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EC PULMONOLOGY AND RESPIRATORY MEDICINE

Review Article

The Respiratory Cost of "Making Charges": Occupational Lung Disease and Health Economics in the Indian Jewellery Sector

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Received: October 22, 2026; **Published:** November 12, 2026

Abstract

An Indian jewellery price is the value of its gold plus a making charge, and only the making charge pays for manufacture. This review argues that occupational health and safety (OHS) controls in unorganised workshops are cheap but go unbought, because no one who decides on them pays for the disease. Karigars (artisans), their households and the public health system pay instead. A karigar earns about 1.3% of the gold processed. This is about a fifth of the lowest retail making charge of 6% of gold value, so the margin at the bench is thin. Cadmium-exposed Indian goldsmiths show a dose-dependent loss of lung function, and silicosis raises tuberculosis risk and, in India, predicts drug resistance. The only Indian jewellery silicosis series concerns imitation-jewellery polishers. Wages are unlikely to price the risk, and compensation follows diagnosis. At 2024-25 prices a Khambhat-type dust collector costs under 1% of the lowest retail making charge and about 3% of a karigar's earnings so the barrier is who bears the cost rather than affordability. No study has tested this against measured exposure, and we propose a field test.

Keywords: *Silicosis; Cadmium; Jewellery Manufacturing; Informal Sector; Occupational Health Economics; Cost Externalisation; India*

Introduction

The making charge as a price signal

An Indian jewellery price has two parts. The first is the gold value, which is set by bullion prices. The second is the making charge, quoted as a percentage of gold value or as rupees per gram and usually between 6% and 25% of the gold value [1]. Jewellers interviewed by Narayanan and Baghel reported making charges of Rs 400 to 500 per gram for machine-made bangles and Rs 800 to 1,500 per gram for handmade work [1]. The author's Zaveri Rate Engine compares retail prices across sellers and separates the two components. The making charge, including any wastage allowance, is the only part of the price from which labour, workspace and safety can be paid.

Thesis

This review argues that dust control is cheap but goes unbought, because no one who decides whether to buy it bears the cost of the disease. First, the margin at the bench is thin. A karigar earns about 1.3% of the gold processed [2], and the lowest retail making charge is 6% of gold value [1]. Both are shares of gold value, so the karigar's labour receives about a fifth of the cheapest making charge. This is the karigar's pay and not the whole workshop's receipts, which are not published. Industry testimony also reports retailers booking an 18% wastage charge on outsourced job work while paying artisans 2.5 to 6% [3], although booked wastage may be inflated for gold-stock accounting. Second, pay rewards keeping dust in the room. Karigars are paid from gold wastage, workshops switch off fans to keep gold

dust in the room, and a single workshop sells its escaping dust to an agency for a new mat and Rs 500 to 700 a year [2]. Third, the cost of disease falls outside the decision. Lung disease appears years after exposure, and the authors of an Indian cost-benefit study attributed non-adoption of an Rs 8,000 dust collector to public payment for treatment [4]. No study has measured exposure against these incentives, so the claim is an inference, and Section VIII proposes a test.

Scope and Method

This is a structured narrative review. We searched PubMed, Europe PMC, Crossref and OpenAlex and ran targeted web searches for government, court and industry documents. About 1,050 records were screened by title, 200 were assessed in detail and 60 were included. One reviewer screened and extracted the evidence without formal quality appraisal or PRISMA reporting. The sector employs an estimated 4.3 to 6.1 million workers [3,5]. We found no Indian measurement of airborne silica in jewellery workshops and no Indian silicosis study of gold workshops [6]. The review therefore also draws on foreign jewellery studies and on India's gem-cutting trades.

Heritage and the production system of the karigar

From caste craft to migrant labour

Goldsmithing in India was a hereditary caste occupation. The Gold Control Act of 1968 restricted the trade, and its repeal in 1990 coincided with rising demand that expanded informal manufacture [7]. Kanungo and Chakrabarti traced a new workforce recruited from West Medinipur in West Bengal after the 1978 floods. Most of the Bengali goldsmiths they interviewed (68.33%) were Mahisya small landholders with experience of bell metal and copper work. About 70% of artisans learned through apprenticeship to a master craftsman, and Bengali goldsmiths now dominate workshops in Kolkata, Kanpur, Delhi and Mumbai [7]. Recruitment through kin networks and payment through head karigars leave most workers without an employer of record.

The workshop as workplace and dwelling

Varkkey and Jha interviewed 123 karigars in eight cities in 2020 and 2021 [2]. Five to six karigars typically share a 20 by 12 foot room, work about 14 hours a day on average and more than 16 hours in peak season and often cook and sleep at the workstation. A larger survey of 552 gold units recorded working days of about 9.5 hours in manufacturing [5]. Basic ventilation was absent from most workshops that Varkkey and Jha visited. Most workshops avoided using fans "mainly because of avoiding gold dust loss," and the authors name the "cost sensitivity of karigars" as a major reason for "small, dingy, and suffocated workshops" [2]. Among the 552 units, 71% provided no social security and more than 88% gave no Employees' State Insurance cover [5].

Pay tied to gold wastage

Karigars are paid on a "gold wastage plus making charges" basis [2]. Head karigars receive an allowance for gold lost in manufacture, typically 2 to 3% for plain jewellery, and a karigar's performance is judged by how much of that allowance he saves [2]. This pay system rewards keeping gold dust inside the room, and fans, breaks and cleaning all cost the karigar metal or time. A review of 31 studies found that 27 reported harmful effects of piece rates on health and safety [8]. Chain stores with high making charges also source from informal karigars, and most principal manufacturers in the outright outsourcing model do not audit their vendors' working conditions [2]. A high retail making charge therefore does not guarantee better conditions at the bench. Narayanan and Baghel concluded that discounting on making charges keeps karigars from "their fair share of remuneration" [1].

Respiratory hazards along the production chain

Cadmium and metal fumes

The strongest Indian evidence concerns cadmium, which enters the workshop through cadmium-bearing solder and adulterated silver. Moitra., *et al*. compared 133 workers in Indian jewellery workshops with 54 sales staff [9]. Exposed workers had ten times the urinary

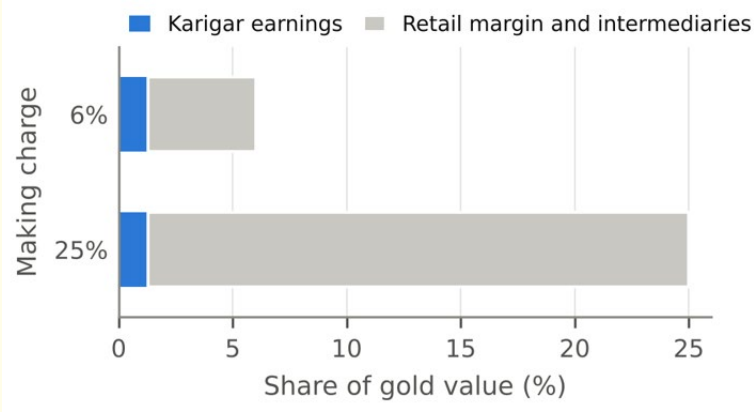


Figure 1

cadmium of referents, 75% reported respiratory symptoms against 33% of referents (OR 3.1 from logistic regression), and FVC and FEV1 were each more than 600 ml lower. Each 1 µg/dl rise in urinary cadmium was associated with a 39 ml lower FEV1 after adjustment for smoking and airborne oxidants [9]. A second study by the same group found sputum neutrophilia and DNA damage in 69% of lung cells from exposed goldsmiths against 14% in referents [10]. Among 118 unorganised-sector goldsmiths, lung function was lower with longer exposure [11]. All three studies are cross-sectional. A 25-year-old silversmith developed acute respiratory distress syndrome after 15 minutes of fume from silver he believed was heavily adulterated with cadmium [12]. Brazilian home-based jewellery workers who soldered had five times the urinary cadmium of non-workers, and every solder powder sample exceeded national limits [13].

Crystalline silica in casting and polishing

Lost-wax casting uses a gypsum-bonded investment that is mostly crystalline silica. Italian investigators found 60 to 80% crystalline silica in an investment powder that users treated as plaster [14], and NIOSH measured 25% quartz and 14.8% cristobalite in investment at an American studio that melted metal without local exhaust [15]. Among 100 Italian goldsmiths exposed to casting moulds, high-resolution CT showed silicosis in 23, and plain radiographs confirmed only 10 of these [16]. The only Indian clinical series comes from West Bengal. Six of eight jewellery polishers developed silicosis within five years of exposure, against ten years or more for most other patients, and all eight died during follow-up [17]. The same group describes them as imitation-jewellery polishers from Burdwan who were 21 years old on average and had worked in Mumbai polishing units [18]. The series is small, lacks exposure data and concerns base-metal polishing. The silica content of polishing materials in Indian gold workshops has not been measured.

Acid fumes and mercury

One karigar reported that “use of nitric and phosphoric acid creates breathing problem in long run” [2]. Nitric acid fumes can cause pulmonary oedema hours after exposure, which obscures the link to work [19]. Gold recovery can add mercury. A single study of cottage units that recover gold by amalgamation reported raised air and blood mercury in workers [20]. It gives no sample size and no sampling method, so its figures are not used here.

Gem cutting as the adjacent evidence base

Agate bead and ornament workers in Khambhat, Gujarat, work in home-based units without occupational health services or compensation [21]. Among 123 suspected cases at a Khambhat clinic, 69.1% had radiological silicosis, and each additional year of exposure raised the odds by about 12% [22]. Cobalt exposure in Belgian diamond polishing was associated with lower lung function below the occupational limit [23].

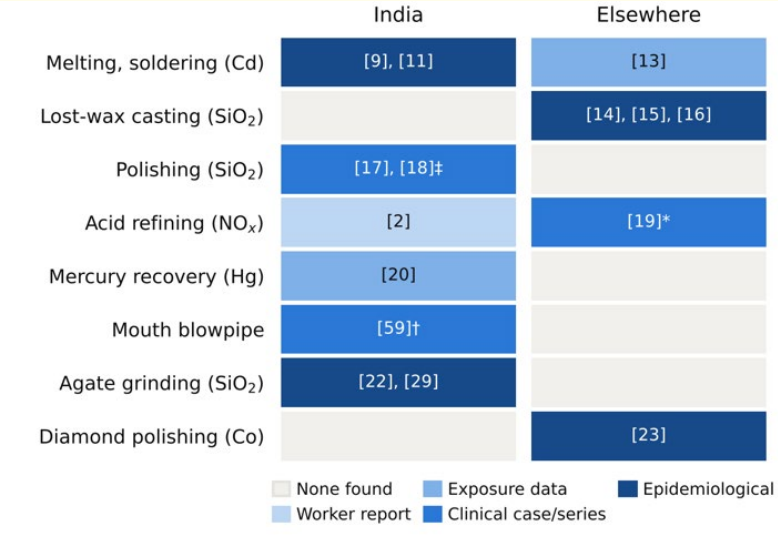


Figure 2: *Strongest published evidence type by process and setting.*

From exposure to pulmonary disease

Silicosis

Silicosis is a fibrotic lung disease with no curative treatment, and lung function continues to decline after exposure ends [24]. Among 52 Californian engineered-stone fabricators with silicosis, 51 were immigrant men, 38% had progressive massive fibrosis at diagnosis and 19% died at a median age of 46 years [25].

Silicotuberculosis

In a South African cohort, radiological silicosis carried a tuberculosis rate ratio of 3.96, and among miners without radiological silicosis, risk still rose with cumulative dust exposure [26]. India has the highest tuberculosis burden in the world [27], and silicotuberculosis there is often missed [28]. In linked Khambhat records, silicosis was associated with 2.5 times the odds of drug-resistant tuberculosis and four times the odds of retreatment [27]. Fifty-eight percent of tested agate workers had latent tuberculosis infection, nearly double the general population [29].

Chronic airway disease

Workplace exposures account for 14% of COPD and 16% of asthma in pooled estimates [30]. India carried 32.0% of global chronic respiratory disease DALYs in 2016, and occupational risks accounted for 16.5% of its COPD DALYs [31]. Occupational particulate matter, gases and fumes caused 450,381 COPD deaths worldwide in 2016 [32].

Invisibility through misdiagnosis

A 2025 scoping review pooled 11 Indian silicosis prevalence studies at 25.98%, and its only jewellery study was the eight-patient series of imitation-jewellery polishers [6]. Informal contractual employment insulates employers from legislative provisions, and symptomatic workers keep working [33]. Californian cases were most often first labelled pneumonia or tuberculosis [25]. The WHO/ILO estimates count silica only as a cause of lung cancer [32]. Recorded case counts are therefore a floor.

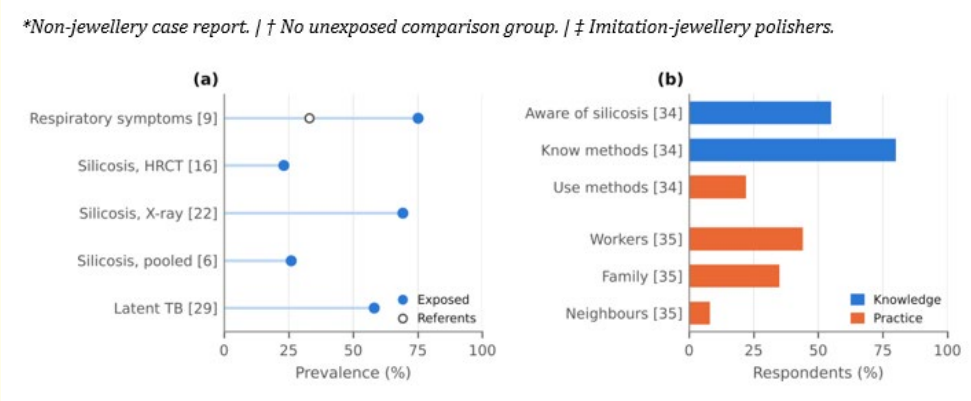


Figure 3: *(a) Outcomes reported in jewellery and gem workers; rows differ in measure and population and are not comparable. (b) Knowledge and use of prevention among Khambhat agate workers [34] and residents [35].*

Health economics: Who pays for the karigar's lungs

Why wages do not price the risk

Compensating wage differential theory predicts that workers accept risk only for higher pay, which would build the hazard into labour costs and the making charge [36]. Two features weaken this mechanism for karigars. Indian risk-premium estimates come from registered factories [37] and from urban surveys that value fatal and injury risk rather than chronic disease [38]. Many non-managerial gold workers earn below the minimum wage [5], and the karigars interviewed by Varkkey and Jha earned Rs 15,000 to 20,000 a month, about the minimum wages of Delhi and West Bengal [2]. Verhaest and Adriaenssens found larger hazard premiums in informal than in formal jobs, which is evidence against this argument [39]. Their premiums concern conditions that workers can observe, while silicosis and cadmium lung disease appear years after hire. We infer that long-latency risk is less likely to be priced, and no study has tested this.

Cost-shifting to households and the public system

Dorman identified the conditions under which firms shift occupational disease costs to society [40]. Competitive markets and small enterprises, a large reserve of under-employed labour and public programmes that absorb disease costs all increase externalisation. The jewellery workshop meets the first two conditions fully and the third through India's free tuberculosis programme and state compensation funds. Even in the United States, workers' compensation missed 46,000 to 93,000 occupational disease deaths in 1999 [41]. Informal employment, which rarely carries employer-funded insurance, was 88.2% of Indian employment in 2012 [42], and households paid 43.41% of total and 49.90% of current health expenditure in 2022-23 [43]. Tuberculosis care produced catastrophic expenditure for 18% of hospitalised households in 2017-18 despite free treatment [44].

Compensation as delayed and partial payment

Rajasthan's Pneumoconiosis Policy pays Rs 3 lakh on certification and Rs 2 lakh on death, plus pensions [45]. By January 2026 it had certified 6,513 people and paid Rs 696 crore in relief to 9,460 beneficiaries, including death cases from earlier portals [45]. Implementation loses workers to misdiagnosis, migration and delay [46]. The Supreme Court case on silicosis took 18 years to close and ended by transferring compensation monitoring to the National Human Rights Commission [47]. Compensation is paid after disease and mainly to mine workers. Rajasthan finances it partly from District Mineral Foundation Trusts and a construction welfare fund [45], which draw on the industries that cause exposure. No equivalent mechanism exists for jewellery manufacture.

The regulatory gap

Worker-count thresholds

The Factories Act, 1948 covered premises with ten or more workers using power [48]. The Occupational Safety, Health and Working Conditions Code, 2020 took effect on 21 November 2025 [49] and doubled this threshold to twenty [50]. Most jewellery units employ two to four workers [3,51] so they fall below the factory definition under either law.

Exposure limits

The silica limit in the Factories Act was a 1987 formula, 10 mg/m3 divided by the percentage of respirable quartz plus 2 [48]. The OSH Code contains no statutory limit and leaves exposure limits to state rules [50].

Hallmarking and process conditions

Mandatory hallmarking shows that the state can trace jewellery to its seller. By December 2025 more than 56 crore pieces carried a unique hallmark code and more than 2.08 lakh jewellers were registered [52]. The scheme verifies the purity of the gold and sets no condition on the workshop where it was worked.

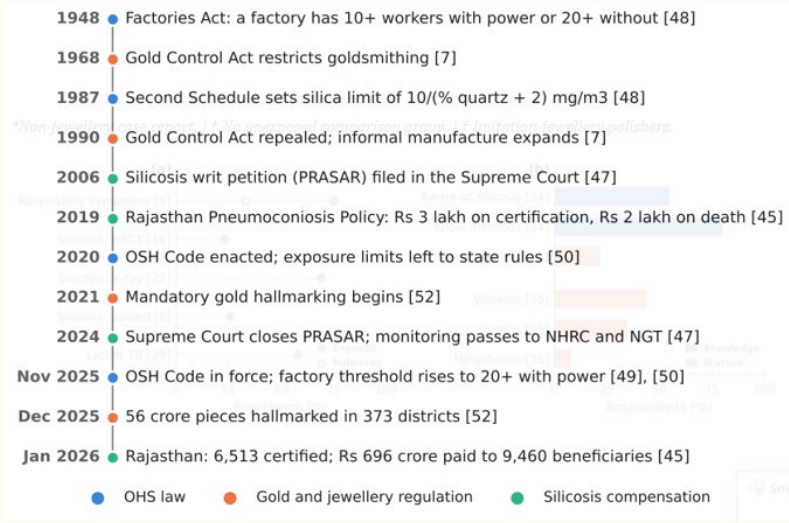


Figure 4: *Timeline of jewellery-sector and occupational health regulation in India, 1948 to 2026.*

Pricing the control

Engineering controls are cost-effective

In Khambhat, a hood, duct, 0.5 HP motor and bag filter cut dust exposure by 93% at Rs 8,000 per grinding machine [4]. Bhagia and Sadhu estimated net savings of Rs 11.5 million in the first year across 500 machines. They wrote that owners and workers did not wish to invest because "the cost of diagnosis and treatment is borne mostly by government hospitals and institutes" [4]. Their estimate rests on simple assumptions and is indicative. Lahiri., *et al*. modelled silicosis interventions for North America and a Western Pacific subregion that includes China, and engineering controls were the most cost-effective, at about $106 to $109 per DALY averted, while dust masks had very limited efficacy [53]. India was not modelled, so applying the result here is an extrapolation. The NITI Aayog-commissioned study nonetheless recommends masks and safety kits for gold workers [5].

Captured dust is recoverable gold

Polishing dusts and sweeps contain 0.5 to 5% gold by weight, and extraction systems and fans are recognised sources of lost metal that filters can capture [54]. Gold in polishing dust can be recovered at 99.97% by direct melting [55]. Indian workshops capture little of this value. Karigars collect coarse dust at the bench and are paid on it, and agencies collect the fine dust on floor mats and clothing for a new mat, work clothes and Rs 500 to 700 a year [2]. That price probably reflects the small volume and weak bargaining position of one workshop. The gold content of the dust has not been measured. A jewellery park at Ankurhati in Howrah pools dust, sells it to a refinery and provides air-conditioned workshops [2]. Recovery is more likely to pay at cluster scale. In Khambhat the collected agate dust, which is reused as an abrasive, offset only the extra electricity [4].

The control cost per gram

A karigar processes 300 to 400 grams of gold a month [2]. One Khambhat-type device per karigar would cost Rs 3,800 a year at 2006 prices for depreciation, filters and electricity [4]. Consumer prices for industrial workers rose 3.1 to 3.3 times between 2006-08 and 2024-25 [56], so the device now costs about Rs 11,800 to 12,500 a year, or Rs 2.5 to 3.5 per gram over 3,600 to 4,800 grams. This is 0.6 to 0.9% of the lowest retail making charge of Rs 400 per gram [1]. Karigar pay is set in grams of gold, so it tracks the gold price. At the 2024-25 Mumbai price of Rs 7,584 per gram [57], 1.3% of the gold processed is about Rs 99 per gram, and the device costs about 3% of the karigar's earnings. The same conversion at 2020-21 prices gives Rs 19,000 to 25,300 a month, which brackets the reported mean of Rs 19,563 [2]. The control is affordable on both measures. The upfront price of about Rs 25,000 is close to a month's earnings for a worker without credit, but the larger barrier is incidence. The karigar does not price a disease that appears years later (Section V-A), the public system pays for treatment (Section V-B), and an unfiltered fan loses gold (Section II-C). The estimate uses an agate grinding device that does not control melting or acid fume, and a consumer price index in place of a supplier quotation, so it is illustrative.

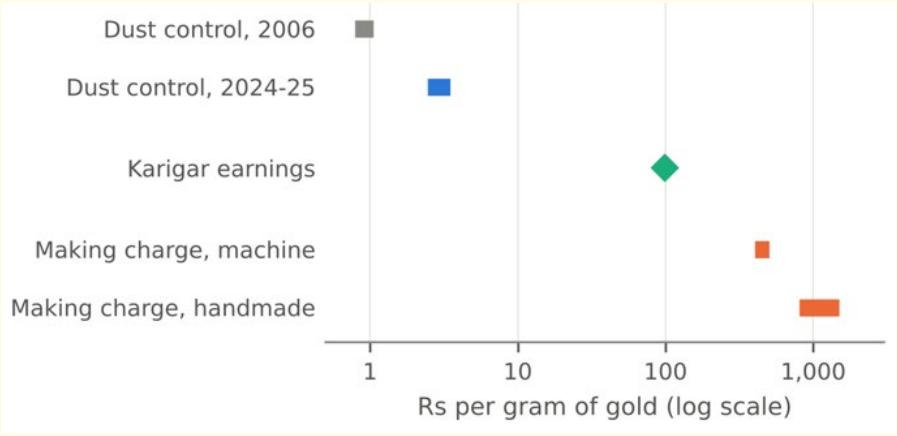


Figure 5: *Illustrative cost per gram of a Khambhat-type dust collector at 2006 and 2024-25 prices [4], [56], against karigar earnings [2], [57] and retail making charges [1].*

Substitution and participatory improvement

The European Union banned cadmium at or above 0.01% in brazing fillers and jewellery metal from January 2012 [58]. A comparable rule on solder sold in India would remove one cadmium source without workshop inspection, although it would not address adulterated silver [12]. Supplier labelling of silica investment is a similar lever [14]. Karnataka goldsmiths accepted a hand-operated air pipe in place of the mouth blowpipe [59], and participatory programmes have delivered low-cost improvements in Asian small enterprises [60]. Knowledge alone does not change practice. In Khambhat 80% of agate workers knew simple preventive methods but only 22% used them [34].

Research Agenda and Conclusion

Testing the cost-incidence hypothesis

No study has linked the incidence of disease costs to workshop exposure. Alternative explanations for unventilated workshops include the security of gold stock [2], low schooling [34] and the belief that prevention does not work [35]. The hypothesis predicts that controls appear where the party choosing equipment also bears disease or gold-loss costs, as in cluster parks or audited supply chains, and that ventilation varies little with the workshop's margin. A field study would recruit workshops across clusters, record the job-work rate, wastage allowance and buyer for each, and measure respirable silica, cadmium and nitrogen dioxide at the bench. India also needs a silicosis prevalence study of gold workshops using CT [16,6] and measurement of the silica content of polishing compounds.

Policy implications

Three measures follow. First, notifying jewellery melting, casting, polishing and acid refining as hazardous activities brings small units under the OSH Code regardless of worker numbers [50], and karigars over 40 would then qualify for the free annual health check-up [49]. Notification reaches units with an employer, so outworkers also need a rule that makes the principal manufacturer or retailer liable for conditions in the workshops it uses. Second, Rajasthan's use of mining and construction funds [45] is a model for a levy on jewellery manufacture, and hallmark registration [52] lists the sellers who would collect it. Third, the levy should be earmarked and spent through cluster parks such as Ankurhati [2], which can maintain extraction and pool dust for refining, because money paid into general revenue would not reach the bench. Each measure moves the cost of protecting the karigar's lungs into the price.

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Volume 15 Issue 12 December 2026
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