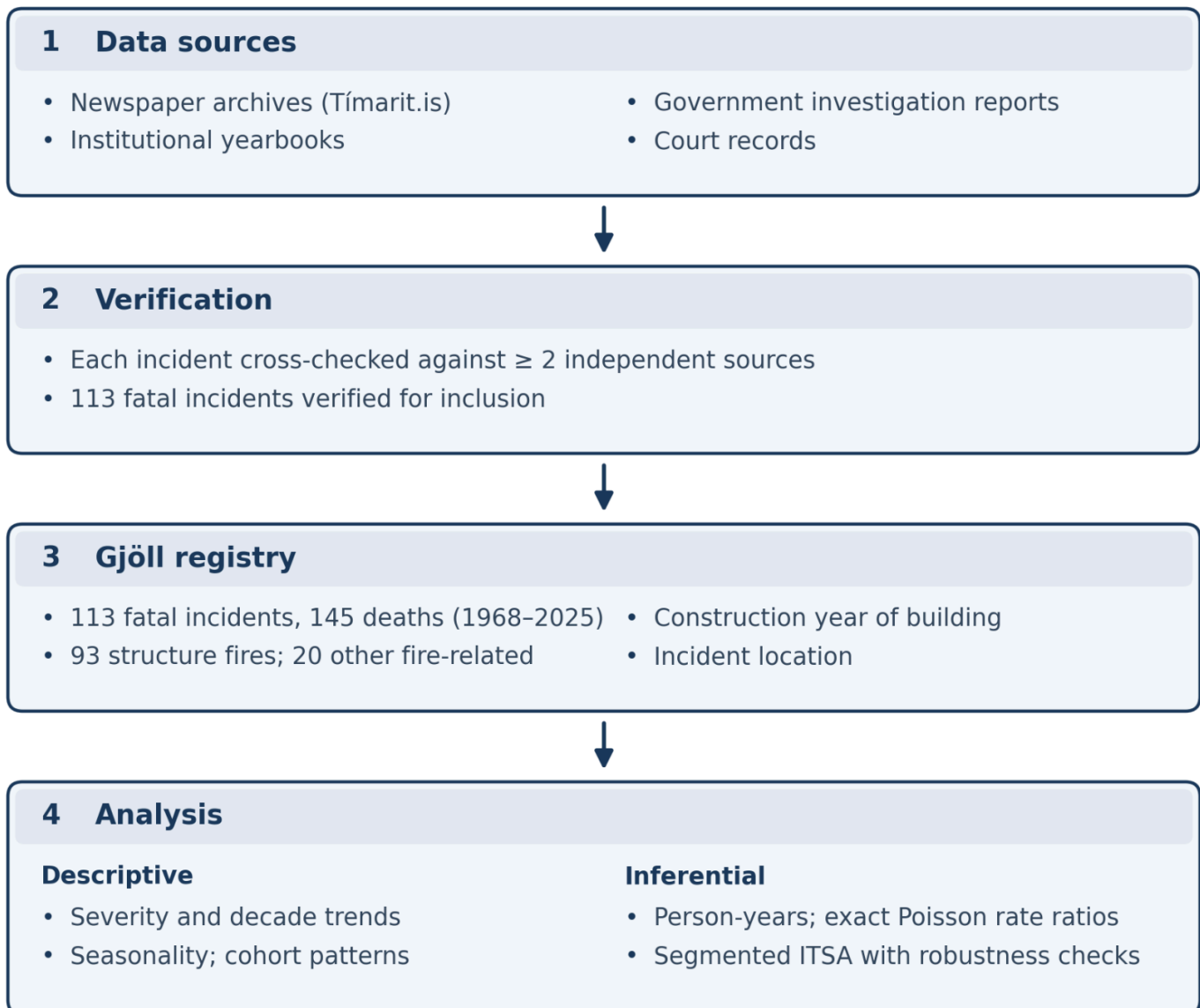


Figure 1

Study design and analytical pipeline. Fatal fire incidents were compiled from multiple independent source types, cross-verified against at least two sources where available, and deposited in the Gjöll registry, which was then analyzed descriptively and inferentially. Source: Gjöll registry.

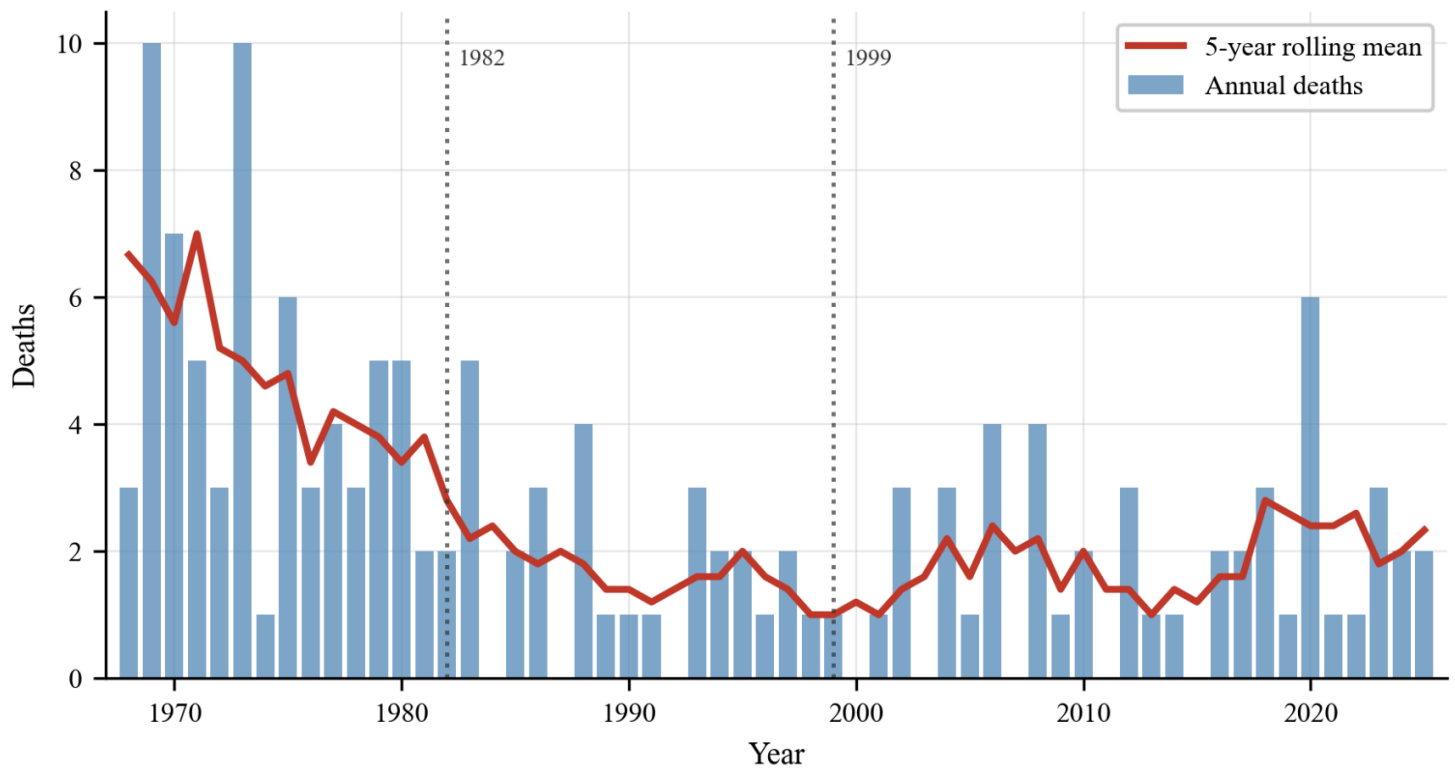


Figure 2

Annual fire-related deaths in Iceland (1968–2025) from the Gjöll registry. The solid line is a centered 5-year rolling mean, illustrating the long-term decline despite substantial year-to-year variability. Source: Gjöll registry.

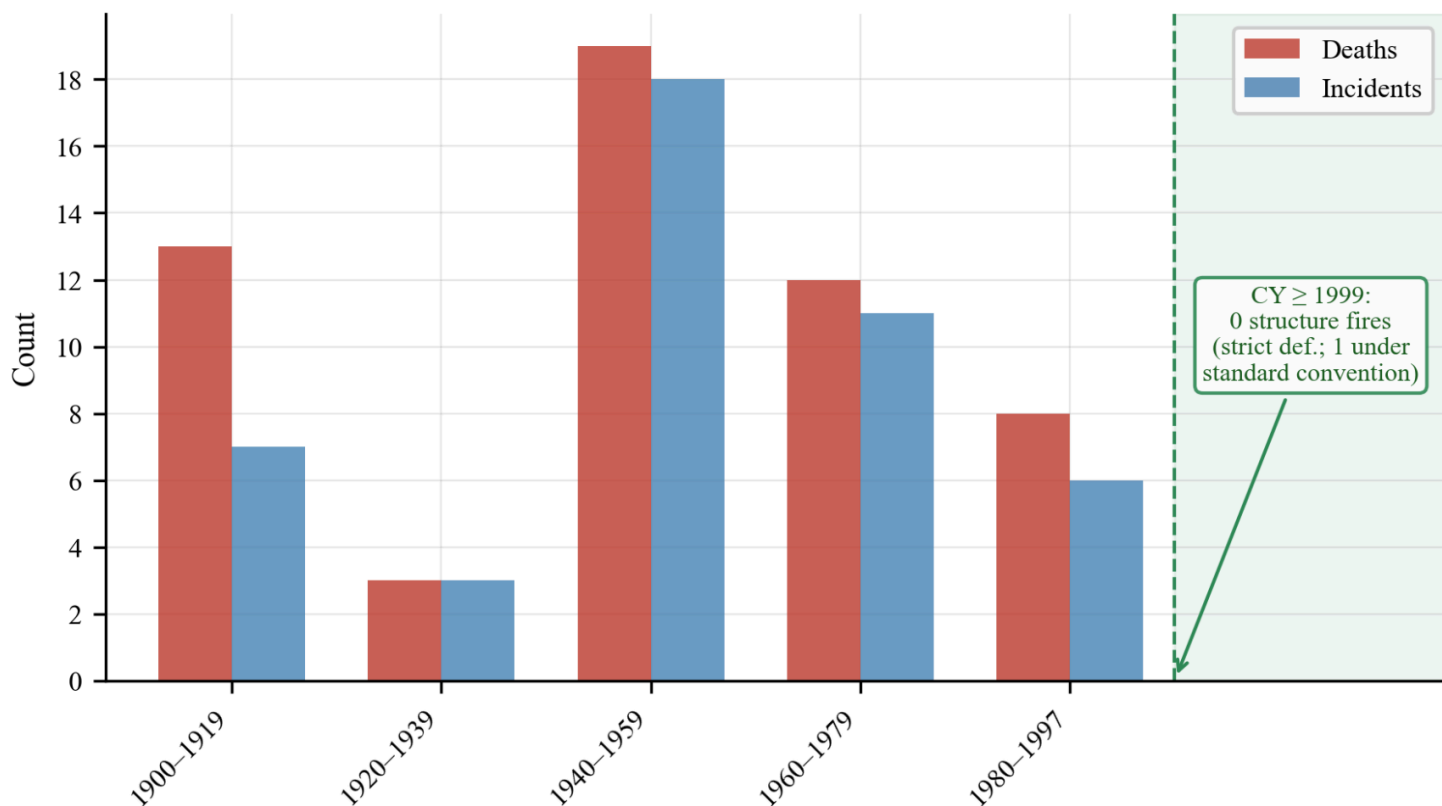


Figure 3

Fatal structure-fire incidents and deaths by building construction-year band, showing concentration of fatalities in older building stock. All 45 fatal structure-fire incidents with a recorded construction year predate the 1999 threshold; the classification conventions and the single standard-convention post-1998 case are detailed in Table 2 and the Data and Methods classification paragraph. The pattern is descriptive and does not on its own establish a causal effect of Byggingarreglugerð nr. 441/1998. Source: Gjöll registry.

Supplementary Files

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- [FatalFireIcelandsupplementaryANON.pdf](#)