What the World Studies, Invents and Reports About Urban Heat

20,422 research papers read sentence by sentence and joined to 96,726 news articles, 4,123 patent families and 14,576 recorded heat incidents, 1990–2025

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Abstract. We assemble 20,422 scholarly papers on urban heat islands (1990–2025), read the 17,101 that carry an abstract sentence by sentence, and join them to 96,726 news articles (2021–2025), 4,123 patent families, 14,576 recorded heat incidents, registers of companies, funding rounds and government funding events, and the annual accounts of Indian companies. Eight results stand out. (1) The field grew about 9 times faster than the scholarly literature as a whole, and in 2015–2019 titles naming "extreme heat" overtook those naming "heat island". (2) Of 2,409 papers that attribute urban heat to a cause, 48% name urbanisation and land-use change; attribution to anthropogenic heat fell from 18.4% to 7.7%. (3) Research and news describe different problems: at equal text length, 28% of research openings raise mitigation against 1.6% of news leads, while 22% of news leads are forecasts or warnings against 1.4% of research. (4) They also describe different places: China accounts for 31% of the research and 2.3% of English-language coverage, and Delhi receives 7.4 times the coverage its research share would predict. (5) Invention has outrun science: patent families for cool and permeable pavements grew 12-fold in a decade against 2.4-fold for the research on them. (6) Across 194 studies the median reported cooling from urban trees is 2.0 °C (air temperature 2.0 °C, surface temperature 2.9 °C). (7) Between 2021–22 and 2024–25 news coverage moved from the hazard to the people exposed: workers, schools, the elderly and hospital patients each rose 1.4- to 2.4-fold as a share of heat articles while wildfire and drought fell by about half and climate change — raised in about one article in ten — fell by a quarter. (8) The market record is thin: 140 of 5.05 million companies state a heat or cooling purpose, and recorded capital is $2.7 billion of cooling-infrastructure finance against $48 million of venture funding; larger Indian cooling companies grew revenue 25% a year over three years against 16% for Indian companies generally. Every cause category extracted from the research was tested against an independent second reader; three failed, and no result reported here rests on them.

Keywords: urban heat island · extreme heat · heatwaves · research synthesis · text mining · news coverage · patents · climate adaptation · cooling industry · India

Introduction

The urban heat island is among the oldest measured effects of cities on climate. Its energetic basis — altered surface energy balance, heat storage in the built fabric, reduced evaporation and waste heat from human activity — was set out by Oke (1973, 1982) and has been reviewed repeatedly since (Arnfield, 2003; Grimmond, 2007; Rizwan et al., 2008). Satellite thermal sensing extended the record from a few instrumented cities to hundreds (Voogt and Oke, 2003; Imhoff et al., 2010; Peng et al., 2012; Zhou et al., 2019), local climate zones gave the field a common site classification (Stewart and Oke, 2012), and global analyses now attribute much of the variation in heat-island magnitude to background climate and population (Zhao et al., 2014; Manoli et al., 2019). The consequences are equally well documented: excess mortality (Gasparrini et al., 2015; Heaviside et al., 2017; Mora et al., 2017), rapidly rising urban exposure (Tuholske et al., 2021), a burden that falls unequally within cities (Hoffman et al., 2020; Hsu et al., 2021), amplification during heat waves (Li and Bou-Zeid, 2013) and rising demand for cooling energy (Santamouris et al., 2015; Khosla et al., 2021; International Energy Agency, 2018). So are the responses, from reflective surfaces and urban greening (Akbari et al., 2001; Bowler et al., 2010; Santamouris, 2014) to daytime radiative cooling materials (Raman et al., 2014; Zhai et al., 2017), district cooling (Gang et al., 2016) and municipal heat action plans (Knowlton et al., 2014; Hess et al., 2018).

What is missing is a view of the whole. Bibliometric studies of the field (Huang and Lu, 2018; Wu and Ren, 2019; He et al., 2023; Li et al., 2024) count publications, keywords and collaborations, but they do not read what the papers assert, so they cannot say which causes the literature blames or which remedies it measures. Studies of how the media report heat (Hopke, 2020) rest on samples of a few outlets, in a tradition of climate-coverage analysis (Boykoff and Boykoff, 2007) that has rarely been joined to the research record. And no study we know of sets either against invention, company formation, private capital or company accounts.

This paper makes three contributions. It reads 17,101 abstracts sentence by sentence to measure what the literature attributes urban heat to and what it says urban heat causes, validating every category against an independent second reader. It joins that record to news, patents and incident records to show where research attention and public attention diverge — by subject, by country and by city. And it measures how little of the world's company formation and capital is organised around the problem, with Indian company accounts as a test of whether rising heat is visible in cooling revenues.

1. Data and method

Source of the records. All records used here are held in Prism, the research layer maintained by Fliar BI, which indexes scholarly papers, news articles, patent filings, company registers, funding announcements and public-funding events against a common set of places, dates and organisations. The joins in §9 to §11 — research against news by country and city, research against patents by technology, companies against funding and accounts — are possible because the records share that index; none of them can be made from a bibliographic database alone.

Corpus. A paper enters the corpus if "urban heat", "heat island", "urban overheating" or "urban cool(ing) island" appears in its *title or abstract*. We keep journal articles and reviews, exclude repository deposits, and de-duplicate on title and year, giving **20,422 papers** spanning 1990–2025. 17,101 of them carry an abstract of more than 200 characters and form the text-analysis set.

Assembling the corpus from the bibliographic index's own topic tags instead returns 122,160 papers. Inspection showed that set was dominated by building-energy and general climate research — its most-cited member was a global climate-surfaces dataset (Fick and Hijmans, 2017) with no specific relation to urban heat. Selection by title and abstract text is the more conservative rule and is the one used throughout.

Two layers of measurement

Layer 1 measures the research itself: publication counts, terminology, geography, venues, citations. These are exact counts. **Layer 2** reads what the papers assert. A paper is counted as attributing a cause only when the cause, a causal cue and the heat-island term appear *in one sentence, in the correct order — cause → leads to → heat island*, or *heat island → due to → cause*. An undirected pass that counted mere co-occurrence within a sentence was roughly half as precise: it scored "urban heat islands increase energy consumption" as evidence that energy use causes urban heat.

Growth is measured on titles only. The share of records carrying an abstract varies by year, so any theme measured over abstracts inherits that variation; title-based counts do not. Theme shares are computed only among papers that have an abstract. Growth is reported relative to the growth of all articles and reviews over the same years.

Validation

Template extraction was validated against an independent second reader: a language model was run over a stratified sample of 620 abstracts — 320 on which the templates fired, stratified across all eleven cause categories, plus 300 on which they did not — and asked to extract the same fields. 565 (91.1%) produced usable output. The model is not ground truth; the table reports *agreement*, and a disagreement may be either side's error. It is nonetheless the discriminating test, because the two methods fail in unrelated ways.

Table 1. Agreement between template and independent extraction, by cause category (template-positive stratum). Categories below 70% are not used for any claim in this paper.

Cause category	n	agreement	Used here
loss of vegetation & green space	47	89.4%	yes
urban geometry & density	46	84.8%	yes
reduced wind & ventilation	6	83.3%	small sample
reduced evaporation & moisture	11	81.8%	small sample
anthropogenic heat	58	81.0%	yes
urbanisation & land-use change	97	76.3%	yes
low albedo & heat-storing materials	40	75.0%	yes
impervious & built surfaces	80	71.2%	yes
population growth & density	44	63.6%	**no — excluded**
climate change & heatwaves (as amplifier)	59	47.5%	**no — excluded**
air pollution & aerosols	34	41.2%	**no — excluded**

Six categories reach 70% or better on samples of 40 or more and carry the results below. Three do not: air pollution (41%), climate change as an amplifier (48%) and population density (64%). **No result in this paper rests on those three**; they appear only as counts.

The validation also corrected the author's own prior estimates in both directions. A manual check of 8–12 sentences per category had put urbanisation at about 90% and anthropogenic heat at about 63%; the 620-abstract comparison gives 76% and 81% respectively. Small manual samples were not a reliable guide.

The templates under-count. Of 234 sampled abstracts on which no template fired, 77 (33%) contained a causal attribution the independent reader identified. The 2,409 attributing papers reported here are therefore a *floor*, and the true figure is plausibly a third higher. Shares between categories are more robust than the absolute count, since the shortfall is spread across categories rather than concentrated in one.

Finally, 28% of the cause statements the independent reader extracted were flagged as restated background rather than the study's own finding. Neither method separates these in the counts below; doing so is the main correction required for v2.

2. The shape of the field

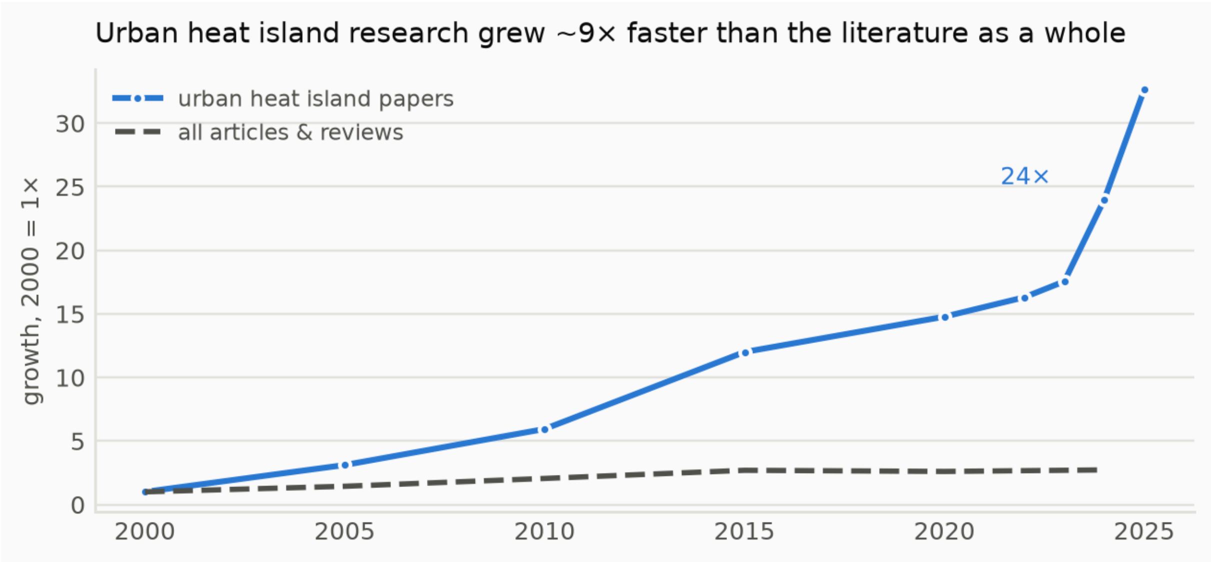

Figure 1. Papers with an urban-heat term in the title, indexed to 2000, against all articles and reviews over the same period.

Annual output rose from 36 papers in 2000 to 864 in 2024, a 24-fold increase against 2.72-fold for the literature as a whole. Review and meta-analytic papers rose from 49 in 2010–2014 to 373 in 2020–2024, indicating a field moving from primary measurement toward synthesis.

The vocabulary changed with it. Titles naming "extreme heat" or "heatwaves" overtook those naming "heat island" during 2015–2019 and led 3,859 to 2,684 in 2020–2024 — the field increasingly frames its subject as a hazard rather than a physical phenomenon. Mitigation became the majority concern, rising from 26.4% of abstract-bearing papers in 1990–2004 to 57% in 2020–2024, while health rose from 4.5% to 19.9% and work on inequality, still a minority topic, from 1.1% to 5.6%.

Research concentrates geographically. Beijing is named in the titles of 381 papers, more than twice Shanghai (155) or Tokyo (131); nine East Asian cities account for 1,166 title mentions against 73 for Cairo, Lagos, Nairobi and Johannesburg combined. Citations are concentrated too: the top 1% of papers hold 27.7% of all citations and 36.5% have never been cited.

3. What the literature attributes urban heat to

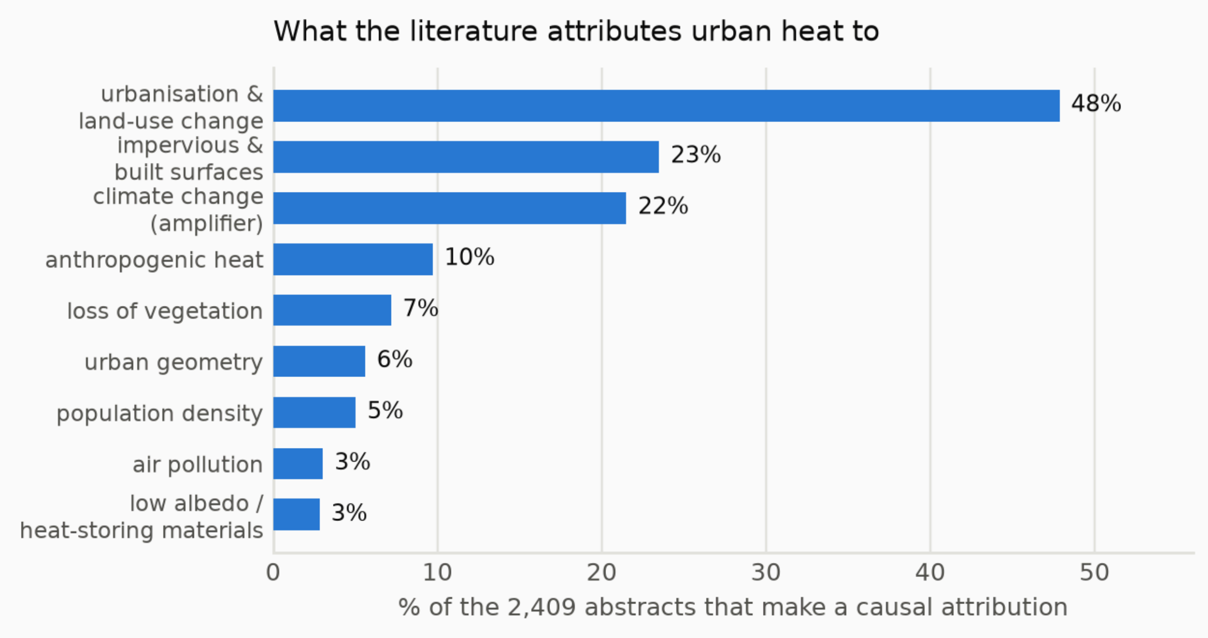

Figure 2. Causes named in the 2,409 abstracts that make an explicit directional attribution. A paper may name more than one cause.

Urbanisation and land-use change dominate, named in 48% of attributing abstracts, followed by impervious and built surfaces (23%) and — on a category that did not pass validation and is reported for completeness only — climate change or heatwaves as an amplifier (22%). Anthropogenic heat — traffic, industry, air conditioning — accounts for 10%, and loss of vegetation 7%. Explanations that dominate textbook accounts of the physics, such as low albedo (3%) and reduced ventilation (0%), are rarely the attribution a paper foregrounds.

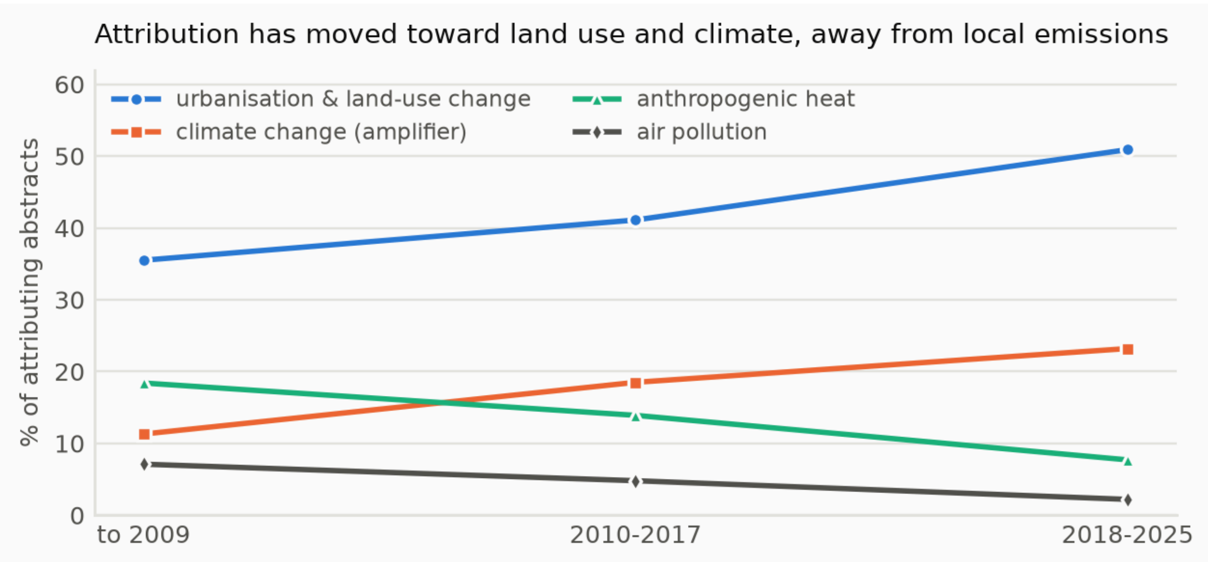

Figure 3. Share of attributing abstracts naming each cause, by period. Denominators: 141 papers to 2009, 525 in 2010–2017, 1,743 in 2018–2025.

The mix has shifted. Urbanisation rose from 35.5% of attributing abstracts to 50.9%, while anthropogenic heat — waste heat from buildings, transport and industry (Sailor, 2011) — fell from 18.4% to 7.7%. Both categories passed validation (76% and 81% agreement). These are shares: every category grew in absolute terms.

Not reported. The same extraction suggests that attribution to climate change as an amplifier doubled over the period and that attribution to air pollution fell. Both categories failed validation (48% and 41% agreement), so neither trend is reported as a result. Figure 3 retains their series for transparency; they should not be cited.

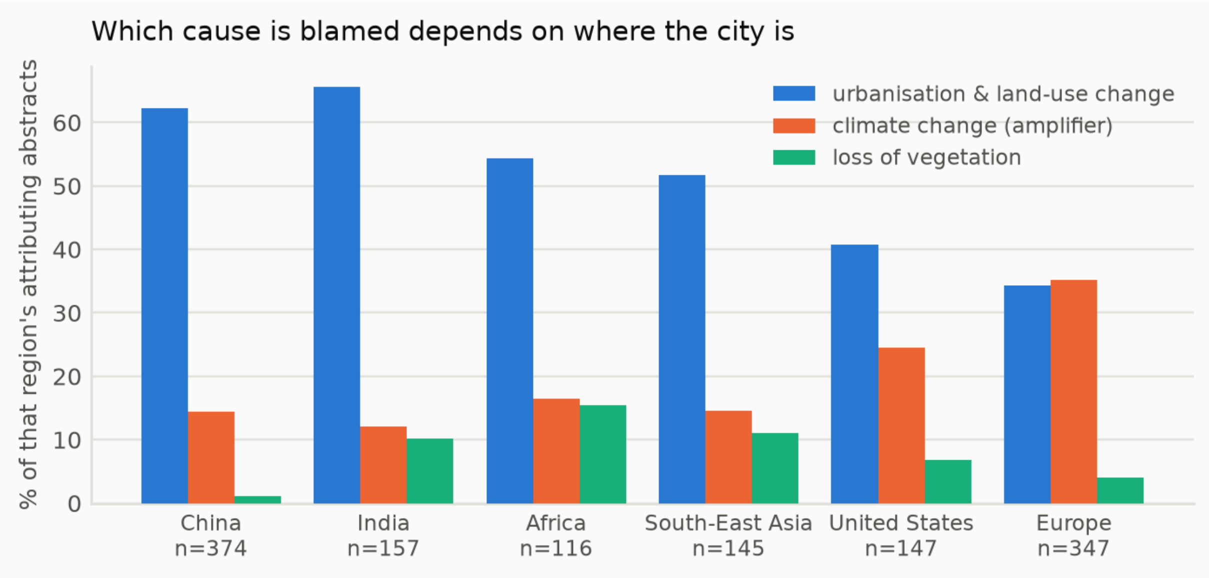

Figure 4. Cause named, by the region the study examines. Regions are detected from place names in title and abstract; a paper may count toward more than one.

Attribution depends on where the city is. Urbanisation dominates in studies of Chinese (62.3%) and Indian (65.6%) cities against 34.3% for Europe, and loss of vegetation is named in 15.5% of African-city studies and 10.2% of Indian ones against 1.1% for China — both categories passed validation. The corresponding contrast for climate-change attribution (Europe 35.2% vs India 12.1%) is not reported: that category did not pass. A plausible reading is that researchers attribute urban heat to whichever process is visibly underway around them — rapid land conversion in fast-urbanising regions, a warming baseline in regions where the built form is already established — but the corpus cannot test that interpretation.

4. What the literature says urban heat causes

Of 1,174 abstracts asserting a consequence, the most frequent are higher energy demand for cooling (25%), thermal discomfort and heat stress (22%), human health and mortality (21%) and degraded air quality (16%).

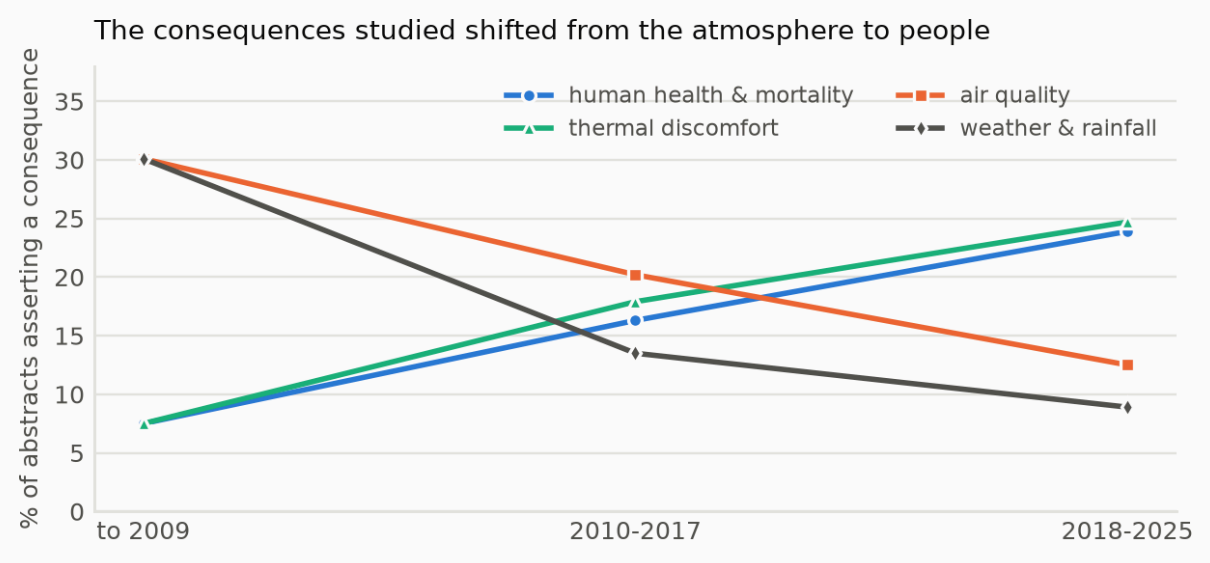

Figure 5. Consequences named, by period. Denominators: 93 papers to 2009, 252 in 2010–2017, 829 in 2018–2025.

The shift here is sharper than for causes. Papers naming human health rose from 7.5% to 23.9% and thermal discomfort from 7.5% to 24.7%, while the atmospheric consequences that once dominated fell away: weather and rainfall from 30.1% to 8.9%, air quality from 30.1% to 12.5%. Urban heat has been reframed from a meteorological curiosity into a public-health problem.

5. Reported magnitudes

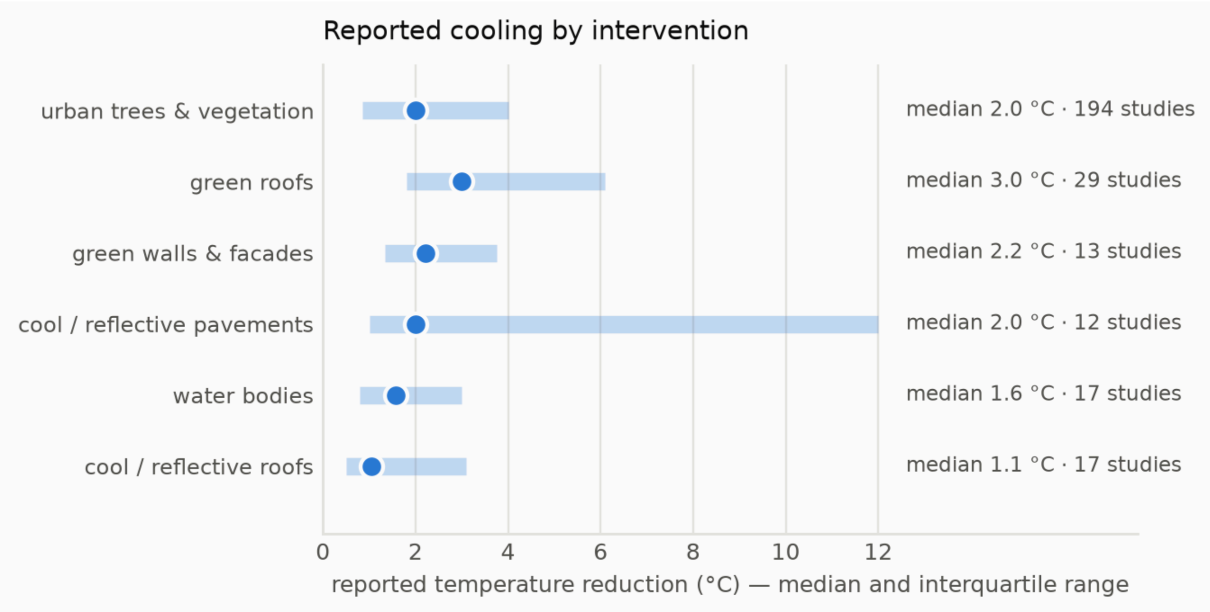

Figure 6. Reported temperature reduction by mitigation strategy. Points are medians, bars interquartile ranges. Values are what studies report, not a pooled effect size.

Across 194 studies giving a figure, the median reported cooling from urban trees and vegetation is 2.0 °C, with half of all values between 0.9 and 4.0 °C; air-temperature reductions (median 2.0 °C) are smaller than surface-temperature reductions (median 2.9 °C). The distinction matters because a single cooling figure is often quoted without saying which was measured. Public reference material widely repeats that trees cool cities by up to 10 °F (5.6 °C), a figure that originates in an advocacy fact sheet (TreePeople, n.d.); it lies above the 75th percentile (3.2 °C) of the air-temperature reductions reported in this corpus, whose modest median is in line with the systematic review evidence on urban greening (Bowler et al., 2010).

Where studies state a heat-island intensity, the median reported value is 2.5 °C for air or unspecified temperature (161 studies) and 3.0 °C for satellite-derived surface temperature (52 studies). A small set of studies quantifies the cooling-energy penalty, with a median reported increase of 17% (17 studies).

> **These distributions are not meta-analytic effect sizes.** They mix measured and simulated values, peak and mean reductions, and different spatial scales. They describe what the literature *reports*, which is the quantity of interest when asking what a reader of this field would conclude — but they must not be read as a pooled estimate of how much cooling a strategy delivers.

6. Who is named as vulnerable

Only 266 abstracts explicitly identify a group as more vulnerable. Among them, 46% name low-income or deprived populations, 42% older adults and 22% ethnic or racial minorities. This is the weakest category in the analysis, at roughly 60% precision, and is reported as indicative only.

7. Invention

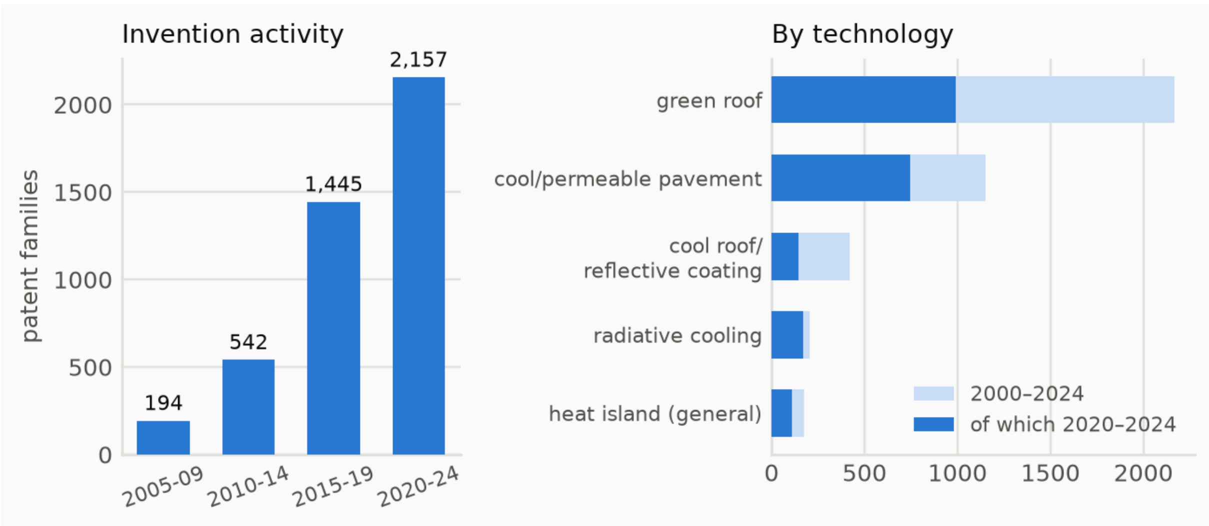

Figure 7. Patent families for heat-island mitigation technologies, matched on English-language titles and grouped into families to avoid double-counting.

Patent activity grew from 194 families in 2005–2009 to 2,157 in 2020–2024, with green roofs the largest category (2,168 families). Passive radiative cooling is the newest: 83% of its families date from 2020–2024. Roughly 83% of all identified families include a filing at China's patent office.

8. How the news covers heat

The news record is 96,726 articles published 2021–2025 that mention urban heat, heat islands, extreme heat, heatwaves, heat domes, heat action plans or heat stroke. The text available for each is its opening — a median of 308 characters — so every measure in this section describes *how heat stories open*, which is also what most readers see.

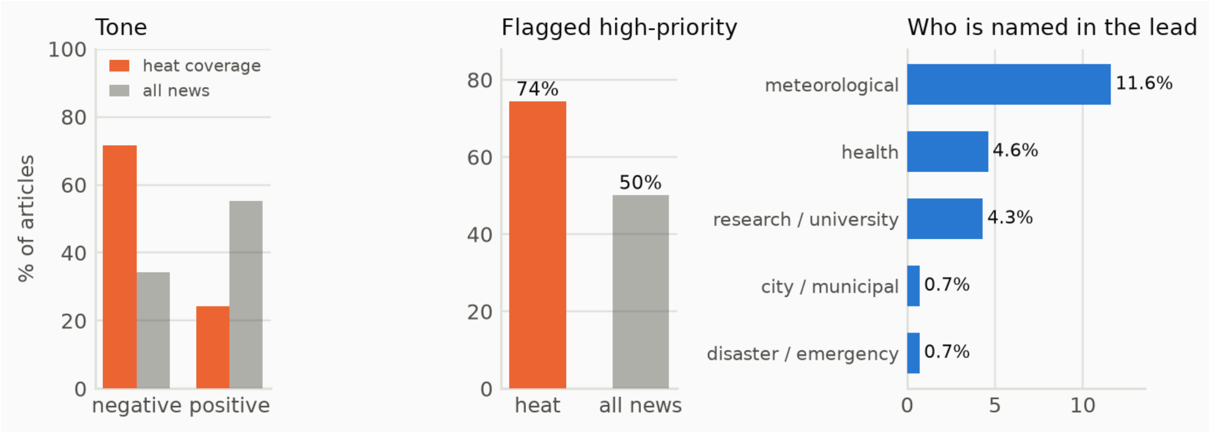

Figure 8. Tone, editorial priority and the institutions named in the opening of heat coverage, against all news over the same period.

8.1 Heat is reported as bad news, and as urgent news

72% of heat articles are negative in tone against 34% of all news — 2.1 times the baseline rate — and 74% are flagged high-priority against 50%. Only 24% are positive, less than half the baseline share.

8.2 It is reported as weather

The single largest category of heat coverage is the advisory: 23,999 articles (25% of the total) are classified as heatwave advisories. Meteorological agencies are named in 11.6% of leads, health bodies in 4.6%, disaster-management agencies in 0.7% and city governments in 0.7%. The bodies that issue forecasts dominate; the bodies that would act on heat — health departments, city halls, emergency managers — are nearly absent from how the story opens. Coverage explicitly about urban heat island mitigation amounts to 666 articles, 0.7% of the total.

8.3 What else is in the story

Table 2. Share of heat-article openings that also mention each subject.

Also mentioned	articles	% of heat coverage
climate change	8,929	9.2%
deaths / mortality	7,723	8.0%
wildfire	6,754	7.0%
water	5,577	5.8%
hospital / illness	4,184	4.3%
power / electricity	3,654	3.8%
crops / farming	2,918	3.0%
schools	2,620	2.7%
transport	2,099	2.2%
air conditioning	2,208	2.3%
workers / labour	1,612	1.7%
heat action plan	1,324	1.4%
cooling centre / shelter	745	0.8%

Climate change is raised in 9.2% of openings and deaths in 8.0%. The institutional responses are the rarest subjects of all: heat action plans appear in 1.4% of openings and cooling centres in 0.8%. Workers — the group most exposed — appear in 1.7%.

8.4 When it is reported

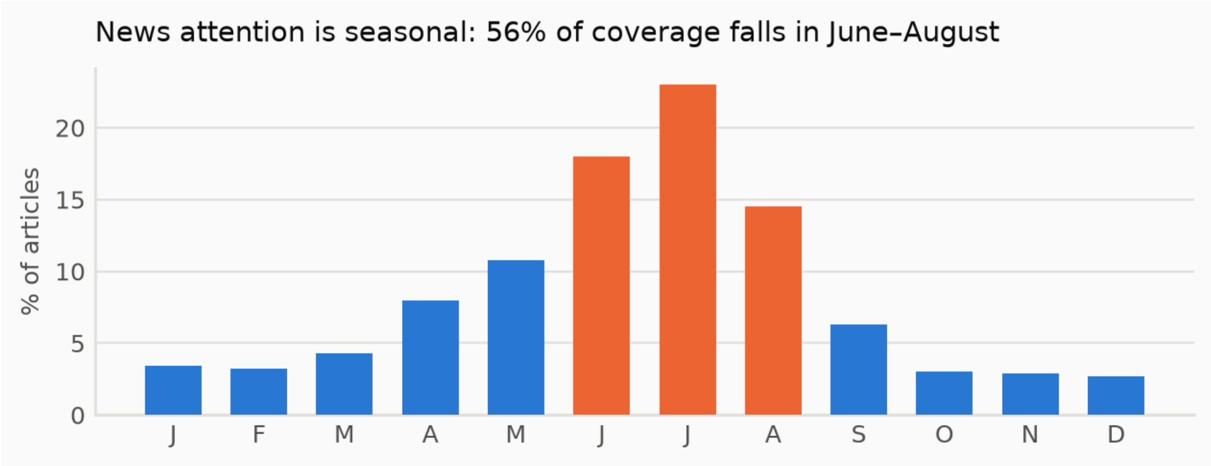

Figure 9. Month-of-year distribution of heat coverage, 2021–2025 pooled. Within-year shares are unaffected by changes in which outlets were collected.

56% of coverage falls in June–August. It is spread rather than spiked: the ten busiest days hold 5.7% of all articles and the fifty busiest 18.2%, across 1,813 days with any coverage. The three busiest days in the five years were 18, 19 and 20 July 2022 (814, 877 and 594 articles), when the United Kingdom first recorded 40 °C.

8.5 The vocabulary of coverage

"Heat wave" appears in 74% of heat articles in 2025; "heat island" — the organising concept of the research literature — in 1.1%. "Heat dome" peaked at 3.4% in 2021, the year of the Pacific Northwest event. "Heat action plan" rose from 0.05% to 0.29% — a seven-fold rise from a negligible base.

8.6 What rose and what fell

To see how the story has changed, each of 21 subjects was counted as a share of that year's heat articles and 2024–25 compared with 2021–22. Because the mix of countries in the corpus shifted over the period, the comparison holds that mix fixed, and a subject is called a riser or a faller only when at least three of four country groups (United States, India, United Kingdom, all others) moved the same way.

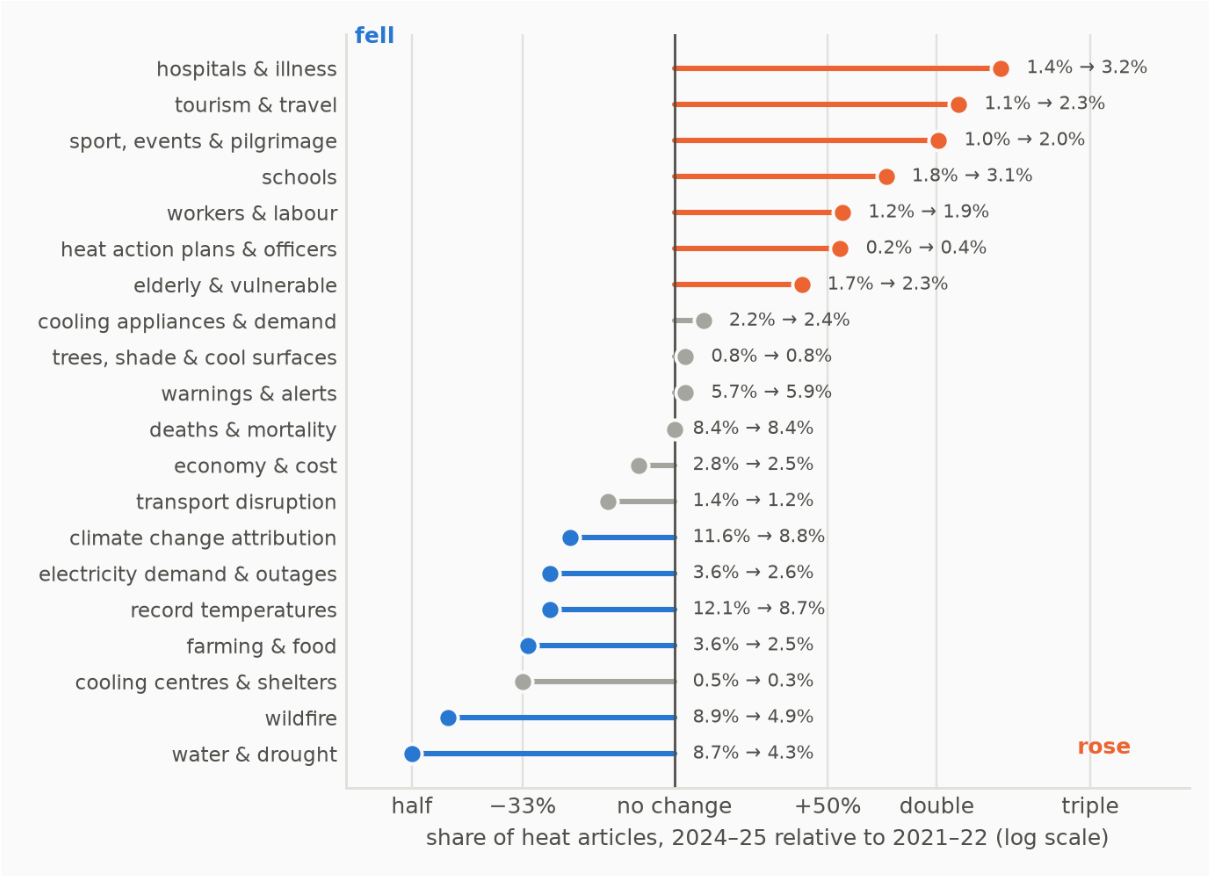

Figure 10. Coverage moved from the hazard to the people exposed to it. Share of heat articles raising each subject, 2024–25 relative to 2021–22, country mix held fixed. Coloured bars moved the same way in at least three of four country groups; grey bars did not, or moved less than about 15%. Labels give the two shares.

The risers are all about who is exposed. Workers and labour rose from 1.2% to 1.9% of heat articles (1.6 times), schools from 1.8% to 3.1% (1.8 times), the elderly and vulnerable from 1.7% to 2.3% (1.4 times), and hospitals and patients from 1.4% to 3.2% (2.4 times), and tourism and travel from 1.1% to 2.3% (2.1 times). A sixth subject, sport, mass events and pilgrimage, rose by a similar factor but its keyword rule failed validation (§8.7) and it is not reported as a result.

The fallers are all about the physical hazard. Wildfire fell from 8.9% to 4.9%, water and drought from 8.7% to 4.3%, record temperatures from 12.1% to 8.7%, farming and food from 3.6% to 2.5%, and electricity demand and outages from 3.6% to 2.6%. All five fell in at least three of four country groups. Part of this is the calendar of events — 2021–22 held the Pacific Northwest heat dome, the European drought and the first 40 °C day in the United Kingdom — and five years is a short series; the direction, not the exact ratio, is the finding.

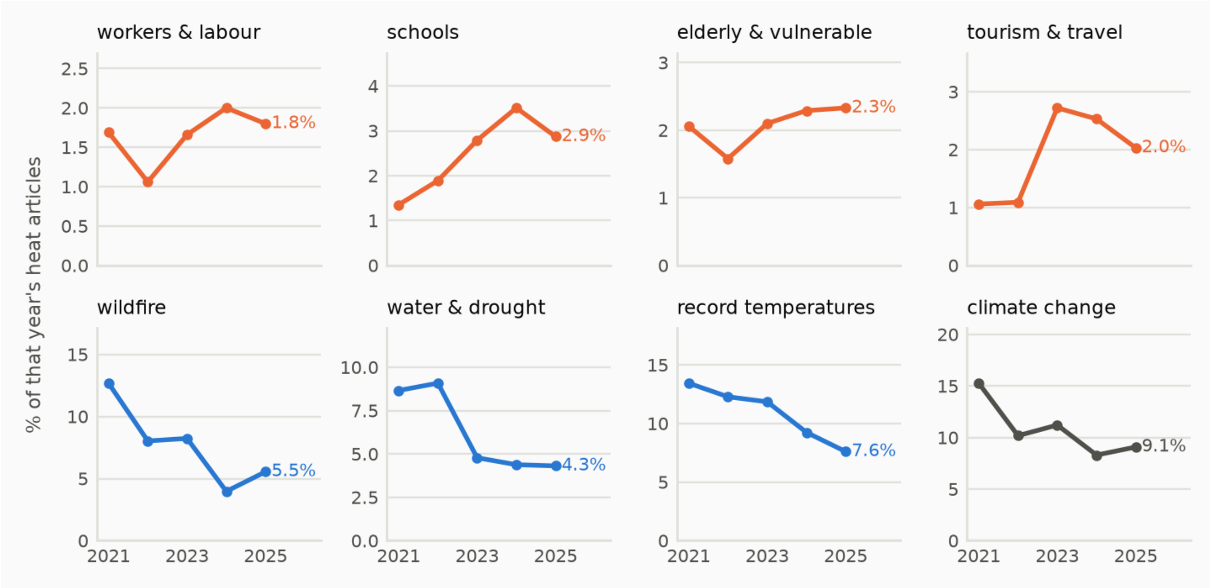

Figure 11. Year by year. Share of each year's heat articles raising the subject. Orange: rose; blue: fell; grey: flat. Vertical scales differ between panels.

Climate change is mentioned less often, not more. It is raised in about one heat article in ten, but the share fell from 11.6% to 8.8% — a decline of about a quarter, and one of only four subjects that moved the same way in all four country groups. Deaths, by contrast, did not move at all: 8.4%, against 8.4% before. So the shift towards the people exposed is not a shift towards the climate framing; coverage became more about who suffers and less about both the physical hazard and its cause. And the responses that the research literature concentrates on remain almost absent from the news: heat action plans and heat officers appear in 0.4% of heat articles and cooling centres in 0.3% — both below one article in a hundred in every year measured, and both rules validated at 88% and 100% agreement. The corresponding count for trees, shade and cool surfaces is not reported: that rule failed validation.

One subject is a single event. Elections and voting appear in 0.3% of heat articles in 2021 and 2.4% in 2024, when India's seven-phase general election was held through a heatwave and polling staff were among the dead; the share fell back to 0.3% in 2025.

8.7 How far the subject rules can be trusted

Every subject in §8.6 is a keyword rule applied to an article opening, so each one was tested the same way the research categories were: an independent second reader was given 912 sampled openings and asked which subjects the text actually raises, without seeing the rule. 875 returned usable output. The table reports *agreement* between the two readings, not ground truth.

Table 3. Agreement between the keyword rules and an independent second reader, by subject. Rules below 70% are not used for any result in this paper.

Subject	articles checked	agreement	found where the rule was silent	Used here
electricity demand & outages	41	100.0%	2.0%	yes
wildfire	54	100.0%	1.6%	yes
cooling centres & shelters	43	100.0%	0.7%	yes
climate change attribution	89	98.9%	4.3%	yes
hospitals & illness	43	95.3%	0.4%	yes
water & drought	61	95.1%	2.1%	yes
deaths & mortality	89	91.0%	1.3%	yes
farming & food	48	87.5%	0.7%	yes
heat action plans & officers	40	87.5%	2.6%	yes
record temperatures	90	86.7%	12.6%	yes
workers & labour	37	86.5%	1.2%	yes
elections & politics	41	85.4%	0.0%	yes
schools	50	84.0%	0.4%	yes
tourism & travel	43	83.7%	0.6%	yes
elderly & vulnerable	55	80.0%	2.0%	yes
cooling appliances & demand	47	78.7%	1.2%	yes
sport, events & pilgrimage	41	65.9%	1.1%	**no — failed**
trees, shade & cool surfaces	38	52.6%	0.4%	**no — failed**

Sixteen of eighteen rules reach 70% or better. Two do not. **Sport, mass events and pilgrimage** (66%) mixes genuine pilgrimage and stadium coverage with research abstracts that merely name an Olympic district. **Trees, shade and cool surfaces** (53%) fails for a specific and instructive reason: the word *shade* is a meteorological convention in weather reporting — "35 degrees in the shade", "fans scurrying for shade" — not a reference to shade as a cooling measure. Both are excluded from the results above. The reader also judged 2.1% of sampled openings not to be about heat at all, which is the false-positive rate of the corpus inclusion rule itself. One rule under-counts badly rather than over-counting: for record temperatures the reader found the subject in 13% of articles where the rule was silent, so that share is a floor.

8.8 Coverage is becoming less negative

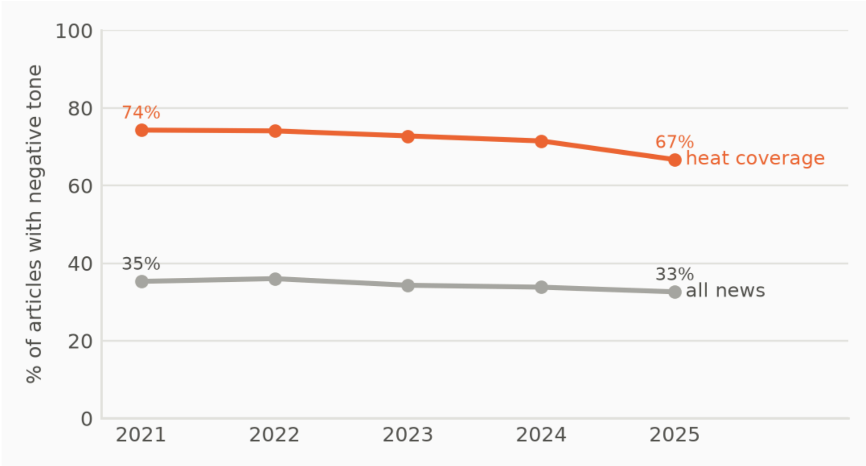

Figure 12. Tone of heat coverage against all news. Share of articles classified negative, by year.

In 2021, 74% of heat articles were negative in tone; in 2025, 67%. News as a whole moved from 35% to 33% over the same years, so the fall is specific to heat. It is consistent with §8.6: advisories, school timetables and workplace rules are written in a more neutral register than casualty reports. Heat remains about twice as negative as the news around it.

8.9 Each country reports a different heatwave

	deaths	electricity	schools	workers	wildfire	climate change	records	water & drought	cooling appliances	tourism
United States (n=20,653)	10	4.1	2.4	2.3	9.2	12	14	5.9	4.1	1.0
India (n=12,481)	8.5	3.6	5.7	1.6	0.5	4.7	9.5	2.1	1.6	0.7
United Kingdom (n=5,533)	3.9	0.3	1.9	0.9	4.6	7.2	15	5.4	1.5	1.2
Australia (n=2,107)	7.0	2.5	0.8	0.6	12	9.8	11	3.8	1.3	1.0
France (n=2,104)	7.7	0.8	1.7	1.1	10	14	9.4	9.7	2.3	2.6
Spain (n=1,615)	14	0.2	2.2	2.6	27	12	13	9.1	1.4	8.2
Italy (n=1,184)	12	1.6	1.0	2.4	23	9.6	20	6.2	1.8	15
China (n=1,169)	5.0	8.8	0.5	2.7	5.0	15	21	19	4.8	2.2

Figure 13. Subject mix of heat coverage by country (% of that country's heat articles, 2021–25; an article can raise several subjects). Countries with at least 1,200 heat articles.

In Spain 27% of heat articles raise wildfire and in Italy 23%; in India 0.5%. Italy's coverage raises tourism in 15% of articles, the United States' in 1%. India's is the most likely to raise schools (5.7%); China's the most likely to raise electricity (8.8%) and water and drought (19%). Deaths are raised in 14% of Spanish heat articles and 3.9% of British ones. Climate change is raised in 15% of coverage located in China and 14% in France, against 4.7% in India. Country here is where the story is set, as recorded for each article; articles with no recorded country (50% of the corpus, including countries below the threshold) are not shown.

9. Cross-domain: what the records say when joined

Each preceding section measures one record. This section joins them, which is what a single-source study cannot do.

9.1 Research and news describe different problems

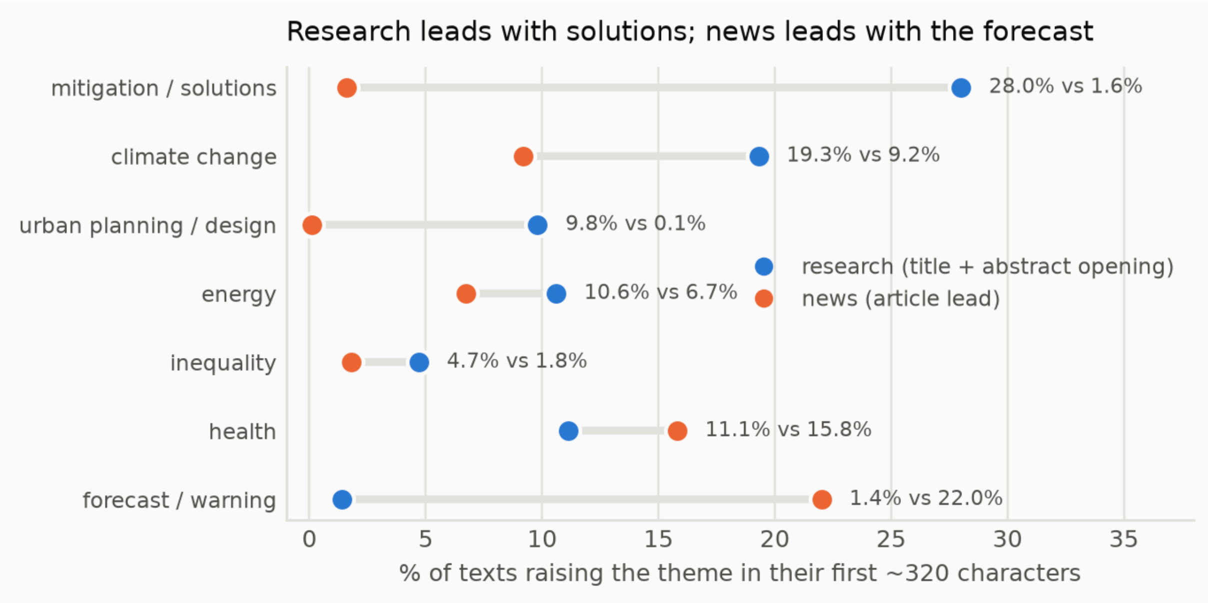

Figure 14. Share of texts raising each theme within their first ~320 characters: research is title plus abstract opening (mean 322 characters), news is the article lead (mean 316).

The comparison is made at equal length on purpose. An abstract runs to about 1,450 characters and a news lead to about 320, and a longer text has more room to mention anything; an unadjusted comparison overstated the mitigation gap at 36-fold and *reversed* the health result. At equal length, 28% of research openings raise mitigation against 1.6% of news leads, and 9.8% raise urban planning against 0.1%. News leads instead with forecasts and warnings (22% against 1.4%) and — contrary to the unadjusted figure — with health (16% against 11%). The literature is about fixing cities; the coverage is about tomorrow's temperature and its casualties.

9.2 Research and invention move at different speeds

Table 4. Research papers and patent families by mitigation technology, 2010–14 against 2020–24.

Technology	papers 2010–14	2020–24	×	patents 2010–14	2020–24	×	Pattern
green roof	159	371	2.3	288	991	3.4	invention ahead
cool / reflective roof	47	77	1.6	417	418	1.0	research ahead
cool / permeable pavement	43	104	2.4	62	720	11.6	invention ahead
radiative cooling	4	51	12.8	10	170	17.0	invention ahead

Cool and permeable pavements are the clearest case of invention outrunning science: patent families grew 12-fold while the research on them grew 2.4-fold. Cool roofs are the mirror image — papers up 1.6×, patent families roughly flat at 417 to 418 — a mature technology still being studied. Urban tree planting is left out of this comparison: patents whose titles name tree planting are overwhelmingly orchard and forestry machinery, not urban cooling.

9.3 The countries studied are not the countries covered

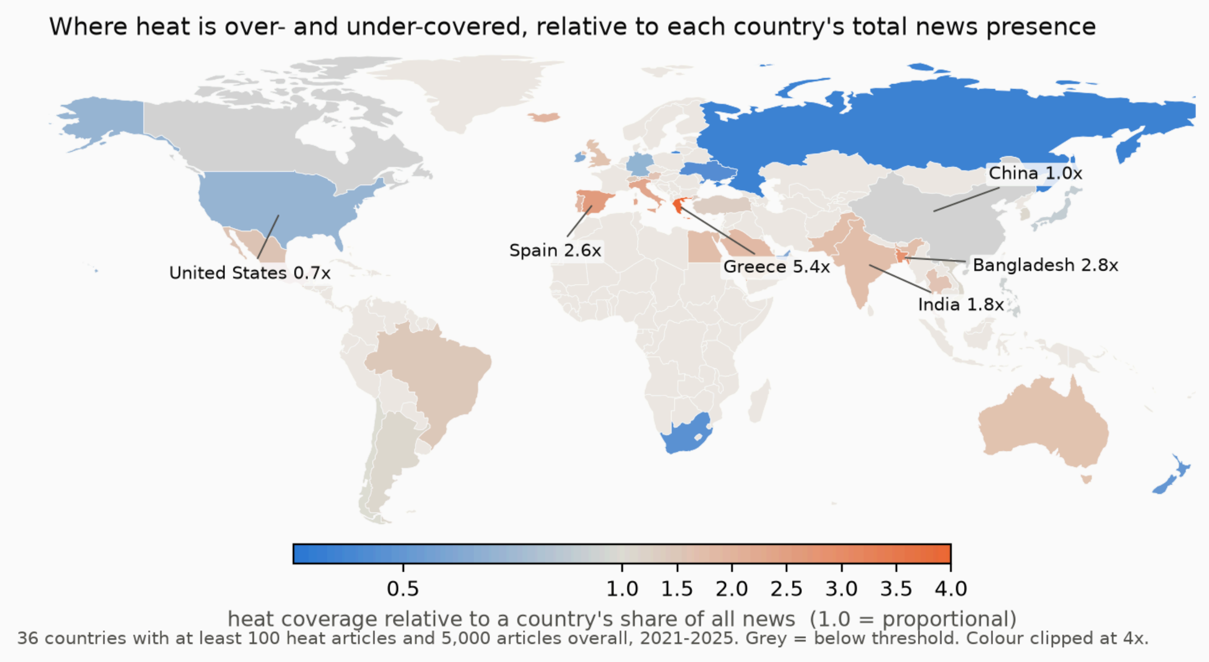

Figure 15. News coverage of heat by country as a ratio to that country's share of all news. 36 countries pass the inclusion threshold. A ratio is used because raw article counts measure the collection, not the world: by raw share the United States "leads" heat coverage, by ratio it is under-covered.

Table 5. Share of research against share of news coverage, by country.

Country	papers	% of research	heat articles	% of coverage	coverage ÷ research
China	2,484	31.1%	1,169	2.3%	0.07×
Japan	561	7.0%	484	0.9%	0.14×
Germany	374	4.7%	435	0.8%	0.18×
Nigeria	173	2.2%	88	0.2%	0.08×
Italy	493	6.2%	1,184	2.3%	0.38×
Brazil	280	3.5%	649	1.3%	0.36×
Australia	336	4.2%	2,107	4.1%	0.98×
France	165	2.1%	2,104	4.1%	2.00×
United Kingdom	385	4.8%	5,533	10.9%	2.25×
India	724	9.1%	12,481	24.5%	2.70×
United States	1,172	14.7%	20,653	40.6%	2.76×

China holds 31% of the research and 2.3% of the coverage; India 9% and 25%; the United States 15% and 41%. Both sides are English-language measures, so this compares two attention systems; it does not establish where heat is worst.

9.4 The same gap, city by city

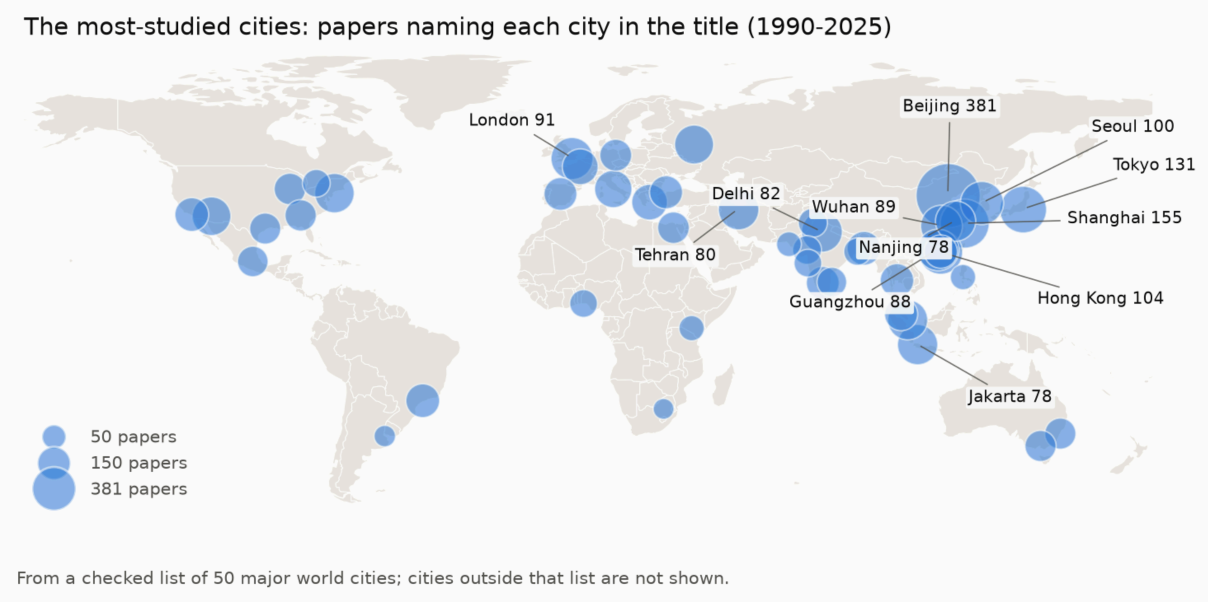

Figure 16. Cities named in the titles of urban-heat papers, from a checked list of 50 major cities, coordinates resolved against a gazetteer and spot-checked.

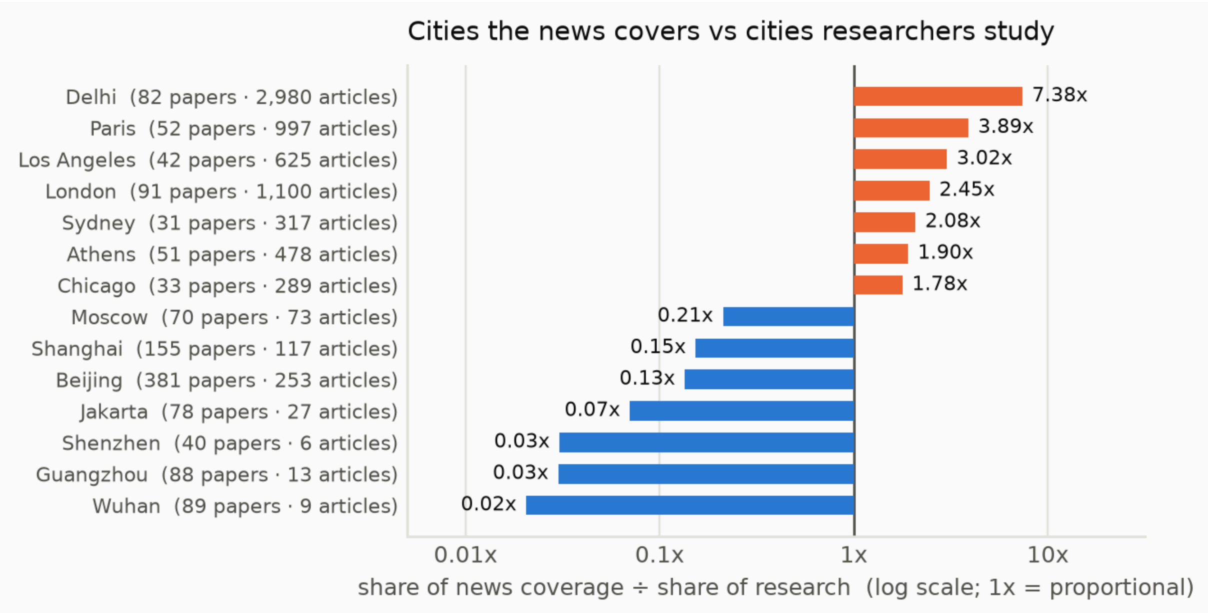

Figure 17. Share of placed heat coverage divided by share of research, for 28 cities with at least 30 papers that are present in the news gazetteer. 7 cities (Tehran, Nanjing, Sao Paulo, Bangkok, Istanbul, Kuala Lumpur, Cairo) are absent from the gazetteer and are excluded rather than shown as zero.

Delhi receives 7.4 times the news coverage its research share would predict, Paris 3.9 and London 2.5. The Chinese megacities run the other way: Beijing, the most-studied city in the world, sits at 0.14, Guangzhou at 0.03 and Wuhan at 0.02.

9.5 Recorded incidents

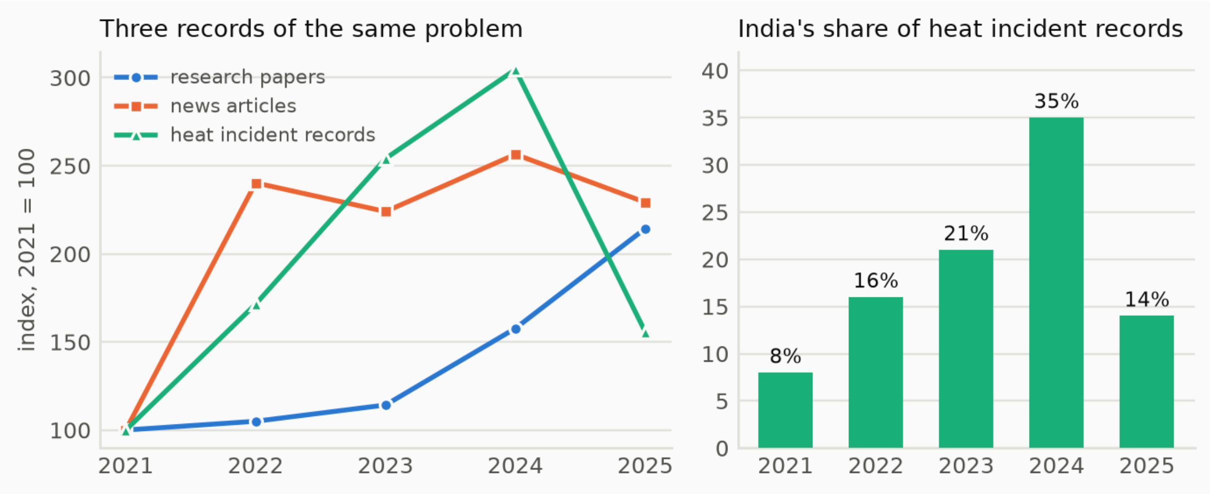

Figure 18. Left: research papers, news articles and recorded heat incidents, indexed to 2021. Right: the share of heat incident records flagged as India.

Separately from the literature, 14,576 news-derived incident records are classified under heat categories — heat wave, heat-related death, heat-related illness, heat stroke. They rose from 1,023 in 2021 to 3,116 in 2024, then fell to 1,592 in 2025. The fall is not an extraction artefact: total incident records per month are flat across 2024–2025. It is largely India. India's share of heat incident records rose from 8% in 2021 to 35% in 2024 — the year of its record pre-monsoon heat — and returned to 14% in 2025. Over the same years research output rose steadily and news volume stayed within a band of 20,635–23,626 articles: the incident record responds to events, the research record does not.

> **Casualty figures in these records must not be summed.** 5,919 records carry a death count, but the field mixes single incidents with annual estimates quoted inside an article — the largest single value is 1,480,000. Counting records is defensible; adding the deaths is not.

9.6 Public money is nearly invisible

A search of extracted government-funding events returns 252 mentioning heat, urban greening or climate adaptation, of which 99 are explicitly heat-framed and only 29 carry a usable amount. That is too thin for a spending analysis and the paper makes none. Set against 20,422 papers, 4,123 patent families and 96,726 articles, the absence is itself the finding. A search on heat vocabulary alone finds 10; most relevant programmes are worded as tree-planting, urban greening or adaptation.

10. Industry and capital

The research, patent and news records are large. The commercial record is not. This section measures how much of the world's company formation, private capital and patent ownership is organised around urban heat, using a register of 5.05 million companies, a register of 365,555 funding rounds assembled from news reports, and the patent families of §7.

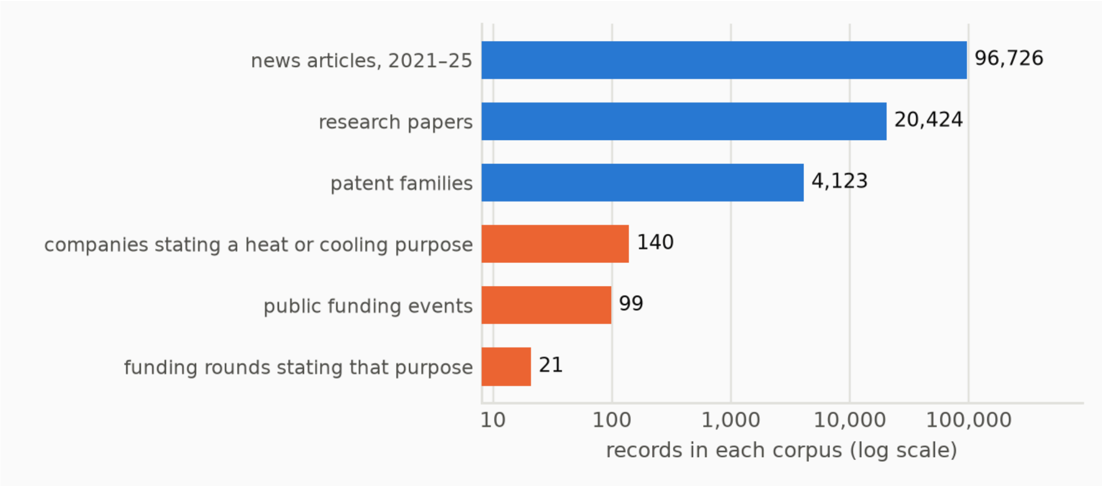

Figure 19. Attention narrows sharply on the way to the market. Records concerned with urban heat in each corpus (log scale). Blue: knowledge and attention. Orange: organisations and money. Periods differ: research 1990–2025, patents 2006–2024, news 2021–2025, companies and funding all years.

10.1 Few companies define themselves by heat

A company was counted only when its own one-line description states a heat or cooling purpose — cool roofs and reflective coatings, radiative or passive cooling, district or high-efficiency cooling, heat-risk analytics, or personal heat protection. 140 companies qualify out of 5.05 million; a further 238 work in adjacent green infrastructure (green roofs, urban forestry, permeable paving) without stating a heat purpose. The largest group by far is efficient and district cooling (95 companies, median founding year 2001). Only 5 companies describe themselves in terms of heat risk, heat resilience or the heat island, the vocabulary that organises 20,424 research papers. 34 of the 78 companies with a recorded country are in the United States and 11 in India.

Table 6. Companies whose own description states a heat or cooling purpose.

Segment	Companies	With recorded funding	Median founding year	Founded since 2015
efficient & district cooling	95	18	2001	19%
personal heat protection	21	1	2013	42%
cool surfaces (roofs, pavements, coatings)	14	1	2010	33%
cooling materials (radiative / passive)	7	4	2022	83%
heat risk, analytics & planning	5	2	2019	100%
adjacent: green roofs & living walls	158	19	2009	18%
adjacent: urban forestry & greening	66	5	2014	49%

The segments differ in age. Radiative and passive cooling is the youngest: median founding year 2022, with 4 of 7 companies funded — the highest funded share of any segment. Heat-risk analytics has a median founding year of 2019. Cool-surface and district-cooling companies are a generation older. These are small groups, and a register of company descriptions will miss firms that do this work under a general description; the counts are a floor.

10.2 The money is in pipes, not in start-ups

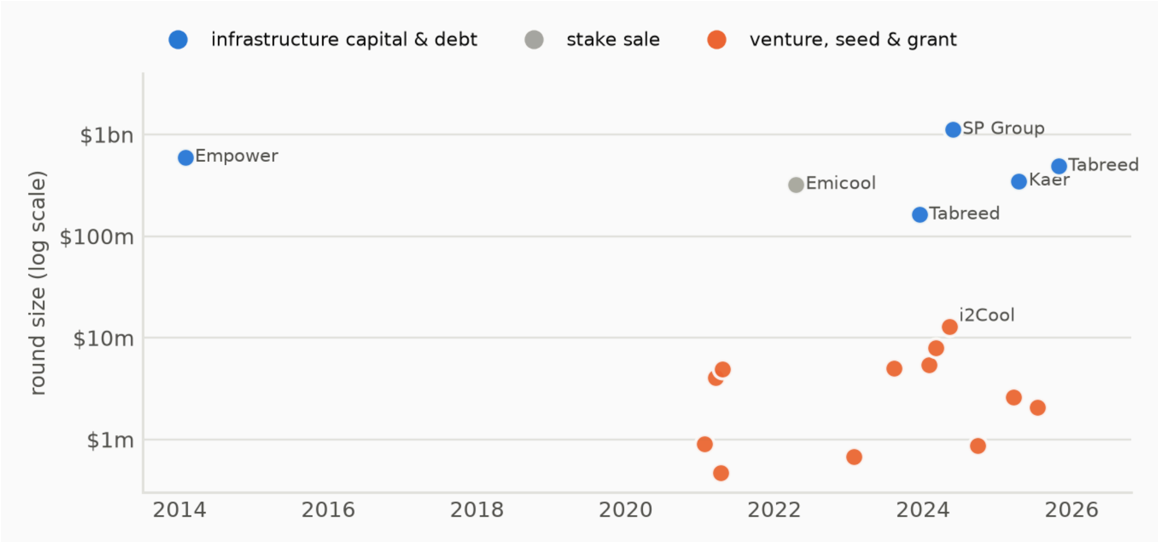

Figure 20. Every funding round whose own announcement states a heat or cooling purpose. One dot per round with a disclosed amount (log scale); duplicates of the same round removed.

Of 365,555 recorded funding rounds, 21 state a heat or cooling purpose in the announcement itself. They split into two populations that do not overlap. 5 rounds of infrastructure capital and debt — district cooling networks and cooling-as-a-service, 4 of the 5 in the Gulf and Singapore — total $2.7 billion. 15 venture, seed and grant rounds total $48 million, with a median of $4.1 million; the largest, $13 million, went to a radiative-cooling company in 2024. For every dollar of venture money recorded, about 57 went into cooling infrastructure. Capital reaches urban heat as debt for delivering more cooling, and hardly at all as equity for reducing the need for it. The register captures only rounds reported in the news, so both figures are floors; the ratio is the robust part.

10.3 Who owns the inventions

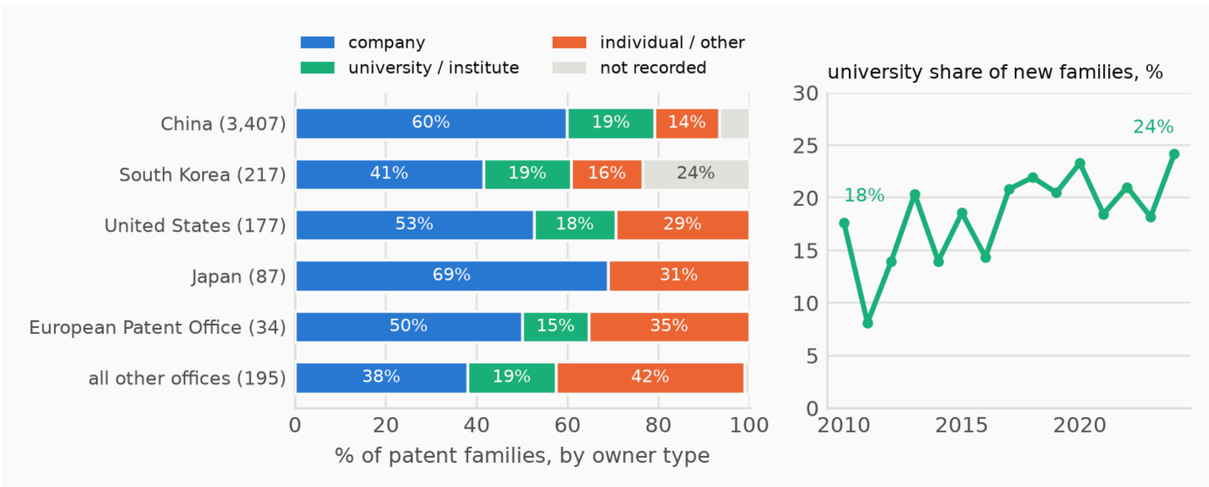

Figure 21. Ownership of heat-mitigation patent families. Left: owner type by office of first filing, 2006–2024. Right: share of new families owned by a university or research institute, by year of first publication.

Companies own 60% of the 3,407 families first filed in China, 53% of those first filed in the United States and 69% in Japan. Universities and research institutes own 19% in China and 0% in Japan. The university share of new families rose from 9% in 2006–2010 to 21% in 2020–2024: the fast growth of invention reported in §9.2 is increasingly academic patenting, which helps explain why 4,123 patent families sit beside so few operating companies. Owner type is inferred from the owner's name and is not recorded for 488 families.

10.4 The appliance market is an Indian news story

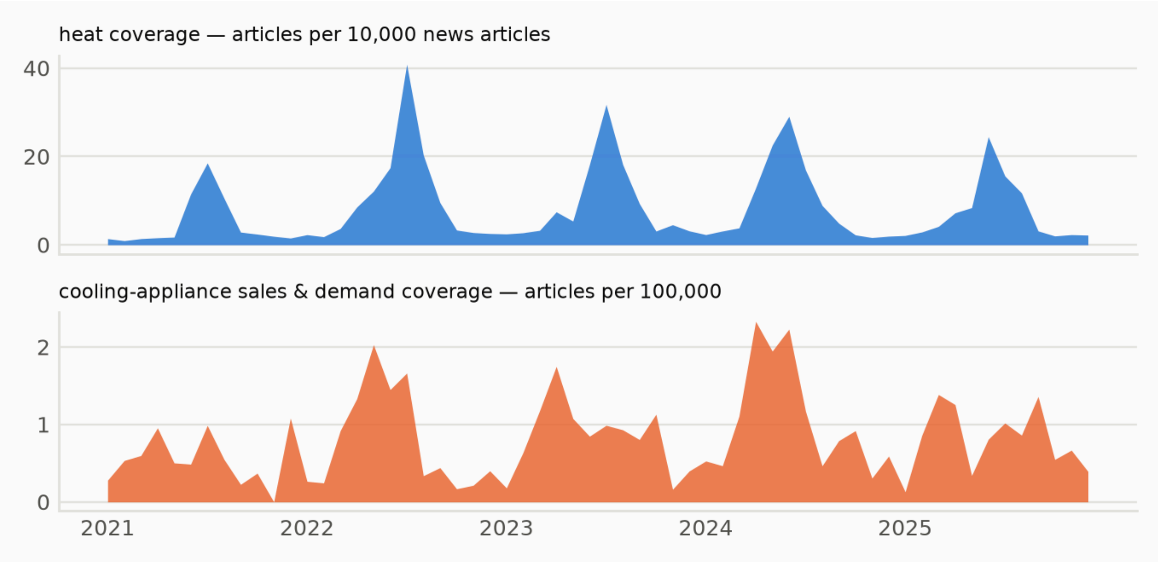

Figure 22. Heat coverage and cooling-appliance market coverage, monthly, 2021–2025, each as a rate per all news articles published that month. Separate panels, separate scales.

999 articles in five years report sales of, demand for, or shortages of air conditioners, air coolers and fans. 57% of those with a recorded country are set in India, which has 25% of country-located heat coverage; the United States follows with 27%. The rate rose from 0.54 per 100,000 articles in 2021 to 1.05 in 2024 and 0.82 in 2025. It tracks heat coverage month by month (r = 0.51; 0.49 after removing the average seasonal cycle, 60 months), but it peaks earlier: April carries 16% of a year's appliance-market coverage, while heat coverage peaks in July (25%). The market is reported ahead of the season, in the country whose season comes first.

11. Indian cooling companies: revenue and profit

If heat is changing demand, company accounts should show it. India is the test case: it has the second-largest heat news record, the largest share of recorded incidents (§9.5), and statutory filings that give revenue and profit by year for private as well as listed companies. Two sources are used: a register with growth rates for 12,175 Indian companies with revenue of at least $10 million, and a filings panel of 11,525 Indian companies with revenue in consecutive years. Indian fiscal years end on 31 March, so FY2025 contains the April–June 2024 heat season.

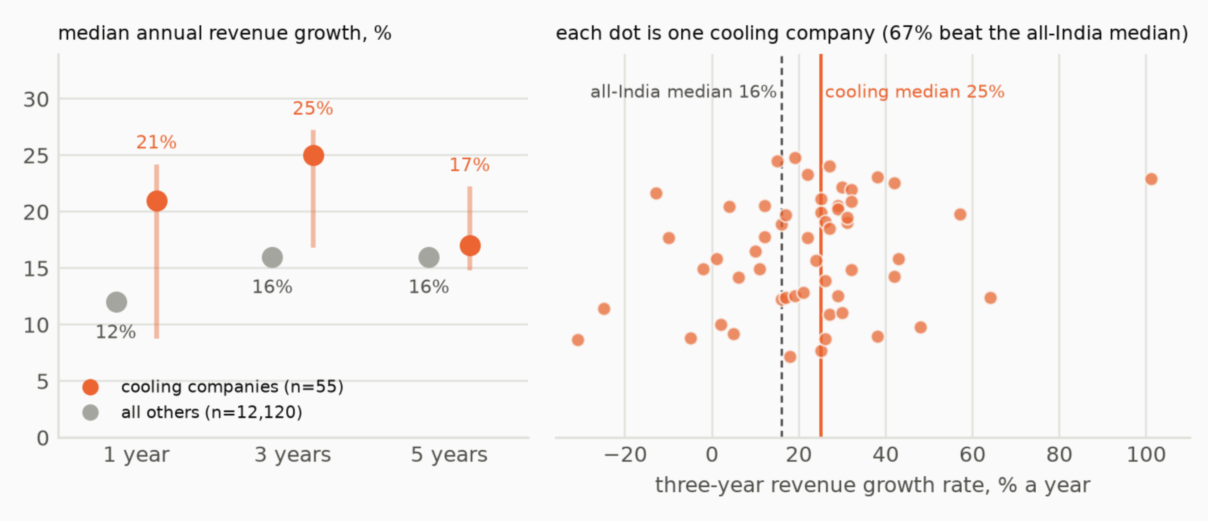

Figure 23. Larger Indian cooling companies grew faster than Indian business as a whole over three years, but not over five. Left: median annual revenue growth, companies with revenue of at least $10 million; the bar is the 95% bootstrap interval for where the cooling median would lie if there were no real difference. Right: three-year growth rate of each of the 55 cooling companies.

Larger companies. The 55 companies that describe themselves as makers or providers of air conditioning, air coolers, fans, refrigeration, chillers or cold chain grew revenue at a median 25% a year over three years, against 16% for the other 12,120 companies — a gap of 9 points (95% bootstrap interval +1 to +11; Efron, 1979). 67% of them beat the all-India median. Over five years the gap disappears (17% against 16%), which dates the acceleration to the most recent three years. Over a single year the gap is 9 points but the interval includes zero. The group includes the two largest listed room-air-conditioner makers, both of which record three-year growth of 25% a year.

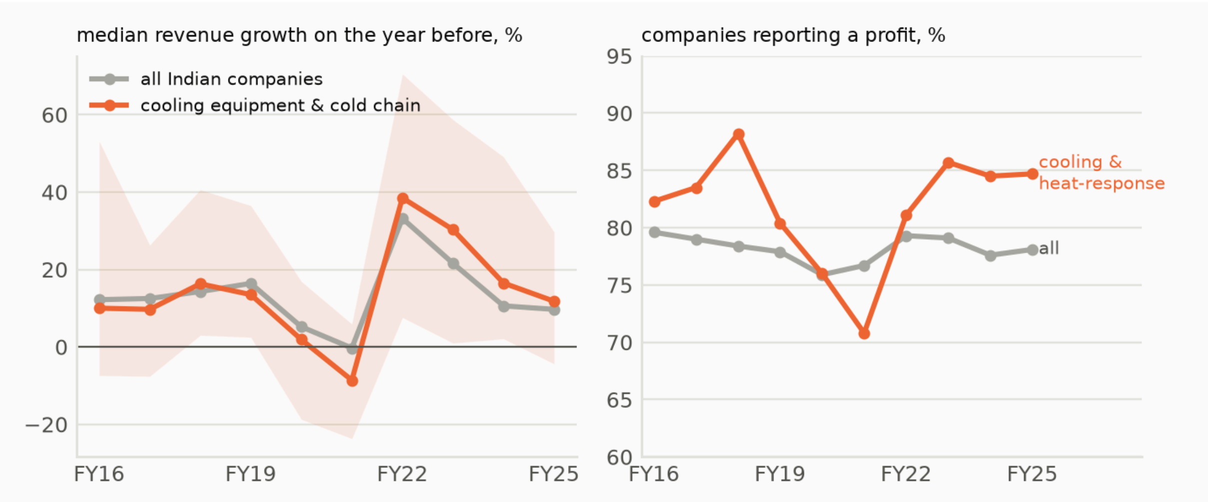

Figure 24. Smaller private companies: no growth premium, but more of them make money. Left: median revenue growth on the previous year for cooling-equipment and cold-chain companies (n = 32–40 a year; band = interquartile range) against all Indian companies in the panel. Right: share reporting a net profit, cooling and heat-response cohort (n ≈ 98) against all.

Smaller private companies. The filings panel tells a different story. Cooling-equipment and cold-chain companies grew 30% in FY2023 and 16% in FY2024 at the median, against 22% and 11% for all companies, but the groups are small and the interquartile ranges overlap almost entirely; in FY2025 the two medians are 12% and 10%. Over the whole period the typical company in the wider cooling and heat-response cohort multiplied its revenue 1.55 times between FY2019 and FY2025, *less* than the 1.85 times of the typical Indian company (8,318 companies). What distinguishes the cohort is profitability: 85% reported a profit in FY2025 against 78% of all companies, and the cohort was ahead in 9 of the 10 years measured, the exception being FY2021.

> **A note on aggregates.** Summed revenue of the 71 cohort companies present in every year rose 109% between FY2019 and FY2025, against 65% for all companies. One company accounts for 46% of that total and five for 70%. The median company, reported above, tells the opposite story. It is reported so that the contrast with the median is on record.

None of this establishes that heat caused the growth. The three-year window also contains the recovery from the pandemic, rising household incomes and a construction cycle, and no unusually hot year is compared with a cool one. What the accounts show is narrower: the growth in Indian cooling revenue has gone to larger branded manufacturers rather than to the small firms around them, and it is recent.

12. Limitations

- **Abstracts, not full texts.** A claim made only in a paper's body is invisible here. Abstract-level analysis systematically favours claims authors consider headline-worthy.
- **Agreement varies by category** (41–89%). Three cause categories failed validation and are excluded; see §1. Consequence, vulnerable-group and measurement categories have *not* yet been validated this way and should be treated as provisional.
- **Counts are a floor.** The templates missed a causal attribution in 33% of sampled abstracts where they found none.
- **News is measured on article openings** (median 308 characters). Every news share is a share of how stories *open*; subjects raised only later in an article are not counted. Research–news comparisons are made at equal length for this reason.
- **The news gazetteer is incomplete.** 7 of 35 major research cities are absent from it and are excluded from city comparisons rather than reported as zero.
- **News subjects are keyword rules** applied to article openings. All eighteen were tested against an independent second reader (§8.7); sixteen reach 70% agreement or better and two do not, and no result rests on the two that failed. Rise-and-fall results are reported only where at least three of four country groups agree; five years is a short series and single events move it.
- **Company, funding and accounts records are floors.** A company is counted only if its one-line description states a heat or cooling purpose; a funding round only if it was reported in the news and its announcement states that purpose. The Indian accounts analysis is descriptive: it compares cooling companies with all companies and does not isolate the effect of heat from income growth, construction or the post-pandemic recovery.
- **English-language bias** in both the corpus and the news comparison.
- **Region is inferred** from place names in the text, not from author affiliation or study design.
- **Counts reflect collection.** Bibliographic and news coverage both vary by year and source; every trend here is reported as a within-period share or normalised against total literature growth for that reason.
- **No causal claim is made about the phenomenon itself.** This paper measures what the literature asserts, not what is true of cities.

13. Data availability

The Urban Heat Research Corpus (UHRC) v1.0 accompanies this paper: a paper-level table (20,422 rows, 30 variables), 3,175 causal attributions, 1,537 consequence assertions, 424 vulnerable-group mentions and 540 extracted numeric measurements, each linked to its source paper by persistent identifier. Sentence text is not redistributed; each claim carries a character offset and a hash so it can be verified against the source abstract. Released CC-BY 4.0.

The deposit also contains the codebook, the validation results for every extracted category, and ten supplementary tables behind §8.6 to §11, an article-level news table (one row per heat article, with date, place, tone, themes and every subject, framing and term flag used in §8 and §9, but no article text) and a patent-family table: news subjects by year, subject mix by country, tone by year, monthly series, company segments, funding rounds, patent ownership by office and by year, and Indian company accounts by fiscal year. The dataset is deposited at https://doi.org/10.57967/hf/10505.

14. Declarations

Competing interests. The author works for Fliar BI, which maintains the Prism index from which all records in this paper are drawn. **Funding.** This work received no external funding. **Peer review.** This preprint has not been peer reviewed.

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All figures computed from the corpus described in §1. Percentages are within-period or within-stratum shares.