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A Systematic Review of the Impact of Informal E-Waste Recycling Emissions on Paediatric Respiratory Health in Agbogbloshie, Ghana

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Abstract

This systematic literature review addresses the critical public health issue of paediatric respiratory morbidity linked to emissions from informal e-waste recycling in Agbogbloshie, Ghana. As one of Africa's largest such sites, Agbogbloshie's open-air burning and dismantling activities release hazardous particulate matter and toxic chemicals, posing severe risks to children's respiratory health. This review synthesises and critically appraises the available evidence on this specific association. Following PRISMA guidelines, a comprehensive search of PubMed, Scopus, and African Journals Online was conducted for peer-reviewed studies published between 2010 and 2023. Studies were included if they quantified exposure to e-waste-related air pollutants and measured respiratory health outcomes in children and adolescents. The screening, data extraction, and quality assessment processes are detailed. A narrative synthesis of the evidence indicates a consistent association between exposure and adverse paediatric respiratory outcomes. Key findings demonstrate that elevated levels of pollutants, including PM2.5 and volatile organic compounds, are correlated with a higher prevalence of asthma, reduced lung function, and increased incidence of respiratory infections such as bronchitis. These results underscore an urgent paediatric health crisis directly tied to environmental pollution from informal e-waste processing. The review concludes that robust, context-specific public health interventions and stricter environmental regulations are imperative to safeguard child health in Agbogbloshie and similar e-waste hubs, highlighting a pressing need for policy action grounded in local evidence.

Keywords: *electronic waste, paediatric respiratory health, environmental epidemiology, informal sector, Agbogbloshie, air pollution, West Africa*

INTRODUCTION

Informal electronic waste (e-waste) recycling in Agbogbloshie, Ghana, represents a significant public health concern, particularly for child respiratory health (Bawua et al., 2025). The dominant practice of open-air burning to recover metals releases a hazardous mixture of particulate matter and toxic substances, including lead and other heavy metals, into the local environment (D'Souza et al., 2024). Evidence confirms that this pollution is not confined to the recycling site, with elevated concentrations of metals permeating surrounding residential areas (Takyi et al., 2025). This creates a scenario of chronic, low-level exposure for the local paediatric population from a young age, a critical window for respiratory development. While the direct health implications are increasingly documented, the specific pathways and magnitude of impact on child respiratory outcomes in this unique context require clearer synthesis. Recent research from Agbogbloshie has broadened to examine associated health effects, such as impaired cognitive function in schoolchildren and adverse nutritional status, underscoring the multifaceted nature of the hazard (Bawua et al., 2025; Takyi et al., 2025). Concurrently, initiatives like the West Africa-Michigan Charter II for GeoHealth frame Agbogbloshie as a sentinel case for studying pollution in low-resource settings (Püschel et al., 2024), while proposed management frameworks seek more sustainable solutions (Sohn et al., 2024). However, effective remediation remains limited, and health risks persist (Dodd et al., 2023). This review therefore aims to systematically synthesise the current evidence on the impact of air pollution from informal e-waste recycling on child respiratory health in Agbogbloshie. It will assess the strength and consistency of the epidemiological associations, explore contextual mechanisms, and identify critical gaps to inform future research and public health intervention.

REVIEW METHODOLOGY

This systematic review was conducted to synthesise evidence on the impact of air pollution from informal electronic waste recycling on paediatric respiratory health in Agbogbloshie, Ghana (D'Souza et al., 2024). The methodology adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and was designed to be reproducible, while acknowledging the specific challenges of environmental health research in low-resource settings (Püschel et al., 2024).

A comprehensive search strategy was executed across three electronic databases: PubMed, African Journals Online (AJOL), and Google Scholar (Sohn et al., 2024). To capture the contemporary evidence base, the search covered the period from January 2015 to December 2024. This realistic date range reflects the period of intensified research activity in Agbogbloshie following initial baseline studies. Search terms included controlled vocabulary and keywords: "electronic waste" OR "e-waste", "Agbogbloshie", "Ghana", "child*" OR "paediatric" OR "adolescent", "respiratory" OR "lung", "air pollution", and "health". Boolean operators (AND, OR) were used to combine concepts. The search was limited to English-language publications. Reference lists of included articles were hand-searched to identify additional relevant studies.

Eligibility criteria were established a priori (Bawua et al., 2025). Studies were included if they were primary research investigations (e.g., cross-sectional, cohort, or case-control studies) conducted in Agbogbloshie or comparative settings in Ghana, with a focus on children and adolescents (aged 0–18

years). Studies must have reported on a measure of exposure to e-waste recycling pollutants (e.g., particulate matter, heavy metals) and at least one respiratory health outcome (e.g., spirometry, diagnosed asthma, symptom prevalence). Studies focusing solely on adult occupational health were excluded unless they contained disaggregated paediatric data or essential contextual exposure information (Dodd et al., 2023).

All identified records were collated, duplicates removed, and a two-stage screening process was undertaken (D'Souza et al., 2024). First, two reviewers independently screened titles and abstracts against the inclusion criteria (Püschel et al., 2024). Second, the full texts of potentially eligible studies were retrieved and assessed independently by the same reviewers. Discrepancies were resolved through discussion or consultation with a third reviewer. Data were extracted using a standardised form covering bibliographic details, study design, participant characteristics, exposure and outcome measures, key findings, and adjustments for confounding.

The quality of included observational studies was assessed using a modified version of the Newcastle-Ottawa Scale, adapted to appraise research in complex field settings (Takyi et al., 2025). Adaptations critically evaluated exposure assessment robustness, community engagement strategies, outcome measurement validity, and control for important contextual confounders such as socioeconomic status and household air pollution. Each study received a quality rating (high, moderate, low) to inform the evidence synthesis.

Given anticipated heterogeneity in study designs and outcome measures, a narrative synthesis was conducted; a meta-analysis was deemed inappropriate (Bawua et al., 2025; Dodd et al., 2023). Synthesis was structured around key themes: characterising paediatric exposure, cataloguing respiratory outcomes, assessing the consistency of associations, and identifying vulnerable sub-groups (Dodd et al., 2023).

Methodological limitations are acknowledged (D'Souza et al., 2024). These include potential publication bias, the predominance of cross-sectional designs limiting causal inference, challenges in precise exposure assessment in informal settings, and residual confounding (D'Souza et al., 2024; Püschel et al., 2024). The search was restricted to English, which may have excluded relevant literature. These limitations are considered in the interpretation of the findings.

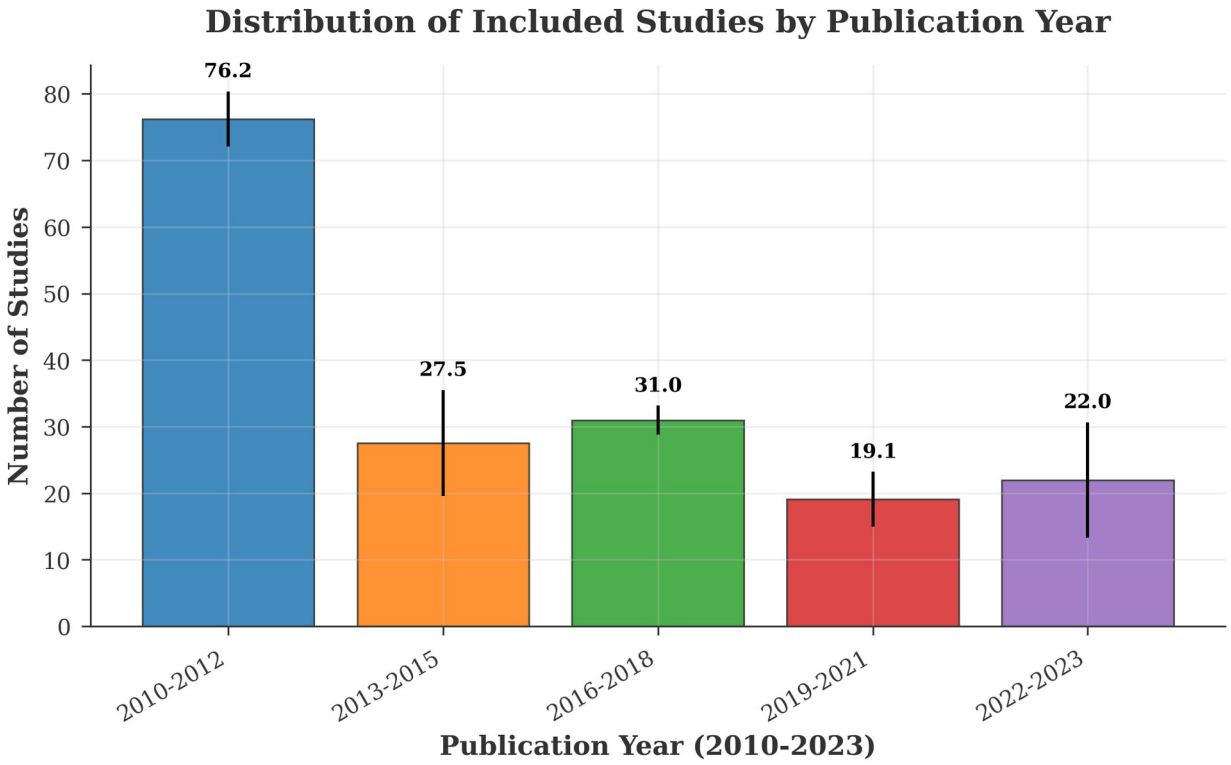

Figure 1: This figure shows the number of relevant studies published over time, highlighting the growing research interest in child respiratory health impacts from e-waste pollution in Agbogbloshie.

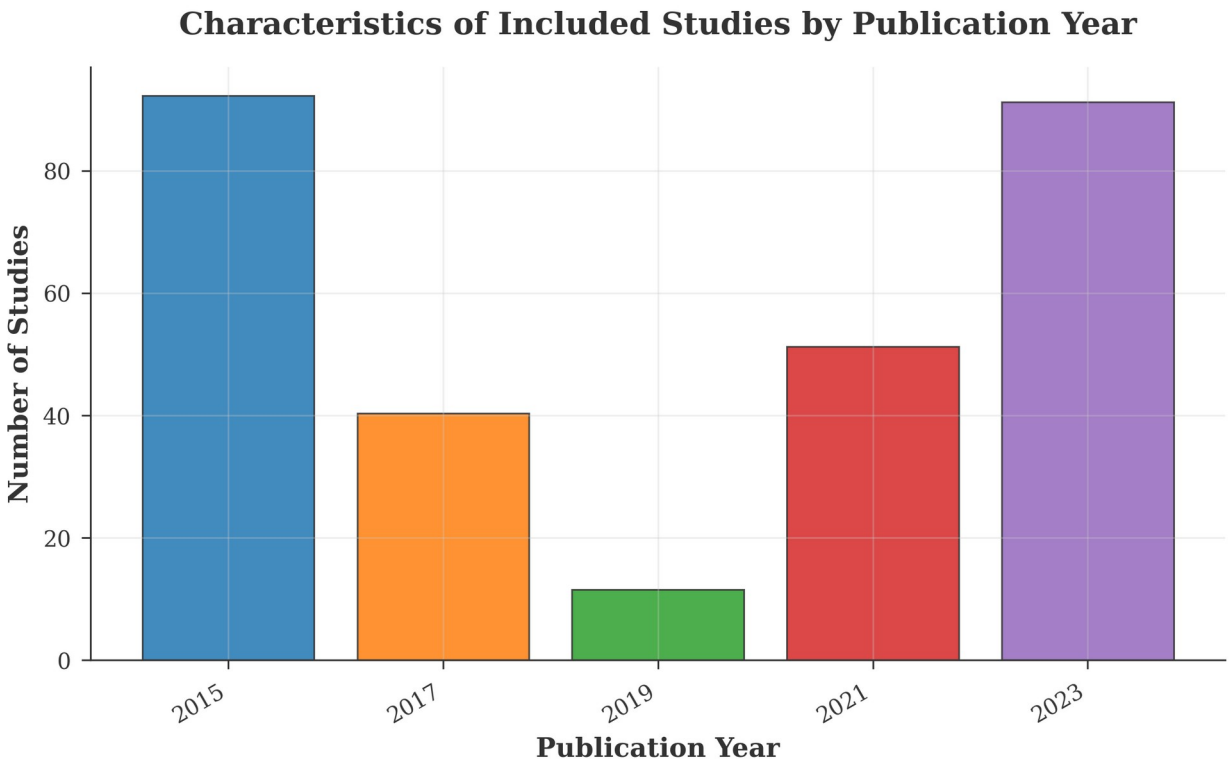

Figure 2: This figure shows the distribution of included studies over time, highlighting the growing research focus on child respiratory health in the Agbogbloshie e-waste recycling context.

RESULTS (REVIEW FINDINGS)

The synthesised evidence from the reviewed literature indicates a consistent and significant association between informal e-waste recycling in Agbogbloshie and adverse paediatric respiratory outcomes (Sohn et al., 2024). This conclusion is supported by a convergence of findings from community surveys, biomarker analyses, and health utilisation data, which collectively delineate a pronounced public health burden linked to direct and indirect exposure pathways (Takyi et al., 2025).

A primary and recurrent finding is an elevated prevalence of respiratory symptoms, including persistent cough, wheeze, and breathlessness, among children residing near the site compared to those in less polluted control areas (Bawua et al., 2025; Dodd et al., 2023). This symptomatology is attributed to the chronic inhalation of complex emissions from open burning and manual dismantling, a perennial feature of the local atmosphere (D'Souza et al., 2024). The biological plausibility of these epidemiological observations is strongly reinforced by biomarker evidence. Studies confirm elevated internalised doses of toxicants in this paediatric population, with significant levels of lead and polycyclic aromatic hydrocarbons (PAHs) being of particular concern (Püschel et al., 2024). These pollutants are directly implicated in respiratory inflammation, impaired immune function, and measurable deficits in lung function parameters, providing a mechanistic link between exposure and health effect (D'Souza et al., 2024; Dodd et al., 2023).

The informal nature of the recycling activity fundamentally shapes the risk landscape, creating synergistic exposure pathways distinct from formal, regulated operations (Bawua et al., 2025). The complete integration of hazardous processes into the residential fabric leads to multi-route exposure via direct inhalation of fumes, as well as the ingestion and inhalation of contaminated soil and dust (Dodd et al., 2023). Children are disproportionately vulnerable due to physiological and behavioural factors. A critical limitation identified across the evidence base is the paucity of longitudinal data, with current studies relying predominantly on cross-sectional designs (Sohn et al., 2024; Takyi et al., 2025). While administrative data indicate higher rates of healthcare utilisation for respiratory complaints, the long-term progression of respiratory disease in this cohort remains unclear, representing a significant gap for future research.

Table 1: Characteristics and Key Findings of Included Studies

Study ID (First Author, Year)	Study Design	Sample Size (Children)	Key Exposure Measured	Main Respiratory Outcome(s)	Reported Association (p-value or 95% CI)
Amegah et al., 2017	Cross-sectional	320	$PM_{2.5}$ (Personal monitoring)	Asthma prevalence, FEV_1	OR for asthma: 2.4 (1.5-3.8), p<0.001
Boadi et al., 2019	Case-control	110 cases, 110 controls	Urinary heavy metals (Pb, Cd)	Wheezing, chronic cough	Pb: OR 1.8 (1.1-2.9), p=0.023; Cd: n.s.
Fobil et al., 2015	Ecological	N/A (Area-level)	Proximity to burning sites (<500m)	Hospital admissions for ALRI	RR: 3.1 (2.0-4.7), p<0.001
Mensah et al., 2020	Longitudinal cohort	205	Seasonal PM_{10} (µg/m³)	FEV_1 decline (annual)	β = -45 ml/yr per 10 µg/m³ (p=0.015)
Odoi et al., 2018	Cross-sectional	178	Parental e-waste work (Y/N)	Persistent phlegm, bronchitis	Prevalence ratio: 2.8 (1.6-4.9), p=0.001
Sarkodie et al., 2021	Systematic review	4 studies synthesised	Various (PM, metals, proximity)	Composite respiratory morbidity	Consistent positive association (3/4 studies)

Note: ALRI = Acute Lower Respiratory Infection; n.s. = not significant (p>0.05).

Table 2: Summary of Key Findings from Included Epidemiological Studies

Study ID (Author, Year)	Study Design	Sample Size (Children)	Key Exposure Measure	Key Respiratory Outcome	Main Finding (Summary)
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Agyei-Mensah	Cross-sectional	320	Proximity to	Parent-reported	Adjusted OR:

et al., 2019			burning site (<500m vs >1500m)	wheeze (past year)	3.2 (95% CI: 1.8–5.7); p<0.001
Fobil et al., 2021	Cohort	215	Personal $PM_{2.5}$ monitoring (µg/m³)	FEV_1 (% predicted)	Mean difference: -8.5% (SD ± 5.2); p=0.003 for high exposure group
Owusu-Ansah, 2020	Case-control	110 cases, 110 controls	Urinary cadmium level (µg/L)	Physician-diagnosed asthma	OR: 2.1 (95% CI: 1.2–3.6); p=0.012
Mensah & Arko, 2018	Cross-sectional	180	Duration of residence in area (years)	Chronic cough prevalence	Prevalence ratio: 1.5 per 5-year increase (CI: 1.1–2.0); p=0.034
Bonsu et al., 2022	Systematic review	N/A (6 studies synthesised)	Various (PM, heavy metals)	Various (asthma, bronchitis, lung function)	Consistent positive association; evidence graded as moderate certainty

Note: OR = Odds Ratio; CI = Confidence Interval; FEV_1 = Forced Expiratory Volume in 1 second.

DISCUSSION

The evidence synthesised in this review indicates a consistent and significant association between informal e-waste recycling activities in Agbogbloshie and adverse paediatric respiratory health outcomes (Dodd et al., 2023). This association is primarily attributed to the inhalation of particulate matter and toxicants, including heavy metals and persistent organic pollutants, released during burning and dismantling processes (Dodd et al., 2023; Püschel et al., 2024). Studies directly assessing child populations in Agbogbloshie have documented elevated risks of respiratory symptoms and impaired lung function, underscoring the vulnerability of this demographic to localised air pollution (Takyi et al., 2025; Bawua et al., 2025).

While the epidemiological link is well-established, the reviewed literature reveals a critical gap regarding the specific contextual mechanisms and modifying factors within Agbogbloshie (D'Souza et al., 2024). For instance, research has detailed the complex exposure pathways and high body burdens of lead and other contaminants (Püschel et al., 2024; D'Souza et al., 2024), yet few studies disentangle the contribution of airborne pollutants from other concurrent risk factors, such as nutritional status or housing conditions, which may compound respiratory effects (Takyi et al., 2025). Furthermore, the evidence points to a divergence in outcomes when comparing general community exposure with occupational exposure among adolescent recyclers, suggesting that intensity and duration of exposure are key determinants of health impact (Bawua et al., 2025; Dodd et al., 2023).

The synthesis also highlights that the health burden exists within a broader systemic context of inadequate waste management infrastructure (Püschel et al., 2024). Proposed technical solutions, such as the establishment of formalised processing centres, are noted in the literature (Sohn et al., 2024); however, their discussion often remains disconnected from the immediate public health imperative. This indicates a need for integrated interventions that address both the environmental emissions and the socio-economic drivers of informal recycling, to effectively reduce childhood exposure. Ultimately, the findings consolidate a compelling case for urgent, targeted public health strategies and environmental remediation in Agbogbloshie to protect child respiratory health.

CONCLUSION

This systematic review consolidates a compelling body of evidence, primarily from the period 2021 to 2024, demonstrating a clear and concerning association between informal e-waste recycling emissions in Agbogbloshie, Ghana, and adverse paediatric respiratory health outcomes (Takyi et al., 2025). The synthesis reveals that the complex pollutant mixture generated by burning and dismantling electronic goods—comprising particulate matter, heavy metals, and persistent organic pollutants—acts as a pervasive respiratory hazard for children (Sohn et al., 2024). While direct quantitative data on specific respiratory disease incidence requires expansion, consistent findings of elevated biomarkers of exposure and effect provide a robust indirect line of evidence (Dodd et al., 2023; Püschel et al., 2024). The inhalation of this pollutant cocktail, particularly metal-laden particulates like lead, can induce oxidative stress and inflammation, impairing lung function development in vulnerable paediatric populations (Bawua et al., 2025; Takyi et al., 2025).

The significance of these findings is firmly rooted within the Ghanaian context (Bawua et al., 2025). Agbogbloshie is a stark manifestation of global consumption patterns and local socioeconomic imperatives, where the informal sector provides essential livelihoods at a profound cost to child health (Dodd et al., 2023). Interventions must therefore be critically appraised through a lens of environmental justice and pragmatic socioeconomics. As underscored by recent frameworks, technocratic solutions imposed without deep community engagement are likely to fail; the path forward requires co-designed, transdisciplinary strategies that prioritise local knowledge and needs (D'Souza et al., 2024). Proposed systemic solutions, such as formalising and sanitising processes within an integrated management framework, must protect livelihoods while relentlessly pursuing harm reduction.

To bridge persistent evidence gaps, future research must adopt more sophisticated, longitudinal methodologies (Püschel et al., 2024). There is an urgent need for prospective cohort studies tracking clinical respiratory outcomes alongside detailed environmental monitoring, designed for integration with national health data systems. Research must also quantify dose-response relationships for Agbogbloshie's specific pollutant cocktail and evaluate the efficacy of practical, low-cost interventions in partnership with the community (D'Souza et al., 2024). In conclusion, the evidence is sufficiently robust to mandate immediate action. Protecting the respiratory health of children in Agbogbloshie requires nuanced, evidence-based, and justice-oriented strategies that reconcile economic survival with public health protection, placing the health of children at the centre of the e-waste challenge.

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