

Article

Portrayals in Print: Media Depictions of the Informal Sector's Involvement in Managing E-Waste in India

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Abstract: For over a decade, media stories have exposed health and environmental harm caused by informal electronics recycling in less industrialized countries. Greater awareness of these risks helped inform regulations across the globe and the development of recycling standards. Yet, media depictions also shape public perceptions of informal workers and their role in handling electronic waste, or e-waste. This paper examines how mainstream print media describes the informal sector's involvement in handling e-waste in India, especially as policymakers and other stakeholders currently grapple with how to integrate informal workers into formal, more transparent e-waste management schemes. This study evaluates depictions of the informal sector in print articles from both non-Indian and Indian news media outlets, employing controversy mapping principles and digital research tools. Findings may help inform stakeholder agendas seeking to influence public awareness on how to integrate informal workers into viable e-waste management solutions. Subsequent research based on these results could also help stakeholders understand the actors and networks that shape such media depictions. Results from the dataset show that most news articles describe informal workers negatively or problematically due to activities causing health risks and environmental damage, but usually do not discern which activities in the value chain (e.g., collection, dismantling, metals extraction) represent the greatest risks. Comparatively fewer articles portray informal workers positively or as contributing to e-waste solutions. Most articles also do not explain challenges that arise when working with informal workers. As such, media depictions today often lag behind policy debates and obscure multiple facets—good and bad—of the informal sector's involvement in managing e-waste. Thus, an opportunity exists for policymakers, manufacturers, and advocacy groups to bridge the gap between current media representations of informal workers' involvement in e-waste management and policy recommendations surrounding their role.

Keywords: informal sector; e-waste management; India; news media; media depictions; recycling

1. Introduction

Over the last 15 years, journalism has played an important role in exposing the health risks and environmental damage that occurs when our technology products land in places ill-equipped to safely recycle them. Media coverage has shown workers, including children, in Guiyu, China and Agbogbloshie, Ghana burning cables and circuit boards to extract precious metals, releasing toxic emissions into abject surroundings. Stories such as these have helped raise international attention and concern over how to manage a growing number of obsolete electronics, often called electronic waste, or e-waste [1,2]. Many stories frame the issue as a consequence of Western consumption, where used or broken electronic devices from consumers in industrialized countries are exported to countries lacking protective measures—'digital dumping grounds'—where scores of informal workers extract any value

they can from discarded material [3–6]. Such coverage has informed global policy responses, including the development of an international recycling standard that restricts exports to avoid sending products to countries without sound processing infrastructure [7]. Media exposés of harm caused by recycling electronics in less developed countries have also impacted the way global electronic manufacturers communicate to the public about their electronics collection and recycling initiatives. They try to avoid being connected to harmful informal activities, knowing that such negative publicity impacts public perception of their brands [8].

Thus, media coverage is key to raising awareness of critical environmental issues. Once the public generally accepts environmental concerns, media outlets can choose to focus on a single issue or present multiple facts to a story, and thus, potentially negatively or positively impact how the public receives and responds to information. For example, the positive role of media in raising public awareness about climate change helped lead to increased worldwide use and production of renewable fuels, including biodiesel [9]. Media discussions on the algae bloom that results from nutrient loading to lakes which then pollutes drinking water depict microalgae, one source of biodiesel, as a harmful species that leads to serious illness [10]. However, microalgae can also be used for pharmaceutical products or in conjunction with wastewater treatment and, therefore, can be beneficial for public health [11]. In this same way, media coverage wields power in shaping our collective understanding of what happens to our electronics when we are finished using them. Where sustained media attention amplifies specific depictions of informal workers, these depictions can further shape our perceptions of them, even if the story has multiple facets.

With more than 44.7 million metric tons of e-waste generated globally in 2016, and with an expected increase to approximately 52 million metric tons in 2025 [12], unsafe recycling is a global concern. Put otherwise, the amount of e-waste generated in 2016 is equivalent to almost 4500 Eiffel Towers, according to the Global E-Waste Monitor 2017 Report (a joint effort of the United Nations University (UNU), the International Telecommunication Union (ITU), and the International Solid Waste Association (ISWA)) [12]. Done crudely without any pollution controls or safety measures in place, extracting material from used electronics can lead to soil and water contamination and serious ailments among workers where haphazard e-waste processing takes place, such as pulmonary and respiratory diseases, cancer, and elevated blood levels, as documented in Guiyu, China [13]. Studies in Guiyu and others in India [14,15] also demonstrated comparatively higher levels of cadmium, hexavalent chromium, arsenic, and mercury in soil and water samples. As many ailments often go unreported among informal workers and long-term health impacts from exposure are difficult to track, the studies that have collected sample health data, such as those showing elevated levels of lead in children's blood, demonstrate cause for significant concern.

In response, over the last two decades, many countries passed e-waste legislation, beginning in Europe with the Waste Electrical and Electronic Equipment (WEEE) Directive, followed by a patchwork of state regulations in the United States. Though regulations have been enacted in countries such as India, China, Peru, Colombia, Cambodia, and Vietnam, national e-waste legislation is still absent in many countries across Africa, Central and South America, Central Asia, Eastern Asia and Melanesia, Polynesia, and Micronesia. Due to the large populations of India and China, regulations or official policies currently cover approximately 4.8 billion people, or 66 percent of the world's population [12]. However, the existence of policies or legislation does not necessarily lead to successful enforcement or the robust growth of environmentally sound e-waste management systems. Globally, documentation estimates that only 8.9 million metric tons of e-waste will be collected and recycled annually—approximately 20 percent of all the e-waste generated [12].

Lack of success in recycling greater amounts of electronics may, in part, be due to how e-waste legislation is designed. Many e-waste regulations are rooted in Extended Producer Responsibility (EPR), where producers, or manufacturers, typically pay by weight for recycling legacy products based on their current market share. The regulations often spur recycling contracts managed by third parties whereby manufacturers must document that the e-waste is safely recycled. Research examining

experiences implementing EPR compliance schemes, more generally, in different European Union (E.U.) countries within the last decade point to mixed success where producers are required to finance the cost of recycling certain products [16]. For example, in some instances, producer-financed collection and recycling schemes adequately compensated local governments for the incremental costs of recycling packaging waste, such as in Germany, but in others, namely Romania, local governments bore significantly higher costs [16]. In the example of packaging waste, despite participation from several producers, evidence of ‘free-riding’ still existed, where producers responsible for introducing packaged goods into the E.U. market still evaded contributing financially to waste recovery operations [16]. These mixed results demonstrate the need to account for regional and local government capacity when designing EPR schemes.

Pairing legislation with adequate and viable economic incentives is also critical to the success of regulatory schemes that seek to foster financially self-sustaining solutions and drive market competition for waste management services. Many e-waste regulations strive to create an environment where producers pay for e-waste recycling and contracted recycling firms compete for their business by offering the best value for collection and processing. Research from Portugal’s experience regulating waste utilities with sunshine legislation, where operators’ records based on government-developed performance indicators were compared and displayed publicly, demonstrated good performance outcomes as operators sought to correct inefficiencies to avoid embarrassment for poor performance [17]. Though such an approach led to initial improvements across the urban waste management sector, economic disincentives hindered long-term progress. Rate-of-return regulation, where payments to firms are based on costs and profits that remain the same regardless of performance, led to overinvestment and eventual decline in productivity and quality of waste management services among firms [17]. In the Portuguese example, it was deemed that economic regulation based on a price cap would have incentivized greater productivity within firms. Such lessons can be instructive to the e-waste management sector, where different EPR legislations create different economic frameworks for implementation. For example, across the E.U. and in 25 states within the U.S., producers jointly finance electronics collection and recycling via a collective platform managed by a third-party organization that contracts out recycling to different firms. Such an arrangement requires collaborative game theory applied within the e-waste network framework and producers collaborate to set up an infrastructure and design collection and recycling networks to comply with the e-waste regulation [18]. In contrast, in California, consumers are charged advance recycling fees at point of purchase, which are used to finance collection and recycling operated by a state-controlled, and price-controlled, system. Producers may join a collective system or operate individual takeback systems that conform to standards in California’s legislation. Adding further complexity, the success of economic incentives for collection and recycling schemes also depends on the type of technologies targeted in the legislation and the business models of producers [18]. For example, recycling legacy televisions often costs more due to the lower value of the material and limited reuse opportunities whereas mobile phones and laptops typically have higher economic value. As such, operational factors, such as how well producers can collaborate via a network to apportion costs and ensure cost-effectiveness in product takeback, can significantly influence the efficiency of legislation in achieving policy objectives related to EPR [18].

As EPR-based take-back policies spread to different countries, applying an operations management lens is critical to link policy instruments with on the ground implementation approaches, recognizing that one solution usually does not apply equally in different regions of the world and in various business contexts [18]. Less industrialized, or developing, countries that enacted e-waste legislation often adopted the EPR-based regulatory framework first promulgated in Europe. Yet developing countries often face weaker institutions and lack the capacity to implement and enforce the laws or foster an economic environment in which producers can establish cost-efficient and productive e-waste collection and recycling systems. Governments in less industrialized countries may find it challenging to collect funds from manufacturers if smuggled, imitation, or small shop assembled products have a higher market share [19]. Lack of strong institutions may contribute to low

trust among producers, which may hinder collaboration to collect and recycle electronics, and thus, inhibit cost-effective scale economies in managing e-waste under EPR regulation.

Most waste management regulations throughout the world—both general waste regulations and those related to e-waste—omit mention of informal workers [12,20]. Until recently, informal recycling and reuse in Europe has not been acknowledged and remains a challenge for policymakers and the solid waste management sector [20]. Across Europe, informal recyclers increasingly collide with formal reuse, recycling, and waste management schemes under EPR systems [20], yet the framework underpinning the WEEE Directive does not account for them. In developing countries with large informal e-waste economies, EPR-based e-waste regulations were often enacted without including an operational framework for addressing the presence of the informal sector, thereby demonstrating a disconnect with on the ground realities. Whereas, in industrialized economies, a formal recycling sector is typically more established and poised to thrive once recycling firms are assured access to volumes of e-waste paid for by producers, such has not been the experience in developing economies. The latter often lack the capacity to enforce pollution control regulations to end unsafe informal recycling. Informal workers still dominate e-waste management in Africa, where modern infrastructure is ‘nonexistent or grossly limited’ [12], in China, despite a growth in formal e-waste recycling [12], as well as in many other countries. In developing economies, the formal sector, which invests in safety equipment and bears administrative costs for its operations, often cannot compete with informal recyclers (who lack the same operating expenses) and therefore struggles to remain economically viable.

While the risks of recycling electronics without safety measures in the informal sector have been documented and regulations have been developed to help foster sound recycling practices with the aim of cultivating a larger formal sector, counter-narratives that involve informal workers also exist. Done safely, repurposing used electronics—often by informal workers—reincarnates scarce natural resources, invents new jobs, and closes the digital divide by providing refurbished products to those unable to afford new ones [21]. According to the International Labor Organization, ‘informal economy’ refers to:

“All economic activities by workers and economic units that are—in law or in practice—not covered or insufficiently covered by formal arrangements. Their activities are not included in the law, which means that they are operating outside the formal reach of the law; or they are not covered in practice, which means that—although they are operating within the formal reach of the law, the law is not applied or not enforced; or the law discourages compliance because it is inappropriate, burdensome, or imposes excessive costs”. [22]

In recent years, the global policy landscape has evolved to where stakeholders, especially those in developing countries, recognize the unavoidable presence of informal workers and now seek to leverage the informal sector’s skills to manage obsolete electronics more effectively and help workers formalize their operations. With an estimated value of raw materials in e-waste at 55 billion Euros, many formal and informal recyclers both seek access to these materials [12]. Current challenges discussed in the scholarly literature and among policymakers center on how to engage informal workers on collection and basic dismantling, while diverting material for further recycling to ‘formal’ facilities with demonstrated good health and safety practices, often located in other countries, usually in the global North. The “Best of Two Worlds” policy framework advocates that workers in less industrialized countries collect and pre-process electronics and partner with such formal facilities to extract precious metals, the last stage of recycling where human health and the environment often face the greatest risks [23,24]. Within the last decade, pilots in different countries have experimented with how to involve the informal sector. While policymakers and other key academic, nongovernmental organization (NGO), and manufacturer stakeholders agree that informal workers can play a substantive role in managing obsolete electronics, socio-economic challenges to integrate them into sound e-waste management practices exist and persist [25]. Current on the ground efforts in regions across Latin America, Southeast Asia, and Asia, for example, continue to try to overcome these challenges by testing new approaches and building informal capacity [26].

Given these developments, how do mainstream media depict the informal sector's involvement in managing e-waste? Has news coverage kept pace with current policy debates on how to involve the informal sector in e-waste management schemes?

This research aims to provide an initial set of comparative insights, not an exhaustive analysis, of media depictions of informal workers' involvement in managing e-waste. The findings are intended to serve as a starting point of discussion for stakeholders interested in shaping the public's understanding and perception of the informal sector. This study contributes to a nascent, but growing, body of research that applies controversy mapping principles to policy discussions in e-waste management. After nearly two decades since the first media reports of harm caused by e-waste surfaced, policymakers can observe if or how mainstream news coverage reflects their agendas. Conversely, how international policymakers and other key stakeholders—themselves consumers of mainstream media—perceive informal workers might impact how they later engage with them to achieve certain ends. Results from this study could serve as the building blocks of a multi-part study that would examine the actors, their networks, geographic locations, and agendas influencing discussions around the informal sector's efforts related to e-waste. Additionally, standalone findings from this study could also complement or add layered insights to other studies examining broader stakeholder debates that might include the informal sector's role in managing e-waste.

India provides the optimal landscape in which to examine the shifting norms and debates surrounding e-waste. Depictions of the informal sector in India can provide insights on how non-Indian and Indian media describe its involvement in e-waste, potentially teasing out global and regional perspectives, biases, and interpretations. Findings from India can provide national policymakers with insights on media coverage in other countries, such as China, Ghana, South Africa, and Brazil, where a robust informal sector also collects, dismantles, and extracts metals from growing amounts of e-waste, and where policymakers have passed, or are working to pass, legislation to improve the quantity and quality of recycling. India represents the experience of informal e-waste management of many countries, just on a much larger scale. Moreover, lessons from media depictions of informal workers in India can inform global stakeholders on the extent to which their agendas are reflected in current media coverage.

With a population of 1.3 billion people, India generates significant volumes of e-waste (2 million tons in 2016) and also imports obsolete electronics from developed countries [12]. Its electronics industry is also one of the fastest growing industries in the world. Though the formal e-waste recycling sector in India is being developed in major cities, estimates cite nearly a million informal workers involved in manually recycling electronics across India [12]. Tens of thousands of informal workers in the Delhi region alone collect, dismantle, or recycle used electronics, as Delhi's scrap markets are among the largest in the world [27].

Research on informal cottage industries in Delhi demonstrates higher levels of contamination and health risks resulting from processing printed circuit boards containing precious metals and plastics containing brominated flame retardants [27,28]. In India, CRT monitors are sought after by scrap dealers for the copper in the yoke and metals in printed wiring boards. Broken CRT glass, lacking demand from international markets, ends up discarded or mixed in with other glass in the recycling ovens in the eastern outskirts of Delhi to make products, such as jewelry and household items, for domestic markets—an example of widespread contamination that is difficult to trace and quantify [29]. A large subset of the tens of thousands of informal industrial units, many of which include electronics processing, are being targeted by government authorities per the Master Plan Delhi, where “all polluting industries need to be shifted out by 2021” [27] (p. 2). In other recycling hubs within India, such as Moradabad, located in Uttar Pradesh about 2 hours from Delhi, a significant number of its several hundred thousand residents extract gold and other precious metals from printed circuit boards (PCBs) via harmful methods [15]. Chennai, Calcutta, Mumbai and Bangalore are also mentioned as places where electronics collection, trading, aggregation and dismantling by the informal sector occur.

India also offers fertile ground on which to conduct studies of the informal sector's involvement in electronics recycling because numerous actors ranging from NGOs, government, academia, trade associations, manufacturers, and multilateral international aid and financial institutions (such as Germany's Gesellschaft fuer Internationale Zusammenarbeit (GIZ) and the World Bank's International Finance Corporation (IFC)) have debated (and continue to discuss) how to reduce the flow of e-waste into India, stem harmful informal recycling, and integrate the informal sector into sound e-waste management practices [15,30–38]. India's Ministry of Environment and Forests passed e-waste legislation under an EPR framework in 2011 and again in 2016, this latest time requiring manufacturers to not only pay for electronics recycling, but also to meet specific recycling targets [39]. The recent regulation acknowledges the role of informal workers but does not provide guidance for how manufacturers can engage them [39]. Since 2009, multilateral institutions have piloted different approaches to working with informal collectors and different organizations with experience engaging waste collectors have also tried piloting e-waste management approaches with the informal sector [40].

Over the past ten years, several media stories highlighted electronics recycling occurring in the small alleyways of Seelampur, a popular hub for trading, refurbishing, dismantling and extracting precious metals from used electronics, in the outskirts of Delhi [41–45]. More recently, Indian media covered government crackdowns in informal recycling efforts in Moradabad [46,47].

Given these multiple factors, India provides a good testing ground to determine which depictions of the informal sector's involvement in managing e-waste feature most prominently in media representations. What narratives do media stories introduce, reinforce, or dispute? Do similarities and differences exist in how non-India-based (non-Indian) media and India-based (Indian) media have covered the informal sector's role in managing e-waste in India?

The remainder of this paper is structured as follows. First, a literature review is presented. Second, the research methods are introduced. Third, the results and their interpretation are presented, followed by a discussion. Finally, conclusions and recommendations for future research areas are provided.

2. Literature Review

2.1. Issue Mapping, Actor-Network-Theory, and Controversy Mapping

Before understanding the nature of media depictions of the informal sector's involvement in e-waste, it is important to note that media stories themselves do not emerge from a vacuum. Bruno Latour posits the 'social' not as a static, pre-determined structure but as the fluid movement of different actors continuously debating, associating and assembling. This movement itself appears as the 'social' or 'society', but is instead a reflection of actors in constant motion shaping and re-shaping the state of affairs [48,49] (p. 15).

“... no social force is available to 'explain' the residual features other domains cannot account for ... [S]ociety, far from being the context 'in which' everything is framed, should rather be constructed as of the many connecting elements circulating tiny conduits ... social is not some glue that could fix everything including what the other glues cannot fix; it is *what* is glued together by many *other* types of connectors. Even though most social scientists would prefer to call "social" a homogeneous thing, it's perfectly acceptable to designate by the same word a trail of *associations* between heterogeneous elements". [48] (pp. 4–5)

Thus, when viewed through such a lens, media representations also reflect a non-static framework influenced by different actors, where some have greater leverage over others to ensure that their voices are amplified and reflected back to a larger audience. Latour advises the researcher to discern which actors are intermediaries, which he defines as those who "transport meaning or force without transformation" [48] (p. 39), versus mediators who "transform, translate, distort, and modify the meaning or the elements they are supposed to carry" [48] (p. 39), [49] (pp. 17–18).

To understand how issues take shape, Latour then points to networks, asserting that we do not act alone and that others support, refute, or enhance ideas disseminated within a network. In this

way, per the actor-network-theory, issues gain prominence ('issuefication') [48]. Thus, facts may not necessarily result in concerns or vice versa. He suggests first tracing how facts were developed and who deployed them in such a way that they did or did not become issues of concern. Tracing the network in this way provides greater clarity as to who might benefit from promoting a particular viewpoint and from gaining consensus from others.

Tommaso Venturini complements Latour's work by introducing 'controversy mapping', a type of issue mapping also rooted in actor-network theory, where "collective life becomes a complex disagreement in which the actors proliferate claims and concerns and when the most crucial beliefs are questioned" [49] (p. 18). In controversies, actors are continuously engaged in tying and untying relations and arguing categories and identities, thereby revealing the fabric of collective existence [50]. Venturini advises selecting controversies where movement exists, where demarcation between different controversies is clear, and where accounts are visible and publicly accessible (not underground) [50]. A controversy map typically starts with a statement from which to build a corpus of documents related to the issue to be mapped. In mapping controversies, or arguments surrounding a debate, one should "move from statements to literature, to actors and their networks, and to the cosmoeses (ideologies) and cosmopolitics (construction of a collective, however temporary)" [49] (p. 18), [50].

2.2. Tools for Digital Research Methods

Current tools to implement digital research methods today provide the researcher various avenues for tracing such networks. For example, the Digital Methods Initiative's GoogleScraper, also known as the Lippmannian device, batch queries Google to determine resonance of a particular term, or a series of terms, in a set of websites; the Reverse Image Scraper queries Google for occurrences of images; Geo IP translates URLs or IPs into geographic locations; and TextRipper extracts all non-html (i.e., text) from a specified page [51]. Using the web as a research tool, Venturini warns us, also contains limitations in that "1. search engines are not the web; 2. the web is not the Internet; 3. the Internet is not the digital; 4. the digital is not the world" [52] (p. 803). Thus, information garnered from the web is itself a reflection of ideas disseminated and promoted by actors and their networks. Not all digital information is shared via the web where networks are not connected and information may be missing due to asymmetries between groups [52].

"Even if portals and search engines are constantly expanding their databases, they cannot grow as fast as the web. Every day hundreds of thousands of new pages are created and only a fraction is reached by the search crawlers. Sometimes contents remain invisible because they are too marginal or ephemeral, sometimes because they are concealed by their authors, sometimes they are just forgotten. Even if more and more information is exchanged via the hypertext transfer protocol (http) and under the form of an xhtml page, a large slice of electronic traffic travels through other routes. E-mails, teleconferences, chats, peer-to-peers exchanges, document transfers and many other data do not transit via web protocols". [52] (p. 803)

Despite these limitations, where data exists, it can be mapped. Jeremy Crampton, in his studies on critical cartography and neo-cartography, defines maps 'as ways of making spatial knowledge instead of ways of mirroring a territory' [53], [49] (p. 25). They "perform by constructing visual claims and telling hardly arguable, or often unassailable, stories capable of exercising power with a high degree of efficiency" [53], [49] (p. 25). Maps themselves reflect "artificial political and social agreements" [53], [49] (p. 25). Which maps emerge due to online issue mapping? [49]. Which issues, actors, places and other key information are missing from the maps? Visual mapping tools can display information that reflects certain ideas and agendas. For example, heat maps use color gradations to denote the salience of terms or issues as they compare to each other; word clouds highlight the presence, relevance, and frequency of certain words or phrases pertaining to a text; layered cartographic maps, especially those using GIS data, relate issues and actors with geographic locations; alluvial diagrams, line maps, and network graphs show the relationships and strengths between networks and which

issues they emphasize; and tools such as DebateGraph help disaggregate meta-actors into specific actors and their statements traced on the web [49,54].

2.3. Mapping E-Waste Controversies Using Digital Methods

In *Transboundary Movements of Electronic Waste: Mapping a Controversy*, Lepawsky, et al., apply Latour and Venturini's issue and controversy mapping principles, coupled with digital search and visualization tools, to examine the most common controversies related to e-waste today, both in the mainstream "wiki" web (Google) and scholarly web [54]. For mapping the mainstream web, the authors selected a statement that encompassed several debates within the stakeholder community, after canvassing a group of approximately 127 members of the United Nations University's Solve the E-waste Problem (StEP). The authors initiated a controversy map using digital search tools based the following news headline:

"E-waste is exported largely for the same reason manufacturing jobs have been sent overseas: lower labor costs and fewer regulatory burdens."

(*USA Today*, E-Waste in Developing Countries Endangers Environment, Locals 1 August 2014).

Results generated by web queries using key search terms from the headline yielded the following four most prominent issues over which actors disagreed:

- How much e-waste is exported from North to South?
- How to create an Extended Producer Responsibility [EPR] based national recycling industry?
- How to regulate North-South trade?
- Should e-waste be traded from North to South at all? [54]

While three out of the four debates above relate to the statement used to conduct the research queries, the debate 'how to create an EPR based national recycling industry' appears less related to the debate around exports. Thus, tracing issues, actors, and networks from statements can reveal underlying discussions not readily apparent without conducting a mapping exercise.

3. Methods

To demonstrate how print news media portrays the informal sector's involvement in managing electronic waste in India, digital research and mapping tools were used to identify statements about the informal sector that provided a broad basis for conducting a web search and subsequent analysis of news articles. A set of search terms were developed from statements and a Google News query then yielded a dataset of the most popular news article URLs. The nature of the contextualized depictions from those URLs, including the frequency of positive, negative, and neutral words used to describe e-waste management practices used by informal workers, were then analyzed. A step-by-step description of the digital methods employed follows below. All results that informed the analyses are also detailed in the Supplementary Materials.

3.1. Research Question and Scope

In applying similar methods and techniques as Lepawsky, et al., employed in *'Transboundary Movements of Electronic Waste: Mapping a Controversy'* [54], one can unearth and examine key issues and, potentially unexpected, debates surrounding the informal sector's involvement in e-waste, as reflected on the mainstream web. Here, the research focuses specifically on how mainstream media depicts the informal sector's involvement in managing e-waste, rather than include other sources of public information such as NGO reports or policy briefs. Since media can wield significant influence on public perception, this study examines media coverage only to gain insights on the most popular depictions of the informal sector as they are communicated to the general public. Anecdotal observations over the last decade indicate that media coverage overwhelmingly focuses on informal workers as they relate

to the risks of recycling electronics, and less on their involvement in reuse and refurbishment. Media coverage, when viewed collectively over the last decade, also appears to omit discussions of deeper, system-wide dynamics that might explain why certain countries possess an informal, waste-collector culture instead of (usually mechanized) waste management systems found in industrialized countries. To remove guesswork on the nature and extent of media coverage of the informal sector as it pertains to e-waste, this study attempts to begin evaluating mainstream media depictions of informal workers by employing digital research methodologies on a limited dataset. Here, understanding to what extent various depictions exist could provide greater insights into whether the mainstream media is in step with the current policy agendas and debates. Moreover, gathering such data provides the starting point for subsequent studies to then trace the literature surrounding statements to the actors and networks that shape them to advance their agendas.

Though numerous multimedia pieces, such as news videos, documentaries, and audio stories, have covered the informal sector's involvement in handling e-waste, the scope of this research examines print media coverage only to provide a comparative analysis of the specific descriptions used in a print format. Time constraints limited the scope to print coverage, as video and audio media coverage require both lengthy transcriptions to analyze dialogue and contextual analysis of how visual content reinforces or contradicts written or spoken content. Print media still yields useful insights because words can conjure powerful imagery and text or captions are important for contextualizing any photographs in news articles. Many images taken in the last decade, especially those taken in the alleyways of Seelampur, look similar but, in some instances, communicate different messages [42,55]. Without accompanying text, such as captions, to contextualize information, readers determine for themselves what they are seeing, bringing their own unconscious biases to bear on their reactions. Conversely, accompanying text often informs them how they should interpret the images. Finally, the research scope is limited to English-language news coverage and thus omits any potential articles from non-English speaking countries and from articles in Hindi or other languages in India. Given that many informal workers in India do not speak English, this study does not capture any potential news coverage in local languages that might reflect debates and discussions amongst informal audiences.

3.2. Developing Key Term to Map Descriptions Based on Controversies and Major Issues

To understand how the news media covers the informal sector, recent headlines mentioning both the informal sector and e-waste were examined to begin mapping any controversies. Headlines examined reflect the following common issues discussed among the academic, policy, NGO, and electronics manufacturer communities within the last decade: (1) many informal workers are involved with recycling electronics in emerging economies and (2) their involvement often harms human health and the environment [12]. Headlines that used the word 'informal' were sought since scholarly research predominantly uses this term to describe unregistered workers. Headlines containing the words 'wastepicker', 'scavenger', or 'ragpicker' were not included since these terms often describe the informal sector's involvement in managing broader and lower value waste streams in India, such as paper, plastic, miscellaneous metals and organics, and have been linked to collection activities at landfills. Since electronic scrap is comprised of comparatively higher value materials, most components typically do not end up in India's landfills. Therefore, only headlines using the word 'informal' were used to try to ensure that search results pertained specifically to e-waste and to examine to what extent mainstream print news coverage also used the term in the same manner. The words 'electronic waste' or 'e-waste' were also selected as search terms since they feature most prominently in mainstream media coverage and in discussions among policymakers, NGOs, manufacturers and several academics. Though the terms 'electronic scrap' and 'e-scrap' more neutrally describe defunct electronics versus 'waste', which carries pejorative connotations, for purposes of this analysis, the term 'e-waste' was considered to yield a broader set of results.

To capture a wide array of potential depictions of the informal sector, the following three headlines were selected from actual articles available online pertaining to e-waste management in India:

“E-waste in India is going to the informal sector”. Sunday Guardian Live. 24 September 2017
<http://www.sundayguardianlive.com/news/11020-e-waste-india-going-informal-sector>.

“Toxic Business: India’s Informal E-Waste Recyclers at Risk”. Sean Gallagher, Pulitzer Center on Crisis Reporting. 18 April 2014.

<https://pulitzercenter.org/reporting/toxic-business-indias-informal-e-waste-recyclers-risk>.

90% of Ewaste is recycled informally. When will government policy recognize this?

Association for Progressive Communications. 14 October 2011.

<https://www.apc.org/en/news/90-indias-e-waste-recycled-informally-%E2%80%93-when-will-govt-policy-recognize>.

The headline from the India-based newspaper *Sunday Guardian Live* provides the most neutral statement that could yield multiple discussion points. The headline from the U.S.-based Pulitzer Center, which helps fund independent news stories that appear in global publications, points to the negative health and environmental impacts within India’s informal sector. Finally, the headline from the Association for Progressive Communications, based in South Africa and legally incorporated in California, mentions the informal sector’s extensive involvement in handling India’s e-waste and government policy. Articles spanned several years (2011, 2014 and 2017) to capture the main concerns circulating within stakeholder discussions during the last decade and that remain relevant to today.

Nine separate GoogleNews search queries were crafted using the actual words found in the three headlines to identify the most popular online print articles.

- “Electronic Waste” OR “E-Waste” AND “India”
- “Electronic Waste” OR “E-Waste” AND “India” AND “informal”
- “Electronic Waste” OR “E-Waste” AND “India” AND “recyclers”
- “Electronic Waste” OR “E-Waste” AND “India” AND “risk”
- “Electronic Waste” OR “E-Waste” AND “India” AND “toxic”
- “Electronic Waste” OR “E-Waste” AND “India” AND “business”
- “Electronic Waste” OR “E-Waste” AND “India” AND “90 percent”
- “Electronic Waste” OR “E-Waste” AND “India” AND “government”
- “Electronic Waste” OR “E-Waste” AND “India” AND “policy”

3.3. Configuring a Clean Research Browser for both U.S. and India Region Settings

Prior to conducting the search queries, a clean research browser was configured in Mozilla Firefox, according to instructions from the University of Amsterdam’s Digital Methods Initiative (DMI) [56], removing any search history, cookies, or other variables that could inadvertently skew results. The first set of Google News queries used the United States as the region setting. The browser was cleaned again, running the same set of queries using India as the region setting. Search results from both geographic locations were captured to examine which news articles appeared in both regional queries and to capture articles that might only appear when queried in their respective media markets.

3.4. Google News Search results from both U.S. and India Region Settings

Each query was first attempted using DMI’s Google News Scraper (see <https://wiki.digitalmethods.net/Dmi/ToolDatabase>), which returns the top 100 results for each query. However, at the time of this writing, the Google News Scraper did not function properly and DMI staff indicated that the tool would be updated in early 2018 [57]. As such, the top 100 URLs for each of the nine queries were manually captured to mimic how the tool works, first using the Google regional setting of “United States” and then running query again with “India” as the regional setting. As reflected in (Table 1. Google News Search

Query Results), duplicate URLs from within each regional setting were removed since the nine separate queries often returned the same articles among their top 100 results.

Table 1. Google News Search Query Results.

Regional Setting in Google Research Browser	Number of Distinct URLs for News Articles Resulting from Nine Separate Queries
United States	403
India	357
Total	760

Each URL was then re-classified based on whether the news media outlet that published the article was *itself* located in India, ostensibly for an English-speaking Indian audience, or outside India, ostensibly for a global and/or predominantly English-speaking audience. Once URLs were classified as “Non-Indian” or “Indian”, as reflected in (Table 2. Number of Distinct Articles from Indian and Non-Indian Online Print News Outlets) any duplicate URLs were removed, since queries conducted under both the U.S. and India regional settings yielded many of the same articles. Of the 220 non-Indian news articles, which provided a robust representative sample of English language mainstream print media and some trade press, 92 outlets were based in the United States, 24 in the United Kingdom, and most the remaining articles were located in Europe or Asia geared towards a global or regional English-speaking audience. Some media outlets did not list their country of origin and maintained an international editorial staff; these were listed as non-Indian news outlets since their target audience is globally focused.

Table 2. Number of Distinct Articles from Non-Indian and Indian Online Print News Outlets.

Online Print News Outlets	Number of Distinct News Article URLs Resulting from Nine Separate Queries
Non-Indian	220
Indian	351
Total	571

3.5. Capturing the Text from Each Article

After classifying URLs into non-Indian versus Indian news outlets, the text from each website was extracted for analysis. To do so, all URLs from non-Indian news outlets were imported into the DMI’s TextRipper tool [58], which extracts all non-HTML (i.e., text) from each website, and the resulting text was then pasted into a separate word document. The same process was applied to URLs from Indian news outlets in a second Word document. The Text Ripper results also showed a small set of URLs (less than ten) for which the tool was unable to extract text from both Indian and non-Indian news outlets. The text from those URLs was manually pasted into the Word documents to ensure its inclusion.

3.6. Tallying the Term ‘Informal’ from the Text

As a next step, the text documents were uploaded into the web-based tool Voyant [59], which allows one to analyze the context in which a word appears in a paragraph and provides the user with a word count and data visualizations, such as word clouds. Two separate Voyant analyses were conducted, one for the non-Indian news articles and one for the Indian news articles.

The Voyant results are available as follows:

Text Analysis for Non-India-based news articles:

<http://voyant-tools.org/?corpus=f58e227ce5614a5d0973ac1af47ff6a6>

Text Analysis for India-based news articles:

<http://www.voyant-tools.org/?corpus=f1569e210c8022fdd94d71a4fe895b2f>

Within the Voyant interface, the frequency in which the term “informal” appeared across the full text in both non-Indian and Indian news articles was determined, as reflected in (Table 3. ‘Informal’ Word Count across All Articles). The word ‘informal’ appeared in tandem with ‘sector’ and ‘workers’, ‘recyclers’, or other similar descriptions.

Table 3. ‘Informal’ Word Count across All Articles.

Combined Text of All News Articles	Number of Times the Word ‘informal’ Appears in the Combined Text of All News Articles
Non-Indian	275
Indian	302

3.7. Categorizing ‘Informal’ Descriptions Based on Articles’ Context

Distinct articles were then tallied to analyze how each article contextualized the use of the word ‘informal’. Since some articles used the word ‘informal’ multiple times, the amount of articles listed in (Table 4. Number of Distinct Articles Containing the Word ‘Informal’) appears less than the ‘informal’ word count across all articles in (Table 3) Voyant is capable of extracting text directly from a set of URLs and displaying each URL text as a distinct article, thus, eliminating the need to use the TextRipper. However, errors occurred each time hundreds of URLs for non-Indian and Indian news articles were entered into Voyant directly. Therefore, the TextRipper tool was employed to create separate text documents which were then uploaded into Voyant. The text in Voyant was then manually sorted into distinct articles, reflected in (Table 4). Thus, if Voyant successfully extracted text directly from the URLs entered, the subsequent steps outlined could have been combined for ease.

Table 4. Number of Distinct Articles Containing the Word ‘Informal’.

Online Print Media	Number of Distinct Articles Containing the Word ‘Informal’
Non-Indian	75
Indian	116

Each article was read to determine how it described the informal sector’s efforts in relation to e-waste in India and whether it provided various explanations and perspectives on how or why the informal sector engages with e-waste. The words and phrases used to describe informal e-waste management practices were also captured to determine if any themes emerged. Did articles use specific words to color a narrative that could shape the public’s understanding of, and possible response to, the informal sector’s involvement in handling e-waste?

3.8. Additional Considerations

In analyzing the text, the search queries resulted in news articles with additional characteristics that should be noted when analyzing the data. First, the majority of articles were written in 2016 and 2017. Second, many of the 75 articles from non-Indian news outlets mentioned India in the larger context of countries with large informal sectors that manage burgeoning levels of e-waste generated domestically and/or imported from other, often industrialized countries. Seventeen articles from non-Indian news outlets describe the experiences and impacts of informal workers, citing examples from countries such as China, Ghana, and Egypt. These articles were retained in the dataset because informal sector dynamics in those countries often mirror those in India. Removing such articles would have resulted in an even smaller dataset to compare with Indian print media coverage. Finally, at the time of capturing and analyzing the data in late December 2017, the United Nations University had just published its 2017 Global E-Waste Monitor Report on 14 December 2017, which garnered coverage

from several of the 75 non-Indian news articles in the dataset citing excerpts from the report. The report featured multiple descriptions of the informal sector's involvement in handling e-waste—negative, neutral and positive—and, therefore, is not considered to disproportionately impact the overall results captured below, despite perhaps higher than usual coverage by multiple media outlets due to the timing of the report's release.

4. Results

4.1. Contextualized Descriptions of the Informal Sector

Since most articles in the dataset were published in 2016 and 2017, they thus reflect the current nature of informal worker depictions that surface most prominently in recent web queries. Two-thirds of both non-Indian and Indian news articles featured most prominently the health dangers and environmental harm due to informal recycling. However, few articles discerned which activities in managing e-waste (e.g., collection, dismantling, metals extraction) represented the greatest risks and why. Both non-Indian and Indian articles generally agreed that the informal sector is “too large to ignore” and workers depend on processing e-waste for employment. Yet, comparatively fewer articles—15% of non-Indian articles and 24% of Indian articles—primarily focused on integrating the informal sector in solutions to managing e-waste. A select few articles balanced discussing health and environmental risk with a recognition that informal workers can contribute positively by collecting and (under some conditions) pre-processing e-waste for safe recycling. One-dimensional representations of informal workers obscure the different aspects—good and the bad—associated with their involvement in e-waste.

Many news articles from both non-Indian and Indian media outlets contextualized the informal sector's involvement in handling e-waste with more than one description. Thus, each article was assigned two descriptions. An initial description both confronts the reader at the first mention of the informal sector and serves as the primary description, or “takeaway”, of its involvement in e-waste handling. A second description either further nuances the primary description or provides a distinctly different depiction. In some instances, articles did not provide a secondary description, offering only a single dimension to informal workers' actions related to e-waste. Descriptions are categorized as negative, neutral, or positive and results are reflected in (Figure 1. Primary Descriptions of the Informal Sector's Involvement in E-Waste Management, Figure 2. Secondary Descriptions of the Informal Sector's Involvement in E-Waste Management, and Table 5. Comparison of Informal Sector Descriptions in Non-Indian and Indian Print News Coverage).

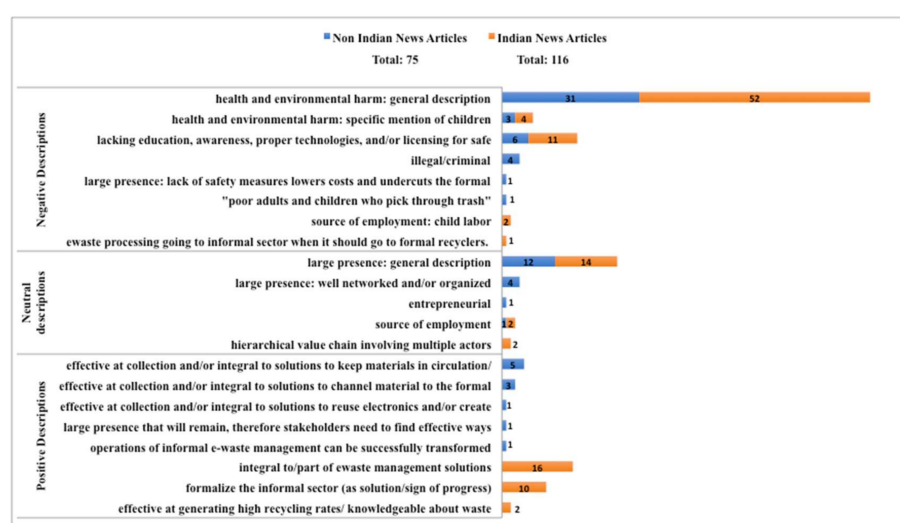


Figure 1. Primary Descriptions of the Informal Sector's Involvement in E-Waste Management.

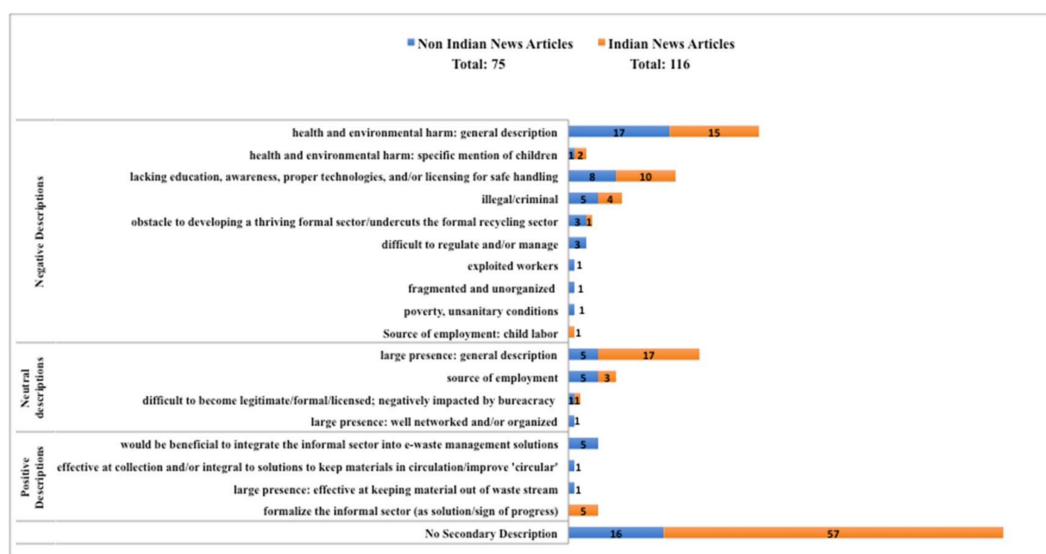


Figure 2. Secondary Descriptions of the Informal Sector's Involvement in E-Waste Management.

Table 5. Comparison of Informal Sector Descriptions in Non-Indian and Indian Print News Coverage.

	Distribution of Primary Descriptions			Distribution of Secondary Descriptions			
	Negative	Neutral	Positive	Negative	Neutral	Positive	No Secondary
Non-Indian Total: 75	46 (61%)	18 (24%)	11 (15%)	40 (53%)	12 (16%)	7 (9%)	16 (21%)
India Total: 116	70 (60%)	18 (15%)	28 (24%)	33 (28%)	21 (18%)	5 (4%)	57 (49%)

Negative descriptions, or those that describe the informal sector as problematic, most often focus on informal workers causing general harm to human health and the environment due to their e-waste handling practices or noting that the informal sector lacks the tools, education, and awareness to know that their actions cause harm. These descriptions do not provide a countervailing view of the informal sector's strengths or offer solutions for how to engage the informal sector effectively to manage e-waste safely.

Most non-Indian articles frame the informal sector's challenges and limitations in managing e-waste as problematic, often referencing specific processes, such as use of acid baths to extract gold and burning of cables to extract copper, and correlate them with respiratory diseases and soil contamination. The articles typically describe the informal sector's involvement in unsafe precious metals recovery—the last step of recycling electronics—often omitting the prior collection and dismantling stages that can demonstrate fewer impacts on health and the environment. Similarly, Indian news articles also most frequently depict the informal sector's negative impacts on health and the environment by referencing gold and silver extraction using acid and cyanide and burning wires to extract copper. They also often gloss over key, and often non-hazardous, collection and some dismantling steps, thus grouping all activities together as negative. Of note, dismantling can produce health hazards associated with dust inhalation, however, it can also easily be done safely with basic precautions, such as the use of masks and gloves.

Articles from both Non-Indian and Indian media sometimes mention child labor, documented throughout different stages of e-waste handling, in tandem with broad contamination and health impacts also involving children. Whereas health and environmental impacts persist most in the metals extraction and some dismantling stages, child labor is often problematic across all stages.

Many articles in the dataset acknowledge that informal workers lack the equipment and awareness to safely dismantle or otherwise process electronics, but omit ideas debated for how to remedy such challenges, such as helping workers access financing to purchase better tools or rent larger workspaces and educating them on health risks.

Finally, some articles describe informal workers as participating in illegal, criminal activity, yet are not specific as to why the activities are illegal. Articles often describe informal workers as ‘well-networked’, referring to such hierarchies that efficiently process material; conversely, others characterize them as ‘unorganized’, possibly (though not definitively) alluding to challenges with engaging informal workers as a collective entity since their activities usually occur hidden from view and hinge on small-scale, interpersonal ties within their communities.

Neutral descriptions reflect facts only without a negative or positive tone or connotation. They describe the informal sector as a significant, well-networked presence, where e-waste handling provides employment, or a source of livelihood, for thousands, and sometimes millions, of workers. Two articles describe the difficulties informal workers encounter when seeking licenses to register their businesses (such as bureaucracy), and thus become ‘formal’.

Positive descriptions, or those that describe the informal sector in the context of e-waste management solutions, highlight the informal sector as an important actor that stakeholders can (or must) engage to help foster both realistic and responsible e-waste management schemes. Such articles advocate leveraging the informal sector’s strengths, such as collection abilities and knowledge of waste management.

Indian news articles feature a comparatively higher percentage of positive initial and primary depictions of how informal efforts provide solutions to managing e-waste in India. Indian articles cover in greater detail challenges to engaging the informal sector, citing pilot projects that NGOs and multilateral institutions, such as the IFC, launched in collaboration with formal recyclers to test ways to leverage informal workers’ collection skills. Some Indian articles also highlight how the informal sector would add value based on its extensive knowledge of waste management and its ability to collect large amounts of material. Comparatively fewer articles from non-Indian media outlets cover the benefits of engaging the informal sector in detail, but those that do mostly cite its role in fostering a ‘circular economy’ and its effectiveness at collection and keeping material out of waste streams more generally. Despite the broad search terms used in the initial queries such as “business”, “government”, “policy”, and “90 percent”, the GoogleNews search query returned a comparatively limited set of results that either described informal workers’ entrepreneurial tendencies or the Indian government’s brief acknowledgement in the 2016 E-waste Rules that the informal sector can play a role (albeit undefined) in e-waste management [39].

For the non-Indian articles with no secondary description, twelve out of the 16 articles highlight negative impacts of informal workers, namely as causing harm to human health and the environment or lacking the awareness and tools to properly recycle electronics. Two articles provide a neutral connotation and two highlight how informal workers can positively contribute to e-waste management. For the Indian articles with no secondary description, 36 out of the 57 articles highlight negative impacts of informal workers, namely as causing harm to human health and the environment, lacking the awareness and tools to properly recycle electronics, or creating an impediment to the formal recycling sector’s growth. Five articles provide a neutral connotation and 16 articles highlight how informal workers can positively contribute to e-waste management.

Additional data analyses reflected in Appendix A shows which primary and secondary descriptions occur together, as each article was individually analyzed to capture the nature of the primary and secondary descriptions. If an article included both negative and positive descriptions of the informal sector’s involvement, ostensibly it might reflect greater balance in its depictions of informal workers. However, while most articles with a positive primary description were followed with a neutral or negative description, the reverse was not true for negative primary descriptions in both non-Indian and Indian news articles. Of the 46 non-Indian news articles with primary negative

descriptions, only 3 demonstrated a positive secondary description. Similarly, of the 70 Indian articles, only 5 demonstrated secondary positive descriptions.

Interpretation of Results for Contextual Descriptions

A chi-square test of independence was applied to determine the significance of the results, as reflected in (Table 6. Observed and (Expected) Values for Primary Descriptions and Table 7 Observed and (Expected) Values for Secondary Descriptions). The null hypothesis tested states that no relationship exists between Indian and non-Indian news outlets and how they depict the informal sector's involvement in e-waste management as positive, neutral, and negative.

The test statistic χ^2 was calculated

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

where

O = observed values

E = expected values

Table 6. Observed and (Expected) Values for Primary Descriptions.

	Negative	Neutral	Positive	Total
Non-Indian News Articles	46 (45.54973822)	18 (14.13612565)	11 (15.31413613)	75
Indian News Articles	70 (70.45026178)	18 (21.86387435)	28 (23.68586387)	116
Total	116	36	39	191

Table 7. Observed and (Expected) Values for Secondary Descriptions.

	Negative	Neutral	Positive	No Secondary Descriptions	Total
Non-Indian News Articles	40 (28.66492147)	12 (12.95811518)	7 (4.712041885)	16 (28.66492147)	75
Indian News Articles	33 (44.33507853)	21 (20.04188482)	5 (7.287958115)	57 (44.33507853)	116
Total	73	33	12	73	191

Thus,

$$\chi^2_{\text{(primary descriptions)}} = 3.747402258$$

$$\chi^2_{\text{(secondary descriptions)}} = 18.53975092$$

The following p values were calculated with two degrees of freedom for $\chi^2_{\text{(primary descriptions)}}$ and three degrees of freedom for $\chi^2_{\text{(secondary descriptions)}}$:

$$p_{\text{(primary descriptions)}} = 0.153554285$$

$$p_{\text{(secondary descriptions)}} = 0.000340335$$

The p value for primary descriptions at 0.15 (rounded) is higher than the conventionally accepted 0.05, but not high enough to where the null hypothesis appears to hold true. Rather, there appears to be a weak correlation between the place of origin for the media outlet (non-Indian vs. Indian) and the type of depiction of the informal sector. More data might draw a stronger conclusion or show a stronger correlation, where $p \leq 0.05$. However, this weak correlation appears to support the findings

from the contextual descriptions that not much difference exists between Indian and non-Indian news articles' negative portrayals of the informal sector. Articles from either India or outside India contain the same proportion of negative portrayals and are, overall, higher in count when compared to neutral or positive depictions. The p value may skew lower overall, staying at 0.15 rather than being even higher, potentially due to some nuance among Indian news articles that depict more positive portrayals in total count relative to non-Indian articles' positive portrayals. Overall, the weak correlation between variables may indicate that that country of origin may have less bearing on how the informal sector is portrayed.

In contrast, the p value for secondary descriptions at 0.0003 is significantly lower than the conventionally accepted 0.05, disproving the null hypothesis with greater confidence. Here, results may indicate a stronger overall correlation between non-Indian and Indian news outlets and portrayals of the informal sector due to the inclusion of the additional data point "no secondary description". Thus, there appears to be a relationship between whether the news article is non-Indian or Indian in origin and the lack of a second, perhaps more nuanced, description of the informal sector's involvement in e-waste management.

4.2. Key Words Used in Association with 'Informal'

Since words can introduce or reinforce particular imagery found in a text, specific words and phrases used in conjunction with the word 'informal' (to denote the informal workers or the informal sector more broadly) were also analyzed, after the contexts in which informal workers were described in news articles were assessed.

For the non-Indian news articles, 368 total words and 237 unique word forms appear in tandem with or in proximity to 'informal'. Total words refer to every occurrence of every word, whereas with unique word forms, multiple occurrences of words are only counted once. Voyant results indicate 371 total words but 368 are relevant to the text analyzed for non-Indian articles. The most frequent words or phrases, as displayed in Figure 3 were: 'illegal' (12 times); 'backyard' (9 times); dumping (8 times); open burning (8 times); toxic (8 times). For the Indian news articles, 412 total words and 258 unique word forms appear in tandem with or in proximity to 'informal'. Voyant results indicate 412 total words but 407 are relevant to the text analyzed. The most frequent words or phrases to appear were: kabadiwallahs (11 times); collection (10 times); low literacy (10 times); dismantling (8 times); open burning (8 times).

4.2.1. Most Frequently Used Words and Phrases

Results from Indian articles demonstrate use of 'rag pickers' and 'waste pickers' to describe informal workers, indicating some crossover use of terms often germane to general waste collectors in India. However, 'kabadiwallahs', a term commonly used throughout India among the general population to describe waste collectors, appears most frequently. For purposes of the analysis, all minor spelling variants were included as 'kabadiwallahs'. Anecdotal findings suggest that kabadiwallahs face deep stigmatization [60,61], and thus more research would elucidate if, or to what extent, the term 'kabadiwallah' is intentionally pejorative or if people use it so commonly that they do not intend for it to have, or even realize it might have, a derogatory meaning.

Overall, both non-Indian and Indian articles demonstrated a higher incidence of negative connotations associated with e-waste management practices, health and environmental implications, labor issues, and illegal activity, complementing the findings in the contextual analysis. Terms from non-Indian articles include: "hazardous; children; unorganized; gold; acid; dumps; lack of awareness; inefficient; little awareness of dangers; environmental damage; absence of protective materials; leach out; environmentally hazardous; dangerous; inappropriate methods; harmful emissions; rudimentary processes; organized crime; criminals; pulmonary and cardiovascular diseases; respiratory ailments; unlicensed; slowly poisoned; smuggling networks; illegal dismantling; burning; abuse; pollute; low literacy". Most words in Indian articles used to describe informal workers also reflect the

harmful impacts associated with their activities, highlight their poverty and lack of education, name key cities and towns where harmful activities occur, and portray informal efforts as exploited by others or nefarious. Terms from Indian articles include: “dumping; low literacy; pollution; cyanide; children; little awareness of the dangers of operations; environmentally harmful; unsafe; burning wires; ailments; contamination; Seelampur; Moradabad; sulphuric acid; respiratory ailments; unsafe; illegal; crude; toxic; human and environmental health risks; backyard; haphazardly; highly unscientific; leaching; child labor; without proper safety; open burning; damage of nervous system; skin disorders; not recycled safely; acid baths; choice between poison and poverty; unauthorized; primitive”.

Few accompanying descriptions reflect positive connotations in non-Indian articles, such as the following words and the number of times they appear: “good at what they do (2); adept at collection and conserving natural capital (1); need to train and integrate (1); efficient (1); identifying material and resource value (1)”. More solutions-oriented descriptions are found in Indian news articles and include the following: “microfinance; skilling; waste is as much about people who handle waste as it is people who discard waste; innovative; capacity building; solutions; need to set up cooperatives; need to convert into a more organised sector; cleaning and segregating waste; helping to save the public money and reduce greenhouse gases; social enterprise; inculcates repair and recycle process; solutions”.

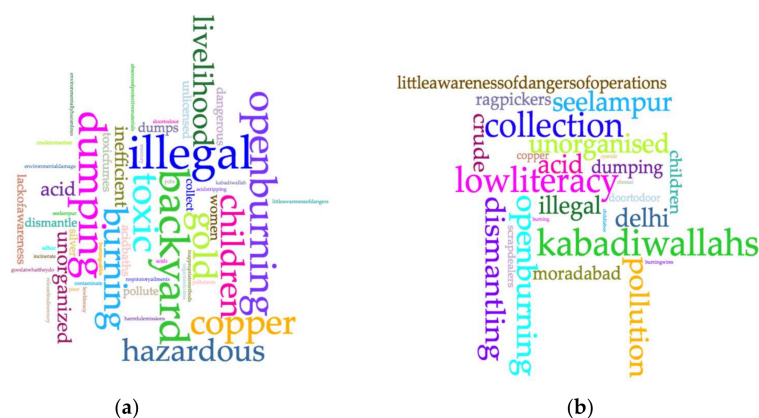


Figure 3. This figure represents a word cloud of the most frequently used words and phrases describing the informal sector in news articles: (a) contains the most frequent words in non-Indian print news articles (source for non-Indian articles analysis in Voyant: <http://voyant-tools.org/?corpus=e3210ac0b0ad25bdcdcf2a5649e1349>); (b) contains the most frequent words in Indian print news articles (source for Indian articles analysis in Voyant: <http://www.voyant-tools.org/?corpus=e256bfbe02713b755a6889732ca43119>).

4.2.2. Words and Phrases Describing E-Waste Management Practices or Methods

Since many of the words and phrases used in conjunction with ‘informal’ across all articles refer to how e-waste is managed, analysis was conducted on whether certain methods were framed as neutral/positive or negative. Neutral words or phrases lack adjectives and are usually a noun (e.g., “collection”); positive words or phrases (only six words throughout non-Indian articles and four across Indian articles) include ameliorative words (e.g., “good as what they do” and “sustainable harvesting”); negative words or phrases include pejorative words (e.g., “crude”, “highly unscientific”, “contaminate”, “improper”). Of note, though the terms ‘collection’ and ‘dismantling’, occur with greater frequency in Indian articles as compared to non-Indian articles and are themselves described in neutral terms, when examined in context, they appear in sentences discussing the informal sector’s problematic involvement in managing e-waste. Without clearly defining risks attributed to each activity in the e-waste management chain (i.e., collection, dismantling, metals recovery), articles often lump ‘collection’ and ‘dismantling’ together with harmful activities, and thus the overall impression for the viewer may be a net negative one. Figure 4 reflects the number of negative and neutral/positive

words or phrases that describe e-waste management practices or methods in non-Indian and Indian news articles.

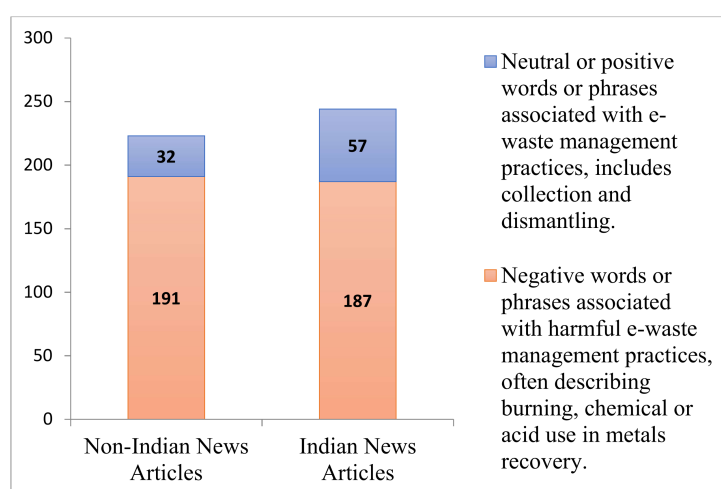


Figure 4. This figure represents the amount of words or phrases that are negative or neutral/positive in describing e-waste management practices or methods across both non-Indian and Indian news articles.

4.2.3. Interpretation of Results for Key Words and Phrases Associated with E-Waste Management Practices or Methods

Another chi-square test of independence was applied to determine the significance of the results as reflected in (Table 8. Observed and (Expected) Values for Specific Words & Phrases Describing Methods Associated with Informal Workers' and E-Waste Management). The null hypothesis tested states that no relationship exists between non-Indian and Indian news outlets and the specific words and phrases they use to describe the methods the informal sector employs to manage e-waste.

The test statistic χ^2 was calculated

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

where

O = observed values

E = expected values

Table 8. Observed and (Expected) Values for Specific Words & Phrases Describing Methods Associated with Informal Workers and E-Waste Management.

	Negative	Neutral or Positive	Total
Non-Indian News Articles	191 (180.5010707)	32 (42.49892934)	223
Indian News Articles	187 (197.4989293)	57 (46.50107066)	244
Total	378	89	467

Thus,

$$\chi^2_{(\text{methods})} = 6.132875822$$

The following p value was calculated with one degree of freedom for χ^2 (methods):

$$p_{\text{(methods)}} = 0.013269087$$

The low $p_{\text{(methods)}}$ value effectively disproves the null hypothesis, indicating a strong correlation between non-Indian and Indian news outlets and the types of words and phrases used to describe e-waste management practices and methods associated with the informal sector. Of note, when Yates' continuity correction is applied to this chi-square test, the results are also statistically significant, where $p_{\text{(methods)}} = 0.0183$.

5. Discussion

Though findings from this study reflect mainstream media portrayals for a limited dataset, should they indicate larger trends in media depictions of informal workers—both within India and globally—they could help inform stakeholder agendas seeking to influence public awareness on if and/or how to integrate informal workers into viable e-waste management solutions. The data also provides a preliminary mirror for stakeholders to see the how their agendas are or are not currently reflected back into the public sphere.

First, a more complete and nuanced picture that parses out the environmental, health, and labor impacts of each step in the e-waste management chain would more effectively describe how and why specific informal sector activities are harmful to human welfare. Both non-Indian and Indian articles accurately and consistency describe the harmful impacts due to informal recycling, reflecting the success of sustained (often NGO-led) campaigns over the last decade to bring attention to the dangers of key informal activities, namely use of acid baths and open burning in uncontrolled environments without safety measures, and also some dismantling activities under conditions that do not prevent harmful dust inhalation. Yet findings across non-Indian and Indian articles demonstrate that negative impacts from the informal sector's involvement in e-waste management, such as child labor, health risks, and environmental harm, are often grouped together without denoting which activities are more alarming than others for environmental or social reasons or both. As such, audiences—predominantly Western readers from industrialized countries who are less familiar with different aspects of e-waste management among informal workers in India—may form an opinion of the informal sector that accounts for only the negative aspects of its involvement with e-waste without fully understanding the nuances of how informal workers' involvement in collection and (some) dismantling carries much lower risks and can help solve challenges to enacting e-waste management solutions. Several stakeholders, including prominent NGOs such as the U.S.-based Basel Action Network and India-based Toxics Link have advocated stopping the flow of obsolete electronics from the global North to the global South to reduce harm, a perspective represented in the articles. Such is but one solution, however, it does not address the problem of growing amounts of e-waste within India. As such, some NGOs, including Toxics Link, have therefore been active in helping to devise capacity building training programs for informal workers and issued reports on ways to design schemes that integrate informal workers to leverage their strengths in collection [31].

Likewise, without clearer demarcations of what kinds of informal activities are harmful or illegal versus helpful or accepted in managing e-waste, readers may also perceive all informal sector involvement as problematic and not consider the informal sector's strengths in collection and most dismantling. Moreover, describing the informal sector's involvement generally as 'illegal', may confuse the public's perception of what constitutes environmentally sustainable and unsustainable e-waste management. Does "illegal" refer to violating environmental regulations (as uncontrolled use and disposal of chemicals likely do) or to operating businesses without proper licenses or to avoiding paying taxes? Many informal workers' incomes are usually below the minimum tax threshold, defined as subsistence activity, and therefore cannot be perceived as illegal; in contrast, activities are illegal where operators with incomes above the minimum tax threshold bypass national and/or local laws

and regulations [62]. Thus, when articles use the term ‘illegal’, it is unclear which activities they are referring.

Second, a ‘systems-based’ versus ‘linear’ narrative would help illuminate other socio-economic factors impacting how and why the informal sector engages in e-waste management. Most news articles in the dataset present the informal sector’s involvement in handling e-waste as a simplified linear narrative, where illegal exports of used electronics from industrialized countries enter less industrialized countries and are processed in “digital dumping grounds”. In India, a tapestry of issues surrounds and affects informal workers engaged in e-waste related to employment, education, urban migration, and stigmatization based on religious or caste affiliation, among others [38,63]. Thus, lack of nuanced depictions oversimplifies other dynamics affecting informal workers’ choices to engage in e-waste. A systems approach would move beyond cause-effect and include multiple contributing factors mutually influencing each other. For example, recent high-profile crackdowns on informal recycling operations in Moradabad reflect progress in stemming the spread of harmful processing, potentially as a result of sustained public attention [46,47]. Yet further discussion of what happens to thousands of informal workers when their recycling operations are raided and shut down by authorities might prove illustrative on whether the problem has been solved or if informal recycling will simply migrate elsewhere, especially since many informal workers (in Moradabad in particular) have been engaged in the scrap and metals trade for a long time. Critical media coverage can still recognize the benefits of eradicating harmful informal operations but can also examine challenges informal workers face regarding issues such as employment, education, health, and gender equity when their incomes from recycling cease. The challenge for the media lies in doing so without overgeneralizing or over-romanticizing the circumstances of such workers.

In another example, certain non-Indian and Indian articles mention the hierarchical, well-networked nature of the informal sector, but do not tease out the interdependencies and complexities of how informal workers work with each other. Scholarly and NGO research have combed through such interactions [38,64]. Translating academic findings for a mainstream audience could inform the public on how to engage informal workers successfully or why challenges to do so persist. Do the relationships between informal workers, often built on trust and kinship ties, affect external efforts to leverage their skills or integrate them into formal recycling efforts? Perhaps, controversially, how does the presence of corruption affect initiatives seeking to promote transparency? Do any dynamics resulting from larger societal power structures remain unchallenged with the current portrayal of how informal workers engage in e-waste management? Who stands to gain or lose should the narrative become more nuanced? Both non-Indian and Indian articles also generally do not describe the different informal actors, hierarchies and power dynamics present within those hierarchies, which could highlight who possesses greater agency than others in managing e-waste.

Third, a simplified narrative, where the informal sector’s role is associated with a cradle-to-grave trajectory for e-waste, also limits a more expansive discussion of the informal sector’s role in a ‘circular economy’ which “design[s] out waste and pollution, keep[s] products and materials in use, [and] regenerate[s] natural systems” [62,65].

According to the Ellen McArthur Foundation, in a circular economy.

“Companies need to build core competencies in circular design to facilitate product reuse, recycling and cascading. Circular product (and process) design requires advanced skills, information sets, and working methods. Areas important for economically successful circular design include: material selection, standardized components, designed-to-last products, design for easy end-of-life sorting, separation or reuse of products and materials, and design-for-manufacturing criteria that take into account possible useful applications of by-products and wastes” [66].

Reuse, collection, and basic dismantling of used electronics exemplify such circularity. Yet, most articles that highlight the harmful impacts from metals extraction either gloss over or omit mention of

reuse. Informal workers have a large presence in refurbishing used products in India, as seen from the basements of Seelampur that repurpose used CRTs to the shops in Delhi's Nehru Place hawking repairs for mobile phones and laptops. Refurbishment of used products provides employment to many informal workers, often distinct from informal recyclers.

Recycling in most industrialized countries tends to rely on mechanized separation and recovery, whereas in other countries, especially in India, many aspects of managing obsolete electronics depend on manual labor. 'Circularity', therefore, may appear different in different countries. Portrayals of workers manually dismantling electronics with simple tools, often seen in the informal sector, can be construed and interpreted differently, depending on how the narrative is contextualized for specific audiences. Articles in the dataset often referenced "rudimentary" and "inadequate" tools that, when used correctly, can safely and effectively separate components to recover high-value material. In cases where Western audiences are not familiar with which kinds of manual activities are harmful or benign—because they live in more mechanized economies and are less exposed to manual labor—they would be more reliant on media depictions for explanations. What place do non-mechanized, labor-intensive activities occupy in debates around fostering a circular economy, as understood by stakeholders in both industrialized and non-industrialized countries alike?

6. Conclusions

Most current print news coverage of the informal sector's involvement in e-waste from both non-Indian and Indian media outlets lags policy discussions currently focused on integrating informal workers into sound e-waste management schemes. For example, stakeholders are currently considering piloting approaches that include using mobile devices to track e-waste collected by informal workers; leveraging informal capabilities to collect e-waste from municipal governments; and examining the role of microfinance or other financial incentives for informal workers to access capital to operate more transparently and safely [67–69].

Findings from the dataset highlight an opportunity for policymakers, electronics manufacturers, and NGO/advocacy groups to bridge the gap between current media representations of informal workers' involvement in e-waste management and how the stakeholder community debates and envisions the role of the informal sector. Greater context and nuance in media representations of informal workers' involvement in managing e-waste might benefit stakeholders seeking to engage the informal sector in e-waste solutions and generate public support for their efforts. More clearly delineating which activities are deemed beneficial versus harmful to human health and the environment may be important in shaping public perception of the informal sector's evolving role and future involvement in such initiatives.

All stakeholders could benefit from engaging with media outlets to advance a more nuanced portrayal of informal workers. Policymakers would benefit from communicating different aspects of the informal sector's role in managing e-waste and any related progress in formalizing their efforts to the public. A more consistent and thorough explanation of how the informal sector is well positioned to undertake collection, aggregation, and some basic dismantling activities could help the general public better understand how the informal sector can add value to sound e-waste management practices. Manufacturers subject to recycling targets under EPR regulations in India and in other countries with large informal sectors might feel more comfortable participating in pilot initiatives that work with informal collectors and dismantlers to direct material into safe end processing without fear of negative publicity in being linked to informal workers. Nuanced media depictions may also help global electronics companies better explain participation in such pilots with informal workers to Western audiences less familiar with how the informal sector can positively contribute to sound e-waste management. NGOs could benefit if donors possess an understanding of small gains made amidst an evolving and complicated issue, potentially allowing for expectations to align with realistic impacts. Finally, even mainstream media could benefit from multifaceted portrayals, despite short-term gains that favor sensationalist simplistic coverage, such as higher ratings, more re-tweets, and accolades

(per the adage “if it bleeds it leads”). Stories can still lead with coverage of health and environmental risks but then delve into a more comprehensive discussion of how informal workers can contribute to solutions or how broader (and potentially equally controversial) socio-economic factors impact, or are driven by, informal workers’ harmful activities. In short, media outlets can still create riveting narratives amidst more nuanced discussions.

Media stories balancing multiple, and often opposing, viewpoints, may not necessarily reflect that some views may be more deeply shared among stakeholders. Conversely, an unbalanced story may omit viewpoints from stakeholders that lack access to forums where they can express their concerns, or, minimize voices that are less successful in leveraging their networks to amplify and circulate their perspectives in the public sphere. As such, results from this study point to additional research ideas to generate further insights into media depictions of the informal sector’s involvement in e-waste.

As noted earlier, a study of multimedia coverage from different countries would further inform results from this study. Do similar representations exist among a larger dataset of print media in other languages (including local languages in India) and among the numerous documentaries, news video clips, and radio clips available? Does such a wider dataset point to different representations or issues discussed?

Next, studies employing issue mapping and digital research techniques could examine linkages between actors to identify *who* is promulgating specific depictions of informal workers. What agendas are they promoting? Which of their agendas is most often represented in media coverage? Moreover, it would also be interesting to determine the extent to which media depictions are congruent with governments’, NGOs’, and multilateral institutions’ portrayals of informal workers in their reports within India and in other countries.

Future research topics could explore the extent to which media portrayals of informal workers influences the public’s perception of them. How do audiences perceive e-waste collection schemes that try to involve the informal sector, when most mainstream media coverage frames the informal sector’s activities in the context of pollution, crime, and illness?

Other studies could examine the extent to which informal workers themselves are aware of how the media depicts their actions and, if so, what consequences result from such depictions? In many instances, informal workers on the streets of Seelampur and Mustafabad declined to speak about their activities related to handling e-waste [70]. Other studies also cite reluctance or refusal by informal workers to speak to researchers [27]. Studies based in ‘ethnographic refusal’—“where researchers and research participants *together* decide not to make particular information available for use within the academy to ensure that communities are able to respond to issues on their own terms [71]”—could examine why informal workers in India often refuse to provide those outside their communities with information (an ethnographic refusal “is intended to redirect academic analysis away from harmful pain-based narratives that obscure slow violence, and towards the structures and institutions that engender those narratives. It is a method centrally concerned with a community’s right to self-representation” [71]). Does aligning the informal sector with negative impacts of e-waste handling perpetuate any existing biases against informal workers in India?

Finally, a study examining if, and to what extent, repeated use of the term ‘electronic waste’ in conjunction with depictions of informal workers’ involvement in collecting, dismantling, and recycling used electronics is leveraged to justify any slow violence against them. Gidwani and Reddy’s examination of “waste” as the political other of capitalist “value” where “things, places, and lives . . . are cast outside the pale of “value” at particular moments as superfluidity, excess, and detritus, only to return at times in unexpected ways” [63] (p. 1625) points to depictions of slum dwellers in Delhi’s 2021 Master Plan as ‘urban hazards’ and a ‘nuisance’ [63] (p. 1644). Gidwani and Reddy also highlight eviction drives and police harassment of poor hawkers in Bangalore and how informal e-waste workers were initially shunned in government-supported efforts to modernize e-waste disposal practices in 2004 [63]. Existing studies examining ‘humans as waste’ [72] could also provide further insights on the extent to which informal e-waste workers have *themselves* been rendered abject. Does the term ‘waste’,

when applied to obsolete electronics, also correlate, in some way, to how informal workers who handle e-waste are depicted?

Answers to these questions may provide insights into how stakeholders and mainstream media alike can frame the complexities, challenges, and opportunities in managing obsolete electronics going forward in ways that meet their goals.

Supplementary Materials: The following are available online at <http://www.mdpi.com/2071-1050/10/4/966/s1>.

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Appendix

Table A1. Primary Description Followed by Secondary Description for Non-Indian News Articles.

Count of Primary Description Followed by Secondary Description	
Non-Indian News Articles' Descriptions of the Informal Sector's Involvement in Managing Electronic Waste (Denoted as Negative, Neutral, or Positive)	Total
health and environmental harm: general description (negative)	31
difficult to regulate and/or manage (negative)	2
exploited workers (negative)	1
illegal/criminal (negative)	5
lacking education, awareness, proper technologies, and/or licensing for safe handling (negative)	4
large presence: general description (neutral)	4
large presence: well networked and/or organized (neutral)	1
no secondary description	7
obstacle to developing a thriving formal sector/undercuts the formal recycling sector (negative)	1
poverty, unsanitary conditions (negative)	1
source of employment (neutral)	3
would be beneficial to integrate the informal sector into ewaste management solutions (positive)	2
large presence: general description (neutral)	12
difficult to regulate and/or manage (negative)	1
effective at collection and/or integral to solutions to keep materials in circulation/improve 'circular' economy and/or reduce resource extraction (positive)	1
health and environmental harm: general description (negative)	4
health and environmental harm: specific mention of children (negative)	1
lacking education, awareness, proper technologies, and/or licensing for safe handling (negative)	2
obstacle to developing a thriving formal sector/undercuts the formal recycling sector	1
source of employment (negative)	1
would be beneficial to integrate the informal sector into ewaste management solutions (positive)	1
lacking education, awareness, proper technologies, and/or licensing for safe handling (negative)	6
large presence: effective at keeping material out of waste stream (positive)	1
no secondary description	5

Table A1. Cont.

Count of Primary Description Followed by Secondary Description	Total
Non-Indian News Articles' Descriptions of the Informal Sector's Involvement in Managing Electronic Waste (Denoted as Negative, Neutral, or Positive)	
effective at collection and/or integral to solutions to keep materials in circulation/improve 'circular' economy and/or reduce resource extraction (positive)	5
fragmented and unorganized (negative)	1
health and environmental harm: general description (negative)	2
no secondary description	2
illegal/criminal (negative)	4
health and environmental harm: general description (negative)	3
would be beneficial to integrate the informal sector into ewaste management solutions (positive)	1
large presence: well networked and/or organized (neutral)	4
health and environmental harm: general description (negative)	2
lacking education, awareness, proper technologies, and/or licensing for safe handling (negative)	1
no secondary description	1
effective at collection and/or integral to solutions to channel material to the formal sector for recycling (positive)	3
health and environmental harm: general description (negative)	1
source of employment (neutral)	1
would be beneficial to integrate the informal sector into ewaste management solutions (positive)	1
health and environmental harm: specific mention of children (negative)	3
difficult to become legitimate/formal/licensed; negatively impacted by bureaucracy (neutral)	1
lacking education, awareness, proper technologies, and/or licensing for safe handling (negative)	1
large presence: general description (neutral)	1
large presence: lack of safety measures lowers costs and undercuts the formal recycling sector (negative)	1
health and environmental harm: general description (negative)	1
"poor adults and children who pick through trash" (negative)	1
health and environmental harm: general description (negative)	1
effective at collection and/or integral to solutions to reuse electronics and/or create jobs via reuse (positive)	1
health and environmental harm: general description (negative)	1
entrepreneurial (neutral)	1
no secondary description	1
large presence that will remain, therefore stakeholders need to find effective ways to work with informal workers (positive)	1
health and environmental harm: general description (negative)	1
source of employment (neutral)	1
health and environmental harm: general description (negative)	1
operations of informal e-waste management can be successfully transformed (positive)	1
obstacle to developing a thriving formal sector/undercuts the formal recycling sector (negative)	1
Grand Total	75

Table A2. Primary Description Followed by Secondary Description for Indian News Articles.

Count of Primary Description Followed by Secondary Description	
Indian News Articles' Descriptions of the Informal Sector's Involvement in Managing Electronic Waste (Denoted as Negative, Neutral, or Positive)	Total
health and environmental harm: general description (negative)	52
difficult to become legitimate/formal/licensed; negatively impacted by bureaucracy (neutral)	1
formalize the informal sector (as solution/sign of progress) (positive)	3
illegal/criminal (negative)	2
lacking education, awareness, proper technologies, and/or licensing for safe handling (negative)	7
large presence: general description (neutral)	9
no secondary description	28
source of employment (neutral)	1
source of employment: child labor (negative)	1
integral to/part of ewaste management solutions (positive)	16
health and environmental harm: general description (negative)	2
lacking education, awareness, proper technologies, and/or licensing for safe handling (negative)	2
large presence: general description (neutral)	4
no secondary description	6
source of employment (neutral)	2
large presence: general description (neutral)	14
health and environmental harm: general description (negative)	7
health and environmental harm: specific mention of children (negative)	1
lacking education, awareness, proper technologies, and/or licensing for safe handling (negative)	1
no secondary description	4
obstacle to developing a thriving formal sector/undercuts the formal recycling sector (negative)	1
lacking education, awareness, and/or proper technologies or licensing for safe handling (negative)	11
formalize the informal sector (as solution/sign of progress) (positive)	1
health and environmental harm: general description (negative)	2
large presence: general description (neutral)	2
no secondary description	6
formalize the informal sector (as solution/sign of progress) (positive)	10
health and environmental harm: general description (negative)	1
no secondary description	9
health and environmental harm: specific mention of children (negative)	4
formalize the informal sector (as solution/sign of progress) (positive)	1
illegal/criminal (negative)	1
large presence: general description (neutral)	1
no secondary description	1
effective at generating high recycling rates/ knowledgeable about waste (positive)	2
health and environmental harm: general description (negative)	1
no secondary description	1
hierarchical value chain involving multiple actors (neutral)	2
health and environmental harm: general description (negative)	1
illegal/criminal (negative)	1
source of employment: child labor (negative)	2
health and environmental harm: general description (negative)	1
health and environmental harm: specific mention of children (negative)	1
source of employment: general (neutral)	2
large presence: general description (neutral)	1
no secondary description	1
ewaste processing going to informal sector when it should go to formal recyclers (negative)	1
no secondary description	1
Grand Total	116

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