



SYSTEMATIC ASSESSMENT OF OCCUPATIONAL HEALTH AND SAFETY FACTORS AMONG INFORMAL RECYCLING ACTORS IN ISLAMABAD: CHALLENGES AND IMPLICATIONS FOR OCCUPATIONAL SUSTAINABILITY

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Abstract

Although informal recycling actors retrieve valuable resources and relieve pressure on municipal services, they largely exist beyond labour regulations, health monitoring and social protection. This research evaluated OHS concerns among the informal recycling actors group in Islamabad, Pakistan. A cross-sectional survey was carried out in May, 2024 among 121 informal recycling actors (divide into 5 roles, i.e., waste pickers, mobile buyers of waste, local junkshops, scrap dealers and informal processors of recyclables). Structured interviews were conducted on their demographic information, work pattern, injuries, common symptoms, trainings, PPEs usage, provision of medical or social protection and income effects. Role specific patterns were examined using descriptive statistics. The majority of the sample population was men, low in education and informal work training. Waste pickers were the most vulnerable, 86.7% with no formal education and no work-related training; processors and dealers reported high exposure, mainly in informal settings, to work-related training. Almost all workers were injured, nearly all had some scratch or cut, the greatest numbers with piercing injury were among junkshop owners and waste pickers, burning injuries mainly among processors and broken bones most among waste pickers, mostly with sharp items, metal parts, nails, pins, wires and heavy manual labour. Workers also had common reports of skin irritation, musculoskeletal pain, nose irritations, coughs, anxiety and fatigue. The provision and use of PPEs was poor and in particular that of waste pickers and mobile buyers of waste. The mean number of lost working days was 18.6 and the median was 18 days in last 12 months, indicating that otherwise seemingly small injuries could have significant income implications. Informal recycling actors do not form one homogeneous occupational group and different tasks along the recycling chain hold different risks. Recommendations for the cost-effective provision of PPEs, safer work areas (sorting zones), waste segregation, occupational training, vaccination, basic first aid access, and gradual legitimization of informal recyclers into urban planning should be developed in consultation with them, without jeopardizing livelihoods.

Keywords: Occupational health and safety condition, Informal recycling sector, Worker training, Solid waste management practices, Safety hazard, Work-related health issues, Personal protection

1. Introduction

Informal recycling constitutes a prominent but poorly protected facet of urban waste management in most low and middle income countries. Waste pickers, mobile buyers, junkshop holders, scrap dealers and informal processors retrieve papers, plastics, glass, metals and other materials before they enter the landfill or open dumpsite, supporting resource recovery, decreasing landfill burden and assisting with circular economy targets. However, the informal workers often work without an employment contract, health insurance, regular training, adequate tools or municipality support. International reports on waste and e-waste indicate that recovery of secondary materials is becoming increasingly important as urban waste volume increases with urbanization and recycling markets expand (Kaza et al., 2018; Forti et al., 2020; UNEP and ISWA, 2024; Balde et al., 2024). Thus, the social value of this work is evident while the health burden is largely imposed on the poorest of workers.

Previous studies have consistently demonstrated association between informal waste work and cuts, punctures, burns, musculoskeletal disorders, skin diseases, respiratory problems, gastrointestinal conditions and psychological stress. In India, Nepal, South Africa, Nigeria, Ghana and Palestine, direct handling of solid waste, broken glass, corroded metals, needles, chemical containers, animal carcasses and putrefying organic matter constantly places informal workers at risk of injury and the risk is exacerbated by poor source segregation and the inflow of hazardous material into the general solid waste stream (Chokhandre et al., 2017; Black et al., 2019; Schenck et al., 2019; Al-Khatib et al., 2020; Ali and Yusuf, 2021; Uhunamure et al., 2021). Such risks exist even among formal workers collecting waste, and have been found to arise from heavy lifting, prolonged awkward work postures, lengthy transport distances, exposure to traffic and unavailability of appropriate PPEs, resulting in fatigue and injury (Abou-ElWafa et al., 2012; Jayakrishnan et al., 2013; Velasco Garrido et al., 2015; Ephraim et al., 2021; Lissah et al., 2022).

The informal recycling value chain is not monolithic. Street-level waste pickers operate among open dumps, traffic hazards, poor hygiene, and social harassment. Itinerant buyers move within and between residential and market areas, facing strain from lifting and risk from dust and traffic. Junkshop owners and workers deal with substantial volumes of sorted and partially sorted material in cramped and dangerous yards with sharp surfaces, unstable piles and lack of ventilation. Scrap dealers typically deal with heavier materials than junkshop workers. Informal processors may melt, burn, shred, or wash metals and plastics. Informal e-waste recycling in particular, studies show may pose chemical, respiratory, dermal, and ergonomic risks in addition to ordinary injury risks from burning, dismantling and heating metals (Ohajinwa et al., 2017; Acquah et al., 2021; Eckhardt and Kaifie, 2024). These varied roles therefore mean that one size does not fit all, and different informal occupations require tailored solutions to ensure worker safety.

In Pakistan, informal recycling fills many of the voids in formal municipal systems, but few studies have addressed informal worker health. Existing literature notes that the Pakistani informal recycling sector is undocumented, unregulated, and heavily reliant on workers in poverty, many of whom are migrants, Afghan refugees or children (Kamran et al., 2015; Nawaz et al., 2021; ILO, 2023). Children engaged in waste picking in Pakistan are also described by the International Labour Organization as suffering from poor living conditions, low levels of education, hazardous working environments and the exclusion of protective measures (ILO, 2023). Pakistan's hazardous waste policy aims at reducing exposure to hazardous waste by improving governance and safe disposal of hazardous materials (Ministry of Climate Change, 2022), but few studies in Pakistan have empirically measured occupational injury patterns across different formal roles. While blood borne infection risk among formal street waste handlers has been studied (Khalil et al., 2022), information on occupational injury types, absence from work, use of PPE, training and social protection are scarce across the informal recycling chain.

Islamabad is an appropriate setting to study the health risks of informal work because informal recovery activities are conducted in different types of environment: residential areas, markets, informal settlements, roadsides, junkshops and small processing units. These sites connect the formal and informal municipal waste economy and the workers operating there are largely omitted from official occupational health policies. This study therefore examines health and safety conditions for informal waste recycling actors in Islamabad. Specific aims are to: determine the incidence of various hazards and injuries among the different actors; determine their health outcomes and workload patterns; identify access to relevant training, PPE, and medical or social support systems; and determine the extent to which injuries affect the livelihoods and productivity of the informal recycling actors.

2. Materials and Methods

2.1 Study design and setting

A cross-sectional field survey was conducted in the urban setting of Islamabad Capital Territory during May, 2024. A cross-sectional survey was chosen due to its suitability in measuring prevalent exposures to occupational hazards, injuries, symptoms and the prevalence of protective measures for multiple jobs of the informal recycling sector at one time. Occupational and environmental health studies often use cross-sectional study designs to estimate the prevalence and to compare different groups of exposures rather than establishing causality in the long term (von Elm et al. 2007 and Porta et al. 2009). Included areas were collection centers for residents and for commercial and household use, poor settlements, roadside and street based sellers of materials, junk shops, scrap markets, and peripheral units for processing and dismantling.

2.2 Participants and sampling

The study target population was the informal recyclers defined as people who are currently involved in the following activities of recyclable materials: collection, buying, sorting, trading or processing. This kind of workforce is transient and not registered in employment figures so a venue based time locations approach was adopted during the field surveys which is commonly known as appropriate for hard-to-reach occupational groups (Muhib et al., 2001; Raifman et al., 2022). The workers selected should be currently working in informal recycling, working for at least six months to gain a certain level of understanding of the job and occupational exposures, so there were 121 participants that completed structured interview; these included: waste collectors (n=30), mobile waste buyers (n=18), junkshop owner/worker (n=39), scrap dealer (n=23) and informal recycling processor (n=11).

2.3 Data collection tools and variables

A structured questionnaire was constructed in both English and Urdu languages, and pre-tested to check the wording and understanding of the questions. This questionnaire also captured the sex, education, position at work, number of working hours a day, number of working days a week, training information and job satisfaction. Questions on injury captured whether respondents suffered scratches, cuts, piercing injuries, bruises, back pain, strains, sprains, burns and fractures within the preceding 12 months. Respondents were further questioned on whether the injury interfered with their regular work, and the number of days missed from work as a consequence of the injury. A list of probable injury causes was also used which included sharp edges, glass, pieces of metal, nails, needles, wires, faulty tools or equipment, work involving heavy lifting, manual handling, and slippery surfaces, falls, etc.

Questions regarding health symptoms also reported frequently in the literature for waste workers included skin irritation, rashes, pains in joints or muscles, irritation of nose, coughing, chest irritation or pain, headache, dizziness, anxiety or stress, digestive upset (gastrointestinal illness), illness carried by vector, and tiredness (Black et al., 2019; Sapkota et al., 2020; Uhunamure et al., 2021; Gowda et al., 2023). The questions about safety measures covered the presence or absence of worker training, the provision of PPEs by employer and self-reported PPEs use by the worker, medical cover or social security and a first aid kit being present at work. This facilitated associating physical hazards with the relevant practical control measures, rather than just describing the injury itself.

2.4 Data management and analysis

The completed questionnaires were examined by double-entered into a data base to determine discrepancies prior to statistical analysis and then entered using an established codebook (Paulsen et al., 2012). A multiple-response question, each option was separated into distinctive indicator variables to ease analysis. Pattern of missing data was reviewed for transparency, and a complete-case analysis approach was useful to each resulted variables, with clearly reported of corresponding denominators (Ross et al., 2020; Hughes et al., 2019).

Data was analyzed using Pandas, Numpy, Statsmodels, and Matplotlib in Python. Descriptive statistics were presented overall and by occupation. For categorical variables, absolute numbers and percentages were presented. For continuous variables, mean SD and median [IQR] were given. Comparison of number of working hours and number of working days by occupation were performed using Kruskal Wallis tests where necessary (Ostertagov et al., 2014).

For the binary outcomes of injury, proportions were given with 95% Wilson confidence intervals which are more stable for small/extreme proportions than Wald intervals (Newcombe & Altman, 2000; McGrath & Burke, 2024). Occupational differences in the prevalence of injury were analyzed using Pearson chi square tests, with Cramer's V being reported as the measure of effect size (Rea & Parker, 2014). Due to the cell sizes the analysis was largely descriptive for estimating prevalence: this is in line with current recommendations on reporting observational data and caution with small cell counts (Newcombe, 1998; Ostertagova et al., 2014).

The association between occupation and injury was investigated using correspondence analysis on the contingency table and displayed on the first two dimensions (Sourial et al., 2010; Riani et al., 2022). Results were further displayed as bar graphs, heatmaps, correspondence analysis (CA) plots and histograms.

2.5 Ethics

The individuals involved volunteered to take part in the interview and informed consent was taken prior to the interviews. No names were kept in the data file of the analysis. Ethical principles including the right to know, respect, confidential treatment and the duty of care to prevent harm in medical research were applied (World Medical Association, 2013; CIOMS, 2016). Some of the interviewees were migrants or a particularly vulnerable sector of the population, therefore simple mode of questions was used during interviews and the participants were not pressurized.

3. Results

3.1 Workforce profile and occupational roles

As shown in Table 1, the group with the biggest number is the Junkshop holders/workers (n = 39; 32.2%), followed by Waste pickers (n = 30; 24.8%), Scrap dealers (n = 23; 19.0%), Itinerant waste buyers (n = 18; 14.9%), and Informal recycling processor (n = 11; 9.1%).

Table 1. Distribution of respondents by informal recycling role (n = 121)

Informal actor	n	Percent %	Cumulative %
Informal processor	11	9.1	9.1
Itinerant buyer	18	14.9	24.0
Junkshop holder/worker	39	32.2	32.2
Scrap dealer	23	19.0	75.2
Waste picker	30	24.8	100.0
Total	121	100.0	—

Most of the samples were males as indicated in Table 2. The only group that showed female respondents was the waste pickers. Educational profile varied from one role to the other. Most of the waste pickers and the itinerant buyers were uneducated (86.7% and 50.0% respectively), whereas the scrap dealers (60.7%), processors (54.6%), and junkshop holder/workers (35.9%) generally had a high school level or higher education.

Also the training received while working varied according to the job performed. No training was reported by waste pickers and itinerants buyers. 81.8% of processors and 73.9% of scrap dealers and 59.0% of junkshop holder/worker had received some work-related training. Field observations confirmed this instruction was largely informal and provided by experienced workers.

Table 2. Selected demographic and protection characteristics within occupational role (%)

Variable	Junkshop	Waste picker	Scrap dealer	Itinerant buyer	Informal Processor
Male	100	80.0	100	100	100
Uneducated	17.9	86.7	8.7	50.0	9.1
Primary education	46.2	13.3	30.4	38.9	36.4
Middle or above	35.9	0.0	60.7	11.1	54.6
Work-related training	59.0	0.0	73.9	0.0	81.8

3.2 Workload and exposure setting

Table 3 shows clear workload differences between occupational groups. Scrap dealers and junkshop holders/workers reported the longest mean working hours (11.35 ± 0.83 and 11.33 ± 1.11 hours/day), followed by processors (10.73 ± 0.79), itinerant buyers (8.61 ± 0.98) and waste pickers (6.63 ± 1.54). Most groups worked around six to seven days/week, indicating limited weekly rest.

Table 3. Workload indicators by informal actor

Informal actor	Working hours/day, mean $\pm$ SD	Working days/week, mean $\pm$ SD	Median hours/day (P25-P75)
Informal Processor	10.73 ± 0.79	6.45 ± 0.52	11 (10-11)
Itinerant buyer	8.61 ± 0.98	6.44 ± 0.51	8 (8-9.75)
Junkshop holder/worker	11.33 ± 1.11	6.59 ± 0.50	12 (10-12)
Scrap dealer	11.35 ± 0.83	6.70 ± 0.47	12 (11-12)
Waste picker	6.63 ± 1.54	5.97 ± 0.61	6 (6-8)

The exposure environment was role dependent. Waste collectors operate in dumpsites, bins, roadsides, and open waste-sites, with minimal hand and foot protection. Itinerant buyers travel along roads and in business areas using carts, bicycle or motorcycle, they were also exposed to traffic. Junkshop operators sort, weigh, store and accumulate materials in confined spaces with broken glass, sharp edges of metal containers, and unsafe stacking of materials. Dealers handled bulk loads with considerable loading and unloading actions. Processors were exposed to sharp materials as well as heat, smoke, fumes and mechanical exposures (washing, grinding, burning, and heating of materials).

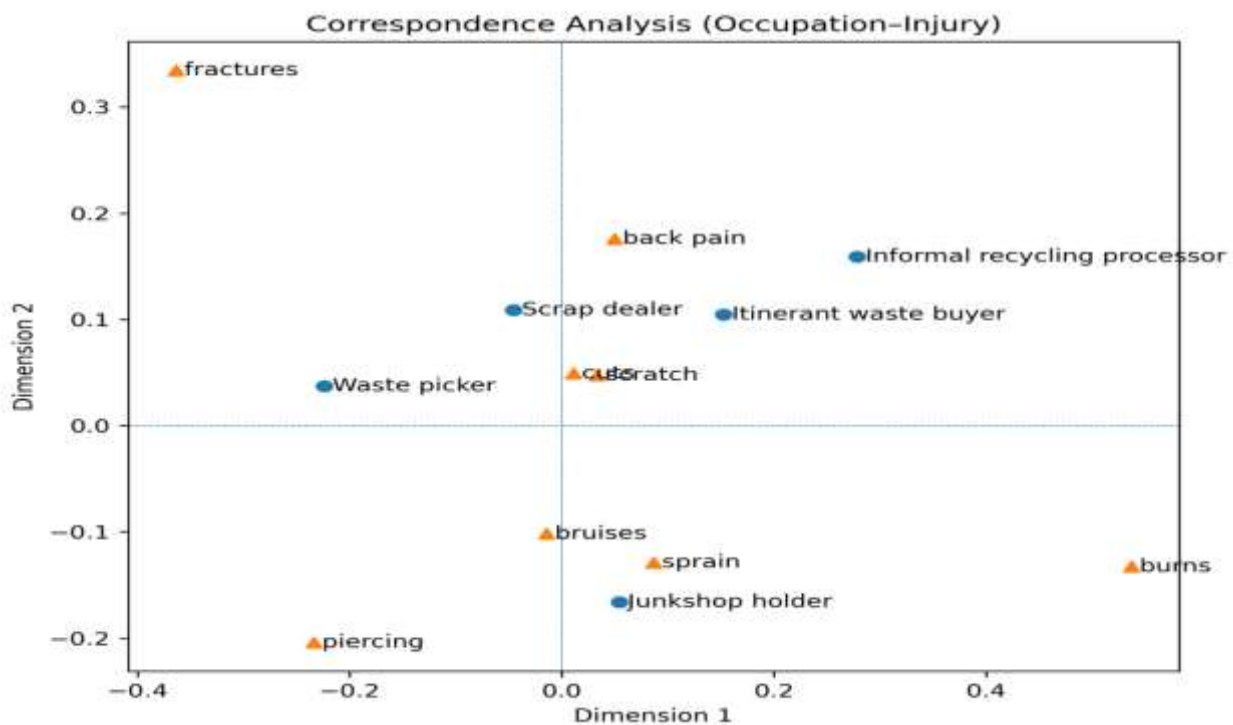
3.3 Occupational injuries and injury causes

Analysis of self reported injuries (Table 4) revealed extensive injury prevalence among all groups of workers. Scratches and cuts were most frequently reported injuries: 93.3-100% scratches and 91.3-100% cuts were reported among the groups. Highest prevalence of penetrating injuries was among waste pickers (60.0%) and junkshop holders/workers (59.0%). Backache was most prevalent among processors (36.4%), also was burns (27.3%), whereas fractures was most prevalent among waste pickers (20.0%). All groups reported bruises and sprains; bruises were most prevalent among junkshop holders/workers (41.0%), whereas a sprain was most prevalent among itinerant buyers and junkshop holders/workers (33.3%).

Table 4. Prevalence of self-reported occupational injuries by occupation (%)

Role	Scratch	Cuts	Piercing	Bruises	Back pain	Sprain	Burns	Fractures
Processor	100	100	18.2	27.3	36.4	18.2	27.3	9.1
Itinerant buyer	100	100	22.2	27.8	27.8	33.3	16.7	11.1
Junkshop	100	97.4	59.0	41.0	23.1	33.3	20.5	5.1
Scrap dealer	100	91.3	39.1	30.4	30.4	17.4	8.7	13.0
Waste picker	93.3	100	60.0	33.3	26.7	23.3	3.3	20.0

In the correspondence analysis map (Fig. 1), there was different injury distribution depending on occupation. Cuts/scratches were found close to the center indicative of common occupational hazards among all groups, waste pickers are associated with fractures and piercing injuries. Processors were aligning close to the backache, junk shop holders/workers were found in close proximity to the sprain/bruises, while itinerant buyers and scrap dealers occupy intermediate location on the plot, screening moderate musculoskeletal strain profile. Burn, fracture, piercing injury etc., further away from the center are responsible for distinct variations between occupations.

**Fig. 1. Correspondence analysis map of occupations and injury types among informal actors**

The specified sources of injury were generally found to be unprotected wires, needles, nails, pieces of metal and broken glass with the highest classifications relating to about 70-90% of all respondents (Fig. 2). Manual handling and carrying large loads occurred more commonly where large volumes of recyclable materials needed moving in bulk. Incorrect or poorly maintained tools and equipment were the cause of injury in approximately 60-75% of all respondents. Slippery ground, dumping height, falling from a height, or materials falling onto the individual were found less often, around 25-40% in each classification.

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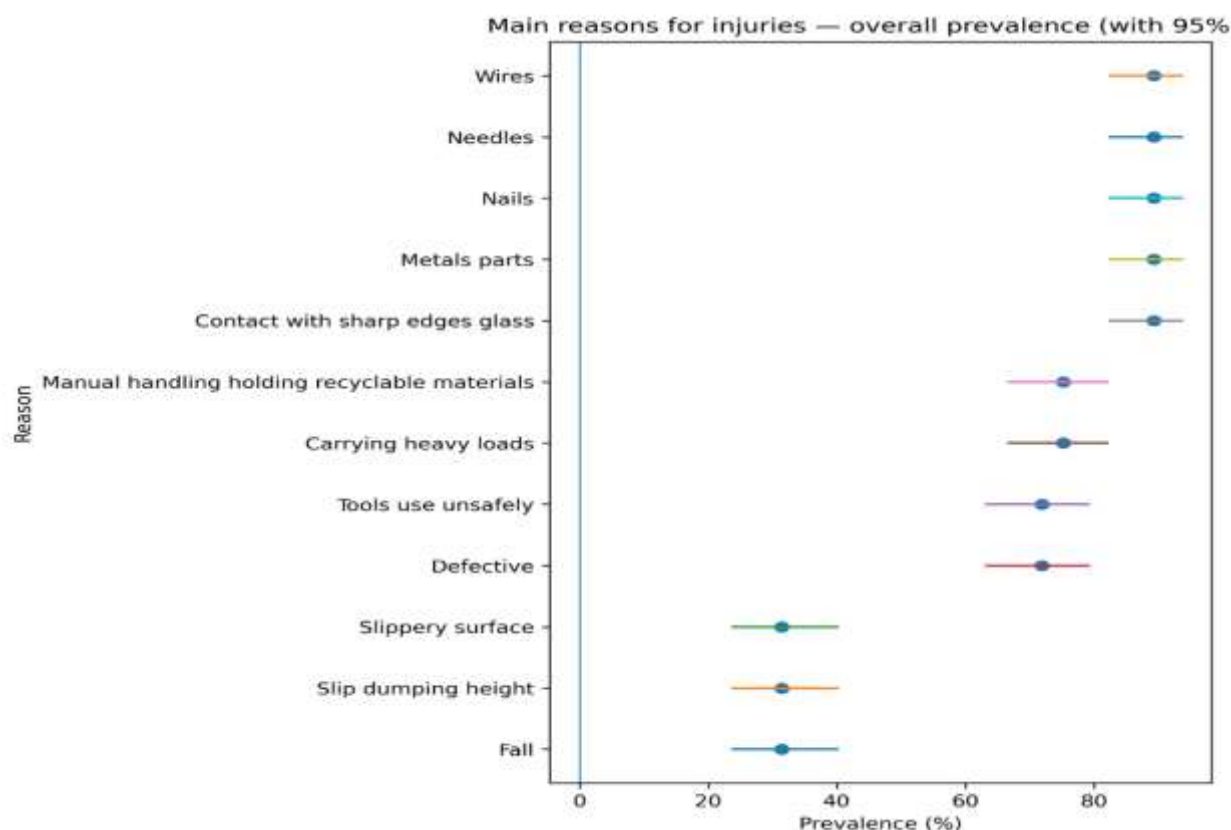


Fig. 2. A consistent pattern of dominant physical hazards across the informal recycling workforce (n = 121)

3.4 Work-related health issues

The heatmap (Fig. 3) indicated that for the majority of health related issues reported, frequencies were low to medium, with few definite concentrations of specific occupational roles. Informal processors, scrap dealers, and waste pickers complained more about rashes and skin irritations. Musculoskeletal pain was evident in all groups and concentrated on roles that involved sorting and manual handling. Nasal irritations were most obvious among processors. Coughing and chest problems had less frequent occurrences but were reported by waste pickers, Junk shop holders/workers and processors. Stress/anxiety was most evident in Junk shop holders/workers. Vector borne illnesses/general ailments and malaria/dengue fever and headaches had low occurrences overall and were scattered among groups.

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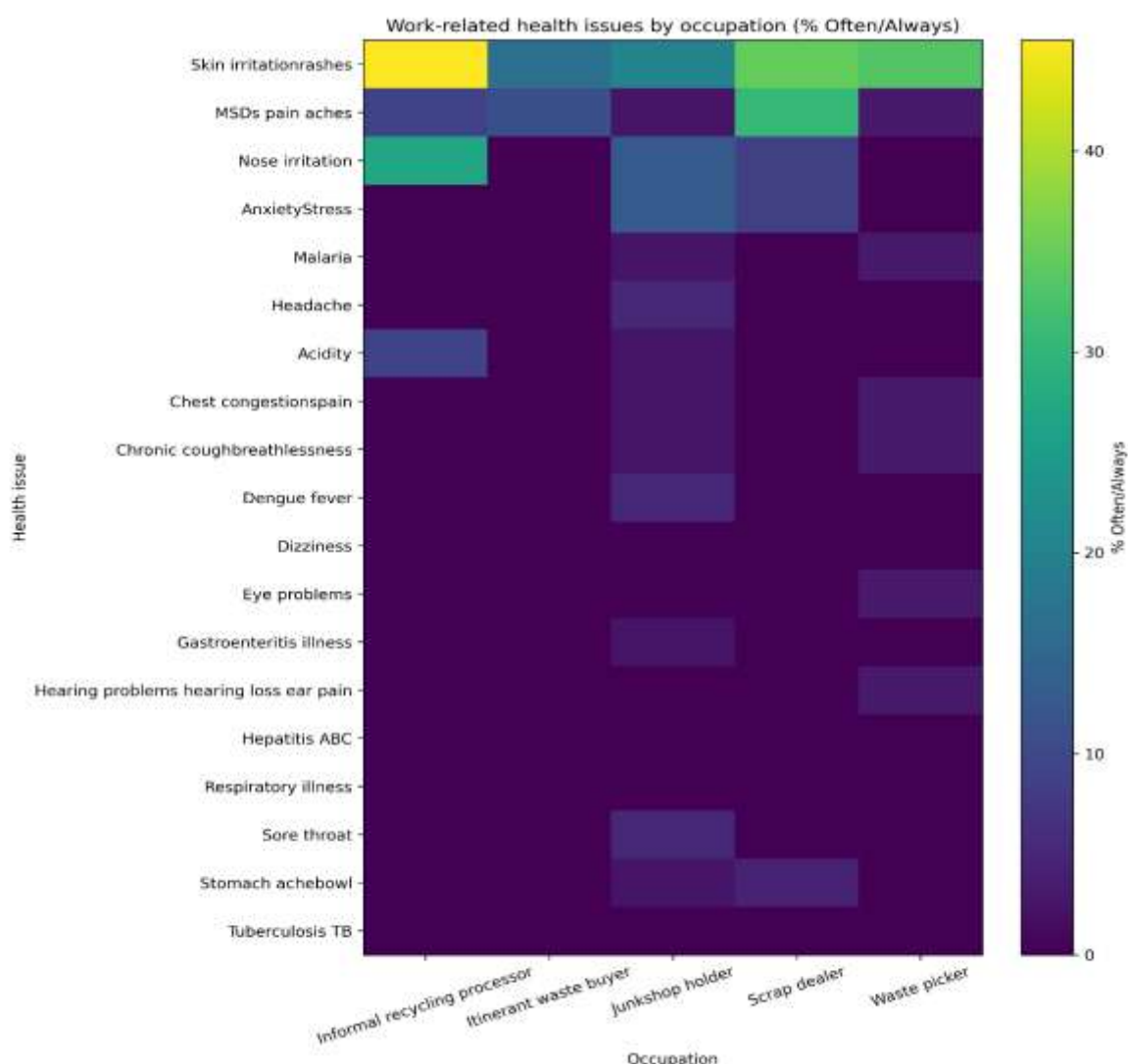


Fig. 3. Work-related health issues by occupation in the last 6 months. The contrast in heatmap intensities indicates differing exposure mixes across the informal recycling chain.

Fig. 4 displays an obvious occupational gradient of the reported number of symptoms. Those most suffering from health problems (highest median counts of symptom) were the scrap dealers and informal processors, reflecting the heavier physical workload and prolonged exposure associated with material handling and processing tasks. Intermediate median values with it were the junkshop holders/workers and waste pickers, indicative of moderate but persistent health concerns spanning dermal, musculoskeletal, complaint such as gastroenteritis, parasitic illness i.e. malaria and dengue and respiratory categories. Itinerant waste buyers showed greater variability, with some reporting fewer health issues and others with more symptoms. This wider dispersion highlights diverse working conditions, ranging from relatively cleaner household collections to more hazardous roadside scavenging. The broader Interquartile ranges (IQRs) observed among junk-shop holders and waste pickers suggest uneven exposure within these groups, some workers endure multiple concurrent issues while others experience few or none.

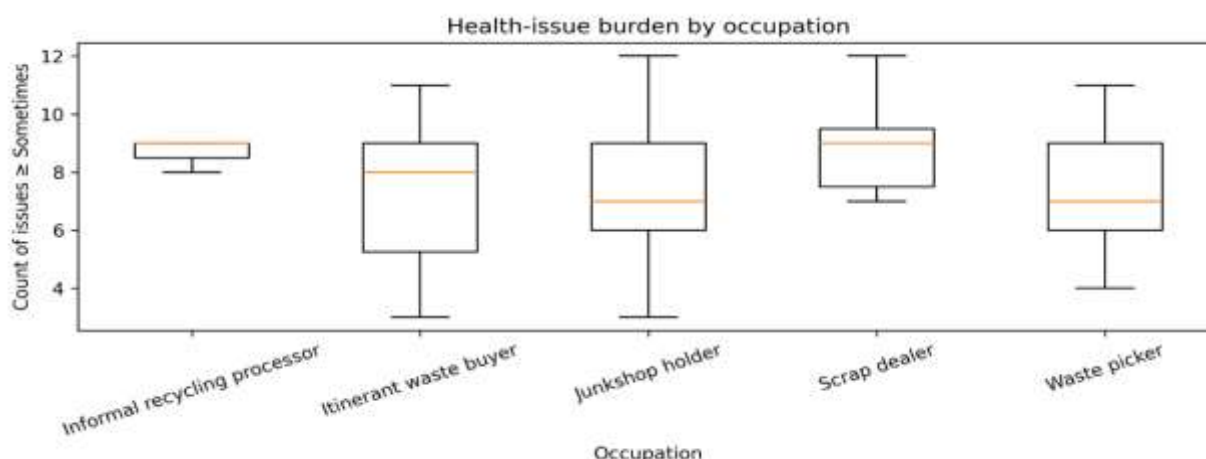


Fig. 4. Distribution of the number of health issues within informal occupational groups $\geq$ sometimes in the last 6 months.

3.5 Training, PPE and social protection

Training and protection (Fig. 5) varied significantly by occupation. Informal Processors and scrap dealers had the best coverage on work-related instruction (75-80%), followed by junkshop owners/workers (55-60%), and little to no coverage on waste pickers and itinerant buyers. This leads to the conclusion that the least protected groups, in terms of training, were the two groups with the greatest physical mobility: waste pickers and itinerant buyers.

Protection coverage was extremely varied across the occupation types. Employers provided PPEs (mainly gloves and masks) to workers most often in the processor occupation (around 65-70% but often not used consistently), while in other occupations employer-provided PPEs was rarely available and often workers purchased their own safety items or worked without any protection at all. Itinerant buyers and waste pickers had very low coverage on protection.

Medical and social protection also varied by occupation type. Health cards or some support from employers or local communities were reported mainly by itinerant buyers and informal processors (around 70-80%), medium coverage from junkshop holders/workers and scrap dealers (around 35-45%), and little coverage on waste pickers (around 5-10%). Afghan workers, in particular, found their ability to access the public systems to be restricted because of their lack of identification papers. In almost all cases, the costs of transport, medicines, treatment, and compensation for lost income were covered by workers themselves.

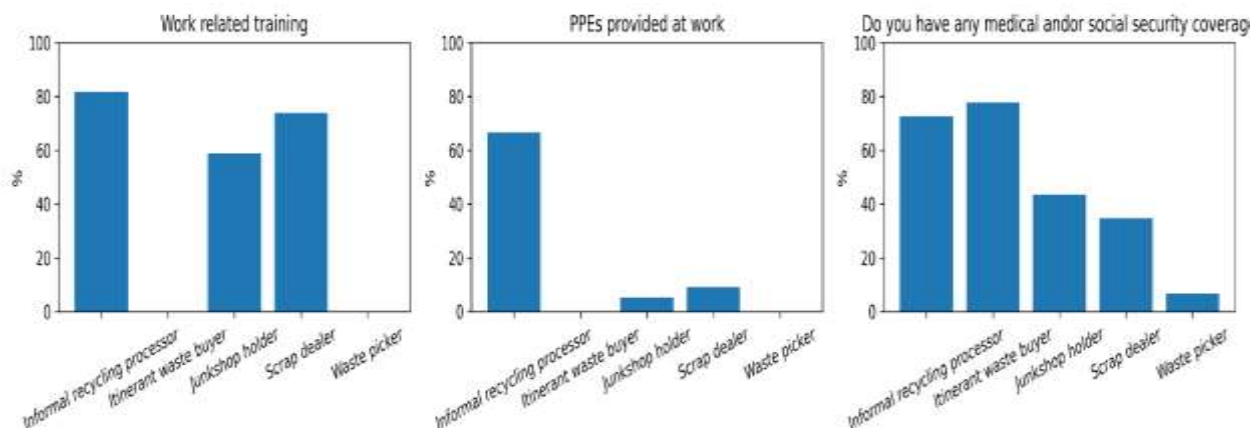


Fig. 5. Workers reporting protection indicators across occupational groups within the informal recycling sector.

3.6 Injury impact on productivity and satisfaction

The majority of informal recyclers (more than 99%) suffered one or more occupational injuries over the past year (Fig. 6). Four of the occupation types had injury rates of close to 100%, while injury rates of scrap dealers were somewhat lower at 91% (revealed 95% Confidence Interval). This variation may reflect their relatively more structured work environments, partial access to safety tools, and lower exposure to direct waste handling compared to collectors.

Work loss from injury was reported for all occupation categories (Fig. 7). 98.3% of respondents could not work as normal at least once in the past year, and 1.7% could work every day. This enormous proportion demonstrates that injuries in the informal recycling sector are not only frequent but also directly challenge to livelihoods.

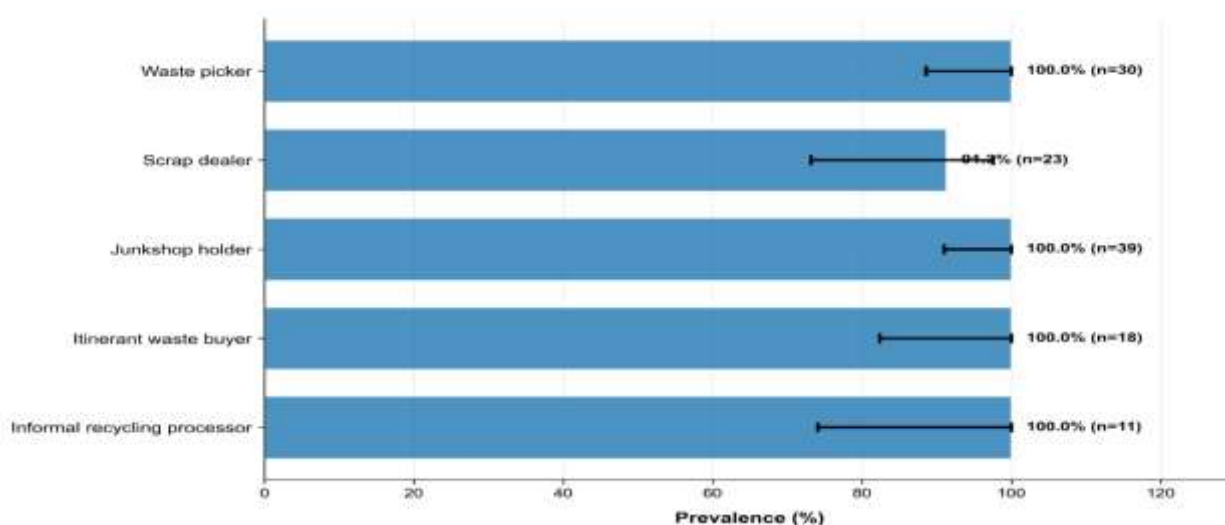


Fig. 6. Prevalence of any work-related injury in the last 12 months by occupations.

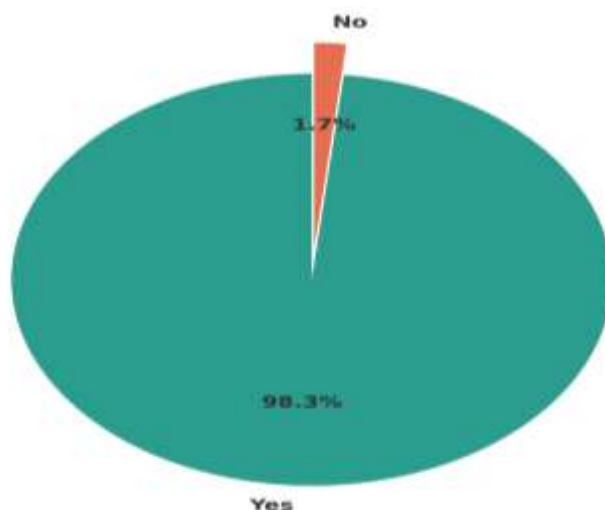


Fig. 7. Collective Share of all occupational workers prevented from doing normal work in the past 12 months due to injuries.

The spread of the number of lost working days is illustrated in Fig. 8, indicating significant working time was lost as a result of the injury. This data ranged from 1-45 days away from work, with a mean of 18.6 days and a median of 18 days. It had a standard deviation of 9.15 and the IQR range was from 10-25 working days, this distribution was slightly right skewed, with a few participants away from work for longer than 30 working days more likely because of severe musculoskeletal and fracture injuries.

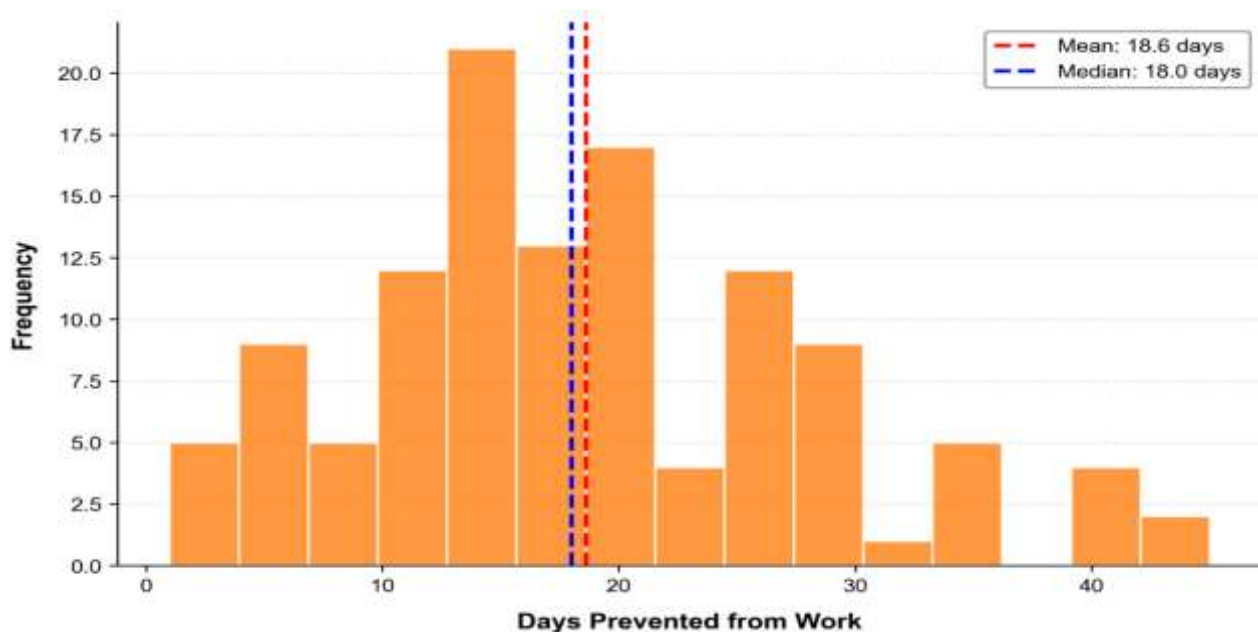


Fig. 8. The distribution of absence workdays related to injury within the informal recycling sector over past year.

Worker satisfaction had generally the same trends with the protection and income security. Itinerant buyers, processors and some scrap dealers have high worker satisfaction. While many waste pickers and junkshop workers are unsatisfied with the poor compensation and unstable price as well as lack of facilities and assistance.

4. Discussion

The results indicate a high burden of injuries among informal recycling actors in Islamabad. Almost all participants reported injuries, although the specific patterns were different depending on their occupation: cuts and scratches represented a common baseline for all workers; piercing injuries occurred among both waste collectors and junkshop keepers/workers; burns were more prevalent among processors; and fractures were highest among waste collectors. The correspondence analysis supports this occupational pattern. Common wounds clustered around the centre of the graph (see Fig. 1), whereas more unusual wounds like burns, fractures and piercing wounds caused separation between different occupations. This supports the contention that informal recycling should not be treated as a single occupation. Similar high exposures have been documented for other studies of informal recyclers, although the nature of work, tools, season and social position varied significantly between different studies (Schenck et al. 2019; Sapkota et al. 2020; Uhunamure et al. 2021).

There appeared to be an inverse relationship between exposure to risk and protection among these workers. Waste collectors and itinerants are likely the least well-trained and least educated groups within this informal recycling subsector and are located in mixed-waste settings during the sorting/collection process. It also appeared from the observations that much of the training carried out by scrap dealers, informal processors, and junkshop keepers/workers was unstructured informal knowledge exchange, based on tasks such as sorting, buying, and estimating quality. Training on the prevention of injuries, hygiene, or on handling loads, fires, and first-aid was less evident. This is related to structural vulnerability, and reflects the realities that poor people in unstable work environments who are not part of the formal labor force have higher exposures and access only minimal, and often useless, protective measures (ILO 2018; ILO 2023; Chen 2012). Similar observation-based safety systems have been described in informal waste sector work in Nepal, Ghana, and South Africa (Sapkota et al. 2020; Lissah et al. 2022; Uhunamure et al. 2021).

It was evident that the work process generated many ergonomic and fatigue related risks for workers. While scrap dealers, junkshop keepers/workers and processors worked the longest number of hours, waste collectors who worked fewer hours carried out the highest exposures of mixed-waste handling in a mobile, open and hazardous setting. Repetitive actions such as sorting, carrying and prolonged standing can be related to back injuries, and sprains and aches (Abou-ElWafa et al. 2012; Velasco Garrido et al. 2015; Acquah et al. 2021; Gowda et al. 2023). Such prolonged durations of work and fatigue have been previously linked with higher number of complaints among refuse workers (Lasota & Hankiewicz 2020). Practical interventions like wheeled carts, work tables, lifting equipment, improved storage arrangements, and store layouts would therefore be far more beneficial than relying purely on instruction.

The results clearly indicate that giving workers Personal Protective Equipment is not enough in itself; even when PPEs was provided by the employer (among processors) its regular use was sporadic, and waste collectors and itinerants waste buyers were the least protected groups even though they had the most exposure to mixed waste. Factors contributing to the gap between PPEs provision and usage include cost, heat, discomfort, poor fit, lack of replacement materials and lack of any expectation that the employer would support its use. Similar poor performance of PPEs for e-waste workers, waste workers and other groups has been reported for various settings (Ohajinwa et al. 2018; Ephraim et al. 2021; Mukiibi et al. 2023), suggesting that appropriate training and supervision coupled with hazard controls and PPE is crucial to achieving the necessary level of safety (Cointreau 2006; WHO 2021; UNEP and ISWA 2024).

The pattern of symptoms is also an indicator of health problems beyond the immediate injury. Symptoms such as skin problems, rashes, nose irritation, coughing, fatigue and musculoskeletal pain suggest repeated, low level exposure to waste dust, decomposition products, biological agents and chemical agents. The higher levels of symptoms in scrap dealers and processors reflect combined burdens of heavy material handling, processing, and sorting; whereas, the wide scatter of symptoms among waste collectors, itinerant buyers and junkshop workers can be accounted for by variations in work patterns within occupations. These general health effects have been observed for other studies on waste collectors in Nepal, Ghana, and e-waste sites, including musculoskeletal issues, infections, burn-out, etc. (Sapkota et al. 2020; Lissah et al. 2022; Eckhardt and Kaifie 2024). This also emphasizes the need for waste segregation at source, as mixed municipal, healthcare, and other waste streams would not directly transmit injury/infection agents and chemicals to waste workers (Khalil et al. 2022).

The injury itself had a direct impact on their livelihoods. All participants had lost multiple work days due to injury, and most of participants who reported loss of work days about 2-3 weeks in last year during occupation. Since the sector involves informal work there is no support in the form of paid sick leave or injury compensation, or even unemployment benefits or sick pay, the loss of work days would inevitably impact their livelihood negatively. Even small injuries like cuts, punctures, burns, sprains and strains can have consequences for physical strength, dexterity, or ability to lift, all of which have implications for ability to work and household income (Chokhandre et al. 2017; Lissah et al. 2022). Linking these workers with the existing local primary care network, offering basic medical and diagnostic care, immunization, basic health training and access to a local referral system could therefore be considered over setting up a new system entirely.

This research has strong policy implications: direct formalization is probably neither immediately feasible nor acceptable for all, due to the complex and heterogeneous nature of the informal sector and workers' fears of taxation and harassment. A stepwise approach that gradually includes and supports the informal sector, through mechanisms such as municipal recognition of sorting centers, improved storage facilities, support for source separation and PPEs provision, and inclusion of workers in awareness programs and health campaigns, would be more successful. Such strategies, based on broad experience in countries like Brazil, India, and Malawi, are best conceived through participatory processes involving the workers themselves, rather than from top-down policies (Medina, 2008; Dias, 2016; Gutberlet, 2015; Kasinja and Tilley, 2018; World Bank Group, 2024).

Also significant is that the nature of worker interventions needs to be highly tailored by stage of the value chain, and not treated as a monolithic problem. Collection interventions are primarily about limiting direct contact and needle-stick risks through effective source separation and provision of appropriate equipment. Junk shop and scrap dealer interventions should focus on preventing material collapse, providing secure and well-ventilated storage areas, promoting orderly workplace practices and provision of suitable tools to reduce manual handling. Processor interventions are about machine guarding, prevention of fires and controlling smoke and fume emissions through adequate ventilation and safe combustion processes, alongside general safety. Designing such staged and differentiated solutions aligns with established occupational health hierarchy of controls (Cointreau, 2006; WHO, 2021; UNEP and ISWA, 2024; Binion and Gutberlet, 2012; Porta et al., 2009; Ferronato and Torretta, 2019).

The study also indicates that addressing occupational safety cannot be separated from broader public waste management strategies. Informal workers are the first direct responders to the heterogeneous waste discarded from all sectors. When mixed waste is inadequately sorted at source-even in the home-this means risks from sharp materials, biological agents and chemicals are directly transferred. Thus, while informal workers must receive protection for the risks they face, achieving safer waste work also requires that waste generators in homes, businesses and institutions take greater responsibility for segregation. International best practices increasingly include the informal sector as part of the solution in a circular economy, but recognizing these workers necessitates commitment to their health, safety and rights, not just their capacity for material recovery (Kaza et al., 2018; Kumar and Agrawal, 2020; UNEP and ISWA, 2024; Balde et al., 2024). Safer informal recycling in Islamabad can therefore both advance the agenda for decent work and support more sustainable waste management.

Data is another issue. Lacking an official registry of accidents, days of sick work, occupational disease and deaths, informal recyclers' harm goes unnoticed and can lead to inaccurate estimates of the severity by authorities. A simple registry could be piloted through voluntary registration, local clinics, junkshop associations, or NGO partners. The goal is not punitive; it is to pinpoint common hazards, ensure basic first aid is available, track vaccination rates, and facilitate referrals of serious cases. Studies of hidden and mobile populations that implemented venue-based or community-linked strategies also managed to collect useful data from worker populations inaccessible through lists (Muhib et al., 2001; Raifman et al., 2022). Routine data also can help prioritize most dangerous jobs and evaluate if any interventions have an effect.

Finally, the results have equity implications. Children and young Afghan migrants group that was the least educated and least protected—were among the waste pickers in this study. Safety planning thus should avoid methods that further stigmatize and eject the most vulnerable workers from an income stream. A rights-based strategy would include: child protection, school access, a migration-aware health care system, child-safe sorting areas, livelihood support for adults, and positive municipal relations with workers; a plan like this is more likely to result in decreased risk than law enforcement, as it works against workers' rational reasons for enduring dangerous conditions (ILO, 2019; ILO, 2023; Lund, 2012).

5. Recommendations

Safe handling must start before waste reaches informal actors. Household, market and clinic-level source segregation needs to be enhanced so that sharps, diapers, clinical waste, chemical containers and broken glass do not go into mixed waste streams. Even very basic source segregation campaigns can decrease direct handling of hazards and improve material quality (Wilson et al. 2006; UNEP and ISWA, 2024).

Low-cost engineering controls should be prioritised. Junk shops and scrap yards need sorting tables, puncture-proof boxes for sharps, covered storage, clean pathways and stable material stacks. Street pickers and itinerant buyers need handcarts, strong sacks, basic grabbing tools, reusable gloves and basic footwear. Processors require ventilation, safe hearth areas, fire extinguishers and control over the open burning of wires and plastics. These controls will provide better security than awareness campaigns.

Training needs to be brief, hands-on and role-specific. Street pickers need training on recognizing sharps, basic hygiene, wounds, animal bites and traffic hazards. Itinerant buyers need training on correct lifting and load handling. Junk shop workers need instruction in stacking, first-aid and fire prevention. Scrap dealers and processors require training in material handling, guarding of machines and prevention and mitigation of chemical risks and smoke. Having peer trainers from within the sector would improve trust and efficiency (Sapkota et al., 2020; Tasnova and Rafizul, 2024).

Primary healthcare services should be linked to accessible public clinics and dispensaries for vaccination against tetanus and hepatitis, wound management, basic first-aid provisions, referral for burns and respiratory diseases and simple health records. Migrant and undocumented workers must not be denied access to emergency healthcare because exclusion of them increases both their own vulnerabilities and public health risks (ILO, 2023).

In the early stages, the municipality must resist using inspections punitively. Instead, Supportive visit, registering volunteer groups, involving NGOs, fostering collaborative efforts and cooperation should be pursued to enhance acceptability and security. The aim must be the gradual inclusion of informal recyclers into the governance of waste without compromising their livelihood and dignity (Nawaz et al., 2021; World Bank Group, 2024).

6. Limitations

This study does have its limitations. The data was self-reported and as such is susceptible to recall error, particularly concerning the injuries sustained over the past 12 months. A cross-sectional study can only show an association and not causality. The females who were found to be working in either processing or sorting areas were under represented due to a number of access and cultural limitations. A more robust study would include larger samples, seasonal follow-up, a screening process that includes a physical examination, immunizations status, bio-monitoring for chemical exposure and sex-specific assessment techniques.

7. Conclusion

The informal recycling actors in Islamabad provide a crucial environmental service in reclaiming reusable items and alleviating stress on municipal waste systems. This study however highlights that this is largely occurring without much protection, training or even access to medical or social support services. It became clear that injury was nearly ubiquitous among the sample: virtually all categories suffered cuts and scratches, while piercing injuries were concentrated among waste pickers and junkshop holder/worker category, burns were observed among the processors, and fractures dominated among the waste pickers. These findings demonstrate that the informal recycling chain is not a single environment for risks, rather a sequence of separate environments. The survey also demonstrated that the health impacts went beyond injuries to a suite of chronic symptoms. These ranged from skin irritation, musculoskeletal problems, nose irritation, cough, anxiety and fatigue-indicating recurrent exposures to waste residues, dust, physical labor, inadequate sanitation and instability of work environment. Whereas waste pickers and itinerant buyers were found to have the least protections, the processing sites and scrap dealer category enjoyed relative better protections in terms of training and support, mostly informally though. The study proved that OH&S is a livelihood issue: since they were on daily income, the IQR range such as loss of 10-25 days of work due to injury affects their ability to purchase food, rent, and health care, thus impacting the whole household budget. Improving OHS of informal recyclers requires pragmatic and sequential steps; source segregation, safe and designated sorting spaces, puncture resistant gloves and boots, task specific training, vaccinations and medical facilities, and non-punitive municipal recognition and engagement. Interventions for workers need to involve them directly, so that improving safety measures for workers does not negatively impact their source of livelihood. Informal recyclers need protection as part of an agenda for sustainable waste management, public health and decent work.

Conflict of Interest

The authors declare that they have no known financial, personal or professional conflict of interest that could have affected the research, its writing or its publication.

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