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ASSESSMENT AND PERCEPTION OF OCCUPATIONAL RISKS IN WASTE PICKER ORGANIZATIONS: A PORTRAIT OF WASTE PICKERS SITUATION AFTER FORMAL INTEGRATION

Luciana Harue Yamane [1,*], Renato Ribeiro Siman [1] and Renato Meira de Sousa Dutra [2]

[1] *Department of Environmental Engineering, Federal University of Espirito Santo, Fernando Ferrari Avenue 514, Vitoria, Espírito Santo, Brazil*
[2] *Fluminense Federal Education Science and Technology Institute, Campos dos Goytacazes, Rio de Janeiro, Brazil*

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ABSTRACT

Waste picker organizations (WPO) are a fundamental link in the integrated management of urban solid waste; however, despite being formally recognized, waste pickers still face unhealthy work conditions. Studies on occupational risks related to waste picker activities have been carried out in a qualitative way, but the quantification of occupational risks is an important research gap to fill. Additionally, an unprecedented comparison between waste picker risk perception and occupational safety technician risk assessment is presented. The risk perception of the waste picker was carried out through a cross-sectional interview study that surveyed 35 WPO by non-probabilistic sampling, and the results showed that waste pickers underestimated the occupational risks (i.e. noise, physical effort, improper physical arrangement, and inadequate use of personal protective equipment (PPE)), it was also possible to identify the necessary strategies to improve occupational safety. Occupational safety technician evaluations were carried out through quantitative analysis on site in 64 WPO. The results indicated the predominance of maximum risk intensity (Level 3 – from a scale of 0 to 3) for biological risk, physical effort, excessive pace, improper physical arrangement, and inadequate use of PPE in all operational activities. The main interventions should focus on implementing Work Accident Reporting, rearranging WPO layout, routinely providing information about importance of PPE use, and continuously developing WPO standards with periodic evaluations of occupational risks using a fractional scale.

1. INTRODUCTION

The collection of urban solid waste performed by waste pickers (formal and informal) is largely observed in developing countries, but it is worth noting that waste pickers play a key role in the circular economy inserting recyclable materials in the productive cycle (Uddin et al., 2020; Velis et al., 2012). The formalization with Waste Picker Organizations (WPO) improves the working conditions by allowing them to demand their rights, improve the collection/sorting, negotiate a better sales price, and provide training to handle hazardous waste (Siman et al., 2020). Moreover, WPO represent an alternative economic development model focused on solidarity and social economy (Gutberlet et al., 2013).

In this sense, the formalization of waste pickers as one of the pillars of the 3S concept (Sanitisation, Subsistence economy and Sustainable landfilling) which together with WPO insertion into integrated management of the city's solid waste can significantly improve the occupational health and safety conditions of these workers (Binion & Gutberlet, 2012; Lavagnolo & Grossule, 2018; Uddin & Gutberlet, 2018). In addition, waste pickers are part of the poor and vulnerable population that need government assistance, as suggests Goal Number 1 of the Sustainable Development Goals (Uddin et al., 2020).

Discussions of occupational risks associated to waste workers such as informal waste pickers (which collect recyclables on the streets or dumps) or formal waste collectors (workers who only collect, but do not sort and commercialize recyclables) in developing (Binion & Gutberlet, 2012; Black et al., 2019; Bleck & Wettberg, 2012; Giovanni et al., 2013; Mehrdad et al., 2008; Scheinberg, 2012; Thakur et al., 2018), and formal workers hired by municipal waste management administration from developed countries (Battaglia et al., 2015; Ibrahim, 2020; Rodrigues et al., 2020; Rubio-Romero et al., 2018) have been reported.

Each study reinforced the importance of the occupa-

* Corresponding author:
Luciana Harue Yamane
email: luciana.yamane@ufes.br

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tional health and safety conditions of waste workers; however, there are still gaps that need to be filled regarding formal waste pickers from organizations that generally receive the waste for sorting and marketing and, whose focus is not on street collection, which is a tendence in low and middle income countries (Dutra et al., 2018; Gutberlet & Uddin, 2017; Kasinja & Tilley, 2018).

Systematic reviews performed by Zolnikov et al. (2018), Zolnikov et al. (2021) and Emmatty and Panicker (2019) pointed out the growing need for low-cost interventions based on the nature of occupational risks, and despite being considered legal workers, little has been done to mitigate health effects (de Araújo & Sato, 2018).

Calderón Márquez et al. (2019) reported that there are still landfill mining initiatives worldwide, the strategy is to employ waste pickers as miners for the recovery of valuable materials as alternative to picking informally in dumps. However, the authors draw attention to the need for authorities to regulate the associated risks and occupational safety and health programs as also highlighted by Zolnikov et al. (2018).

It is important to highlight that previous studies had different worker profiles: informal waste pickers (Black et al., 2019), waste pickers working in dumpsites (Bonini-Rocha et al., 2021; Cruvinel et al., 2019; Thakur et al., 2018; Wilson et al., 2006), workers of recycling centers (Ibrahim, 2020), and municipal solid waste workers (Thakur et al., 2018). Noting these differences, the present study focused on waste pickers formally associated with Waste Pickers Organizations (WPO).

Reinforcing this gap, Zolnikov et al. (2021) point out that future research involving waste picking should include these workers variations since the better understanding of the particularities to each one can improve the health and risk situation.

Therefore, it is essential to understand occupational risk from the perspective of formal waste pickers from WPO to determine risk severity and probability in order to mitigate hazards, as well as identify tools that enable the reduction of occupational accidents and diseases that can be used through these criteria in order to guarantee the health and safety of workers. The findings are also important to portray current work conditions in comparison with informal dump picking conditions providing directions to new improvements.

Thus, the present study presents two sections of results. First, waste picker perception of exposure to occupational risks was compared to an assessment from occupational safety technicians in 35 WPO in 2015 in the State of Espírito Santo, Brazil. And second, a quantitative analysis of the occupational risks was carried out in 64 WPO in 2017 in the State of Espírito Santo, Brazil, which, together, totaled 627 waste pickers who were directly exposed to occupational risks in their 40-hour-a-week work routine.

2. MATERIAL AND METHODS

2.1 Study area

The study was conducted in the State of Espírito Santo, Brazil, which in 2015 had 49 WPOs, of which 35 were in operation, and in 2017 the number increased to 74 WPOs, of which 64 were in operation. The other WPO were in the formalization and start-up phase and therefore did not participate in the research. Data were gathered from 2015 to 2017.

2.2 Experimental procedure

The quantitative analysis of occupational risks in the WPO was carried out in an innovative manner under two points of view for comparison purposes: waste picker perception of risk and risk assessment by occupational safety technicians.

Data collection of waste picker perception of risk was approved by the Research Ethics Committee (CEP/UFES) under Presentation Certificate for Ethical Appreciation (CAAE) n° 80927617.7.0000.5542.

Data collection of risk assessment by occupational safety technicians in the WPO was institutionally approved by the Institute Sindimicro-ES through the Technical Cooperation Term (n° 01/2017) between UFES and Institute Sindimicro-ES and agreement n°782753/2013 between Micro and Small Business Development and Entrepreneurship Agency (ADERES) and Ministry of Labor and Employment/ National Secretariat for Solidarity Economy (MTE/SENAES).

2.2.1 Step 1 - Waste pickers risk perception

In order to understand waste pickers perceptions, all 49 WPO operating in 2015 formally associated with Instituto Sindimicro-ES were invited to respond to an interview. The purpose of the interviews was to identify possible occupational risks to which waste pickers were exposed, as well as whether they were aware of the risks and the possible consequences for their health and physical integrity.

Data collection was performed through an interview with 35 representatives from WPO listed in Appendix A, which represents a response rate of 71% of operating WPO in 2015, through a questionnaire containing open and closed questions, prepared with the Microsoft Excel software (see Appendix B) and divided into 6 sections: workload, physical effort, accident risks, ergonomic risks, use of Personal Protective Equipment (PPE), and environmental risks.

The interviews were conducted on site with the WPO president with technical support from Sindimicro-ES during technical visits. The number of waste pickers per WPO in ES accounts for an average of 10 ± 5 waste pickers/WPO (maximum 28 and minimum 3) as shown in Appendix A, and the WPO president was chosen as a respondent due to familiarity with the WPO work conditions and all associated workers.

2.2.2 Step 2 – Risk assessment in Waste Pickers Organizations by safety advisors

An evaluation of occupational risks by safety advisors was carried out in 64 of the 74 WPO operating in 2017, as listed in Appendix A, in which environmental, ergonomic, and accident risks were identified in the following WPO operating activities: Receiving (i.e. unloading the truck and transporting to the sorting conveyor); Sorting (i.e. primary

and/or secondary); Temporary storage; Compacting and baling; Stocking; and Commercialization.

Data collection was conducted by five independent teams composed of three safety advisors who made 3 visits to each of the WPO, through a checklist presented in Appendix C. From the data collected, occupational risks were quantified in each WPO operating activity through "frequency of risk occurrence" and "occupational risk intensity".

To determine the "frequency of risk occurrence", the absence or presence of the risks involved in each operating activity was accounted for from the collected data. On the other hand, for the classification of "occupational risk intensity", values of 0 were adopted for "no risk", 1 for "low intensity", 2 for "medium intensity", and 3 for "high intensity". Values were adopted to allow for the quantification of risks. The Brazilian Regulatory Standard NR 4 - Specialized Services in Occupational Health and Safety (Brazilian Regulatory Standard NR 4 - Specialized Services in Occupational Health and Safety, 2016) enforces standards by quantifying the intensity of environmental risks through classification as small, medium, and large.

Regarding the evaluated environmental risks, the physical risks were noise, vibrations, heat, humidity, and cold; the biological risks included the possible presence of potentially pathogenic microorganisms; and the chemical risks included the presence of dust.

The evaluation of the presence of dust in each operational activity was conducted based on the visual evaluation of the environment performed by safety technicians, as proposed by Bleck and Wettberg (2012), without the use of equipment.

As for the evaluated ergonomic risks, physical effort and excessive pace, the following facts were detected: accident risks in function of improper physical arrangement, unprotected machines, poor lighting, poor electrical connections, inappropriate tools, and inadequate use of PPE.

3. RESULTS AND DISCUSSION

3.1 Waste pickers risk perception

3.1.1 Workload

Regarding waste pickers workload, it was observed that waste pickers work, on average, 8 hours a day and 5 days a week, totaling 40 hours a week. The workload of independent waste pickers is higher, as they usually work for 12 hours, pushing on average 200 kg and covering a distance of 20 km (Rebehy et al., 2017); and this demonstrates an advantage to the waste picker being associated to a WPO. Similar data was observed by (Gutberlet & Baeder, 2008) in Santo André, Brazil, where more than 70% of the informal waste pickers interviewees reported working more than 8 hours a day, often 6 or even 7 days a week.

31 of the 35 organizations have alternating activities, where waste pickers work in all operating activities of the WPO that range from sorting to compacting the recyclable waste. From the point of view of work safety, this rotation of positions is important to avoid repetitive strain injuries. For example, in other organizations, the rotation is performed as a matter of necessity and not as a matter of health and risk mitigation.

Regarding most waste pickers perspective, the workload is in accordance to Consolidation of Labor Laws (Consolidação das Leis do Trabalho, CLT) (Consolidation of Labor Laws (CLT), 1943); however, it is important to highlight that waste pickers jobs involve manual work with a lot of physical effort.

3.1.2 Physical effort

Concerning the physical effort at work, more than half of the waste pickers rated it as "very intense" (55%), 21% rated it as "intense", 18% as "moderate", while only 3% rated it as "weak", and 3% did not know how to classify or did not respond.

In addition, 31 of the 35 surveyed WPO admitted that this effort may have a negative effect on the health of the workers. Among the specific effects resulting from physical efforts, waste pickers reported the following in descending order: feeling "pain in the arms and back" (expressed by 27 WPO) and "spine problems" (22 WPO), which are usually associated with ergonomic risks. They also reported "stress" (22 WPO), "headache" (21 WPO), "dizziness" (8 WPO), "difficulty breathing" (6 WPO), and "pneumonia/bronchitis" (3 WPO), which are related to general working conditions, such as temperature, physical effort, and work environment climate. In addition, for Bleck and Wettberg (2012) the repetition of similar hand and arm movements in the activity of picking up and disposing into containers causes joint problems.

Beyond these health problems, Thakur et al. (2018) observed that more than 90% of all categories of waste workers (regular and contractual workers) can suffer from musculoskeletal injuries, vomiting, and body aches. Waste workers have more musculoskeletal disorders than the general population (Mehrdad et al., 2008), with prevalence of symptoms in knees, shoulders, and lower back (Reddy & Yasobant, 2015). As an aggravating factor, Ohajinwa et al. (2017) point out that many waste pickers minimize the adverse health effects of their work and prioritize the financial benefits.

In fact, waste picker activities involve considerable physical effort, such as collecting recyclable waste by human traction transport (handcarts), carrying heavy bags, and standing for hours while sorting recyclable waste, among others (Siman et al., 2020). The physical effort is a job characteristic, but this cannot be excessive and under non-ergonomic or unsafe circumstances.

It is noteworthy that in most organizations, the material sorting stage is performed in a covered warehouse in order to minimize worker exposure to sun for long periods. The structural differences between various WPO surveyed were also notable. While some had basic equipment for sorting and stocking recyclable waste processes, such as sorting tables, compressors, drums, and garbage handcarts for transport, others performed the same sorting functions on the ground and sometimes on land without cover.

3.1.3 Use of Personal Protective Equipment (PPE)

Regarding the availability of PPE, 71% of the WPO stated that the waste pickers have PPE for the material sorting and compacting operations; however, it is emphasized

that all WPO must have PPE. Among PPEs, masks (86%), gloves (92%), and boots (92%) are generally used by waste pickers, while hearing protection equipment (47%), goggles (53%), and aprons (39%) are less used.

Studies indicate that waste pickers working in WPO have used PPE more frequently than informal waste pickers working on the streets and in dumpsites. The research carried out by Black et al. (2019) showed that 67.6% of informal waste pickers that work on dumpsites in the Kathmandu Valley and in the adjacent Nuwakot district in Nepal did not use PPE. While the research conducted by Ohajinwa et al. (2017) in Nigeria showed that only 43% of informal waste pickers regularly use PPE. Corroborating this finding, Thakur et al. (2018) performed studies in India and reported that only the street sweepers (28%) and waste collectors (6%) in the capital city received PPE twice in a year.

It can be inferred that waste pickers working in WPO tend to use more PPE, due to the government's financial assistance. According to CNMP (2014), it is up to municipalities in Brazil to provide assistance to support the organization and maintenance of WPO, and this encompasses the material needed for operation process, which must include PPE for workers.

Although 71% of WPO have PPE, the respondents stated that only 57% of the waste pickers use it regularly, while 14% don't use it and 29% use it sometimes. This fact, according to Giovanni et al. (2013), increases the chances of work accidents. Among the reasons for the lack of PPE use, although available, Gutberlet & Uddin (2017) and Moura et al. (2018) highlighted that productivity is a relevant factor for the group, and the use of PPE, such as gloves, masks, and goggles for example, interferes with the handling of waste, which was also observed in the present study.

Using interviews with waste pickers and statistical evaluation (p-value) the study of Asibey et al. (2019) concluded that waste pickers with knowledge of the risks they are exposed to and more than two years of work experience have a higher probability of using PPE, which highlights the need to train the waste pickers.

Also, waste pickers were asked about how often they receive new PPE of each type, and 100% of the interviewees indicated that PPE are only replaced when they are no longer usable, regardless of their integrity or expiration.

The perception of waste pickers about the use of PPE presented some troubling factors. Just over half use it regularly, which demonstrates the lack of knowledge of the importance of individual protection by a significant portion of WPO, and although not all have PPE, its use is mandatory.

3.1.4 Environmental risks

As to physical risks, the noise level in the work environment was reported as "low" by 50% of waste pickers in their organizations, while 41% consider it "medium" and only 9% "high". This perception can in some cases be attributed to the lesser existence of rotating equipment in organizations, which have only compressors and garbage handcarts as the main noise generators. As for the level of vibration, waste pickers were asked if there was equipment that produced vibrations, and 60% stated that there is no equipment that produces vibration. In this regard, studies in Brazil have observed that many WPO have minimal infrastructure for operation and, more often than not, the working equipment is in poor condition (Dutra et al., 2018; Gutberlet & Baeder, 2008; Gutberlet & Uddin, 2017; Tirado-Soto & Zamberlan, 2013).

Regarding the temperature of the work environment, 69% stated that they considered the temperature to be “pleasant” in organizations, 22% as “hot”, 6% as “cold”, 3% as “very hot”, and none of the waste pickers classified it as “very cold”.

In relation to ventilation, given the options of “adequate” and “inadequate”, most respondents (91%) stated that ventilation is “adequate” in the workplace. According to Gutberlet & Uddin (2017) the lack of adequate ventilation or the presence of leaking roofs can promote bacterial growth and the development of fungus, which can cause respiratory disease to the workers in this environment. For lighting in the workplace, 67% of organization presidents that participated in the survey said that lighting is "adequate".

Regarding the level of dust in the environment, 81% of respondents said that the level of dust is "high" in their organizations, while 13% classified it as "medium" and 6% as "low". A possible explanation for this data is that many warehouses and storages do not have paved floors; this contributes to the increase of dust in the workplace in addition to the dust that is usually generated in operating activities, mainly receiving and sorting.

As for the presence of hazardous waste, 35% of the organizations stated that they receive hazardous waste mixed with other waste, such as paint cans, solvents, lubricants, among others. This indicates failure in the municipal selective collection processes and in the reverse logistics of hazardous waste, resulting in possible contamination of recyclable materials. According to Giovanni et al. (2013) prior knowledge of such products could contribute to the implementation of control procedures and to avoid accidents.

Although the majority of WPO (65%) declare that they do not receive hazardous waste mixed with the waste, it is worth noting that hazardous waste must have a reverse logistics system separate from domestic waste to avoid contamination of recyclable materials.

Microbiologically contaminated waste, such as syringes, dressings, toilet paper, absorbents, glasses, dead animals, feces, and even human fetuses, can confer biological risks (Gutberlet & Uddin, 2017; Zolnikov et al., 2018). Due to the inability to distinguish the types of microorganisms, this research sought to identify the presence or absence of vectors, such as cockroaches, mice, and mosquitoes, that can also transmit diseases in addition to causing health conditions.

Of the organizations surveyed, 53% said they have problems regarding the presence of vectors, especially mosquitoes, and they are considered bothersome, can lower productivity, and can also result in leave from work, due to diseases such as dengue, zika, and chicungunha. Waste pickers also stated during the surveys that rats, cockroaches, and dogs are present in the working environment of most organizations, and some WPO even report-

ed the presence of animals such as scorpions. This result confirms the deficiency of public policies to discern the complete transition between informal and formal waste picker operations. The warehouses initially assigned as temporary structures ended up becoming permanent, even in precarious conditions.

With respect to waste contamination of material that reaches the organizations, 57% of the waste pickers stated that the waste comes partially contaminated by molds (fungi), while 26% declared “no” and 17% reported “yes”.

The results indicated that, due to the presence of dust, vectors, molds, and contamination by hazardous waste, waste pickers believe there is a more imminent presence of chemical and biological risks in WPO than physical risks. Although the survey conducted by Ohajinwa et al. (2017) with electronics collectors pointed out that many could not name at least one chemical present and did not know that e-waste contains health-damaging chemicals. To Gutberlet & Uddin (2017) very few WPO are equipped to deal with these materials.

3.1.5 Ergonomic risks

In order to diagnose the ergonomic conditions, waste pickers were asked whether the height of the waste sorting table, where most of the work in organizations is carried out, is at an appropriate height. 54% reported that the table was at an inappropriate height. It was observed in situ that waste pickers, in general, use crates to adjust the height of the table. This result reflected a non-ergonomic work condition and that waste pickers generally perceive or are aware of overly demanding physical efforts with negative health impacts.

Similar results were observed in the research by Gutberlet et al. (2013), who cited as ergonomic risks in the WPO: inadequate posture due to lack of correct infrastructure in the collection, separation and processing of recyclable materials, lack of fresh air circulation, insufficient lightning and unsafe work organization.

Some potential solutions require investments in mechanical support to relieve physical efforts, for example hydraulic winch; However, some simple and non-expensive solutions can promote ergonomic conditions while sorting waste, such as height-adjustable sorting table (Gutberlet et al., 2013).

3.1.6 Accident risks

To investigate the risks and potential accidents, waste pickers were asked about the existence of sharp or piercing objects, such as needles, nails, and broken glass, among others, that exist in the waste that arrives at the organization. Of the respondents, 93% stated that there is a presence of sharp or piercing materials in the waste that reaches the WPO. As noted in the research by Gutberlet & Uddin (2017), some Brazilian cities use compactor trucks for the selective waste collection, which results in high levels of broken glass arriving at the WPO.

The presence of sharp objects, such as broken bottles, razor blades, needles, glass culets, and sharp pieces of steel can cause accidents, cuts, and infectious diseases (Navarrete-Hernandez & Navarrete-Hernandez, 2018), which may be exacerbated by a lack of tetanus, hepatitis A and hepatitis B vaccines (Black et al., 2019; Gutberlet & Uddin, 2017).

Thus, the survey also sought to diagnose the frequency of occupational accidents and injuries in handling solid waste. Although no case of death or serious injury has been reported, the occurrence of tripping, minor cuts, and wrist injuries was noted in the repetitive process of picking at the sorting table, but none of them occur "frequently".

According to the waste pickers in the surveyed organizations, minor injuries such as wrist pain and trips occurred "occasionally" 48% and 50%, "rarely" 19% and 17%, and "never" 33% and 33%, respectively. Small cuts "never" happen in 52% of organizations, "rarely" in 28%, and "occasionally" in 21%, due to the use of gloves.

Jeong et al. (2016) obtained similar results reporting “slips and trips” as the most common (25.8%) type of accident when surveying 325 male workers who have suffered injury or illness while collecting household waste in Republic of Korea.

Serious injuries such as "fractures", "infections", "crushing", and "deep cuts" do not occur (93%, 93%, 90% and 83%, respectively) or occur "rarely" in organizations (7%, 3%, 10%, 17%, respectively).

Waste pickers’ perception of the causes of occupational accidents was also assessed. The main cause of accidents was the “lack of attention by the worker” (59%), while 26% stated the “lack of safety in the activity” as the cause. 11% said “it never happened” and 4% stated “other” reasons.

It was evident from the perspective of waste pickers, despite the knowledge of potential risks, that they have no notion as to the degree of danger. Thus, accidents occasionally occur at work that are mostly less serious, such as small cuts. To Asibey et al. (2019) and Black et al. (2019) effective communication about the risks they are exposed to could improve the health and safety of waste pickers.

According to Moura et al. (2018), waste picker’s understanding of health is the ability to work and not to get sick. However, it is important to emphasize that in the view of work safety, the ideal scenario is that there are zero accidents; therefore, it was investigated if waste pickers usually meet to discuss the importance of work safety. Of the 35 organizations surveyed, 53% stated that they regularly discuss topics related to work safety. Black et al. (2019) associated low perception of occupational risk with older age (55 years) and never receiving information about occupational risks. In this sense, it was also observed that only 2 of the 35 WPO surveyed have Environmental Risk Prevention Programs (Programa de Prevenção dos Riscos Ambientais, PPRA).

3.2 Risk assessment in Waste Pickers Organizations by safety advisors

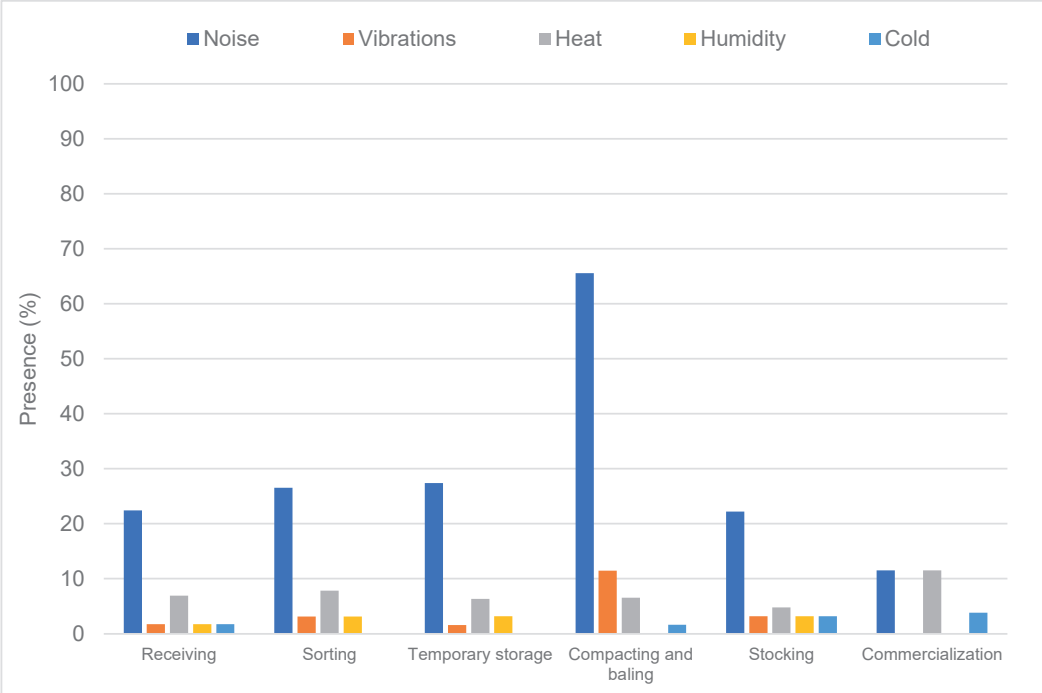
3.2.1 Environmental risks

Of all the physical risks assessed, only noise was found to be present in all WPO operating activities. For the other

physical risks, the frequency of risk occurrence was absent or low (less than 8%), except for heat in the commercialization activities and vibration in the compacting and baling activity. Figure 1 presents the frequency of physical risks occurrence and the classification results of physical risks intensity.

As demonstrated in Figure 1 (A), commercialization was the operating activity that showed lower frequency of noise risk occurrence with only 11.54%, while compacting and baling stood out in comparison to the other activities with 65.57% of frequency of noise risk occurrence in the working environment, as highlighted in red.

(A)



(B)

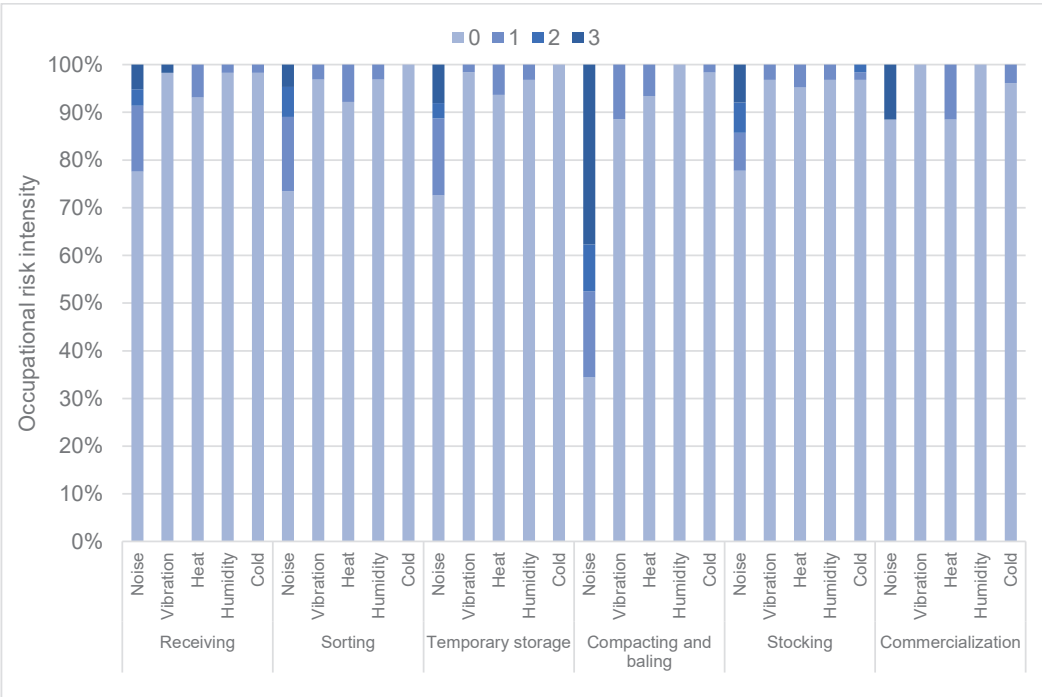


FIGURE 1: Frequency of physical risks occurrence in the WPO operating activities and physical risks intensity in the WPO operating activities.

According to Bleck and Wettberg (2012), the noise can be related to work near busy roads and in the vicinity of loud machinery (i.e. compressor) or vehicles (i.e. workshops, collection trucks).

The frequency of risk occurrence of vibration had a similar behavior with that of noise (see Figure 1 (A)), and this emphasizes the risks of compacting and baling operating activities, due to the compressor operation. The vibration risk of compacting and baling activities is a hand–arm vibration type and, according to Kucuk et al. (2016), it causes vascular damage, sensory nerve damage, and musculoskeletal disorders. However, the compressor is a key equipment to increase sales price of recyclable waste, since the organizations that make use of compressors with larger compression strength are able to generate larger bundles and will have better prices (Dutra et al., 2018).

The physical risks of heat, humidity, and cold were generally absent in WPO operating activities (less than 11%), due to the fact that most workplaces have roofs and masonry walls; thus, waste pickers are protected from heat (sunlight), moisture (rain), and cold (cold winds).

However, it is worth mentioning that even with physical protection against the sunlight, hot days, and poor ventilation make the environment unpleasant with regards to thermal comfort of waste pickers, as manual labor itself requires a high body metabolic rate. According to Zolnikov et al. (2018), waste pickers are exposed to fluctuating temperatures that depend on outdoor temperature.

In addition to the low frequency of physical risk occurring in the WPO operating activities observed in the present study, the physical risks that were reported were classified as "low intensity" with the exception of noise.

As shown in Figure 1 (B), the low physical risks intensity was similar for all operating activities, except for noise and vibration in the compacting and baling that reported 11.48% of the frequency of vibration risks all occurring at occupational risk intensity 1 (low intensity). Occupational risk intensity 3 (high intensity) was observed only in the receiving operating activity, but it presented low representativeness (1.72% of the total).

The physical risks of heat, humidity, and cold showed occupational risk intensity only at level 1 (low intensity). In this regard, cold environments during the stocking process were the only exception, where a WPO presented level 2 (medium intensity).

In general, waste pickers perceived that the work environment conditions did not present physical risks in line with the safety advisor assessment, except for noise. Only a minority of waste pickers (9%) considered noise "high"; however, a high intensity (level 3) was observed in the compacting and baling of 38% of WPO. It was demonstrated that waste pickers underestimate the noise, and this is probably because they are already used to it and do not associate this risk with health effects. As discussed previously, only 47% of waste pickers reported using hearing protector equipment.

According to Occupational Safety and Health Administration (2022) physical risks can be mitigated by adopting control measures such as the use of safety equipment, reduction of sun exposure time (in places without cover), and by granting breaks during the workday.

The Brazilian Regulatory Standard NR 15 states the tolerance limits for continuous or intermittent noise and recommends that for an 8-hour working day, the maximum allowable daily exposure is 85 dB (Brazilian Regulatory Standard NR 15 - Unhealthy Activities and Operations, 2015). The compressors of the WPO are of different year, make, model, and capacity, but the sound level of the presses can vary from 80 to 100dB. Thus, it is essential to carry out continuous measurement of the compressor noise in the WPO.

With regard to other environmental risks, the biological risks were also evaluated in relation to the possible presence of potentially pathogenic microorganisms (bacteria, fungi, and viruses), while the chemical risks were evaluated according to the presence of dust. Figure 2 presents the results of frequency of biological and chemical risks occurrence and the results for frequency of biological and chemical risks intensity in the WPO operating activities.

Overall, as presented in Figure 2 (A), biological and chemical risks are higher in the early operational activities and decrease until commercialization, but they have been identified (over 50%) in most operational activities. As expected, the operating activity that presented the highest chemical risk (dust) is sorting, followed by receiving, as can be seen in Figure 2 (A); however, the presence of dust has been reported with more than 73% frequency in all operating activities.

The operational activities of receiving and sorting in WPO are those that generate more dust suspension when compared to the commercialization activity, where the recyclable material is already compacted in large bales. In developing countries, sorting is usually carried out manually using outdated equipment, without any dust control or protection of workers, which causes greater contact between the waste picker and the waste (Cointreau, 2006; Sembiring & Nitivattananon, 2010; UN-HABITAT, 2010).

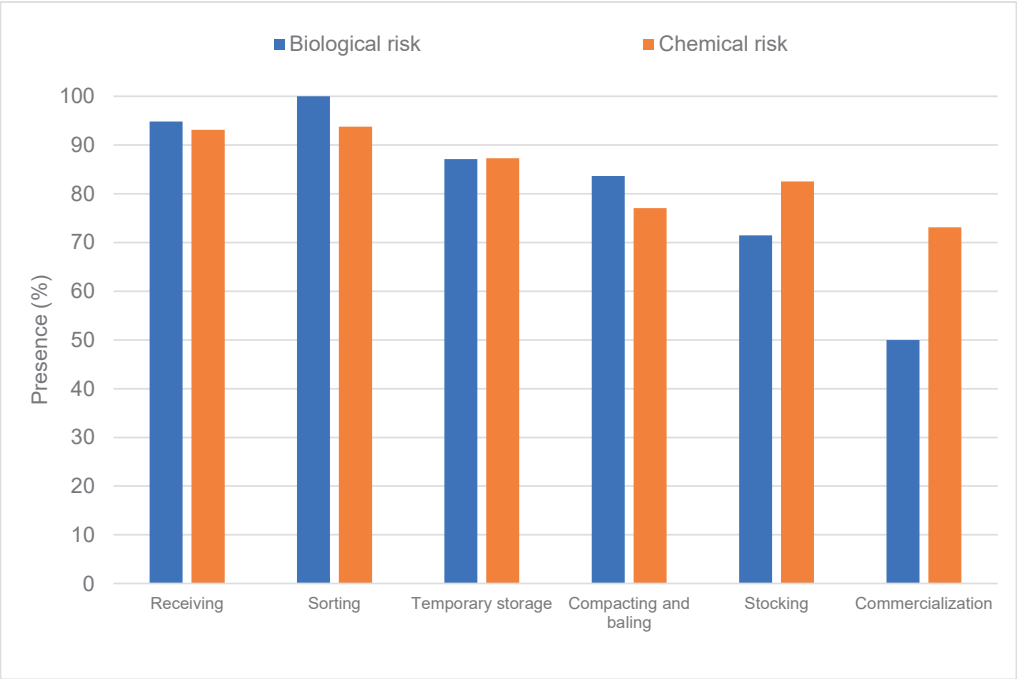
According to Bleck and Wettberg (2012), dust is generated in each operating activity involving waste transferal, such as pouring the waste onto the sorting table, filling collection bags for temporary storage; and during transferal to the containers for commercialization.

Another concern regarding dust is the presence of volatile organic compounds, as paper and cardboard, organic wastes, and plastics are prominent sources of volatile organic compounds in municipal solid waste facilities (Nabizadeh et al., 2020). The inhalation exposure to pathogens can cause bronchial asthma, colds, and other respiratory problems (Bleck & Wettberg, 2012).

With regard to biological risk, it was observed that the risk decreases over the course of operating activities, and by the end, the risk is reduced to 50% at commercialization. It is worth mentioning that in receiving, there was no risk reported in 5% of WPO. However, the risk increases in sorting, even though it is an activity after receiving, as the improper handling of waste can generate consequent inhalation of biological contaminants.

Inadequate conditions for storing waste before reaching WPO can also contribute to the increase in biological risk. According to Madsen et al. (2019), the concentrations

(A)



(B)

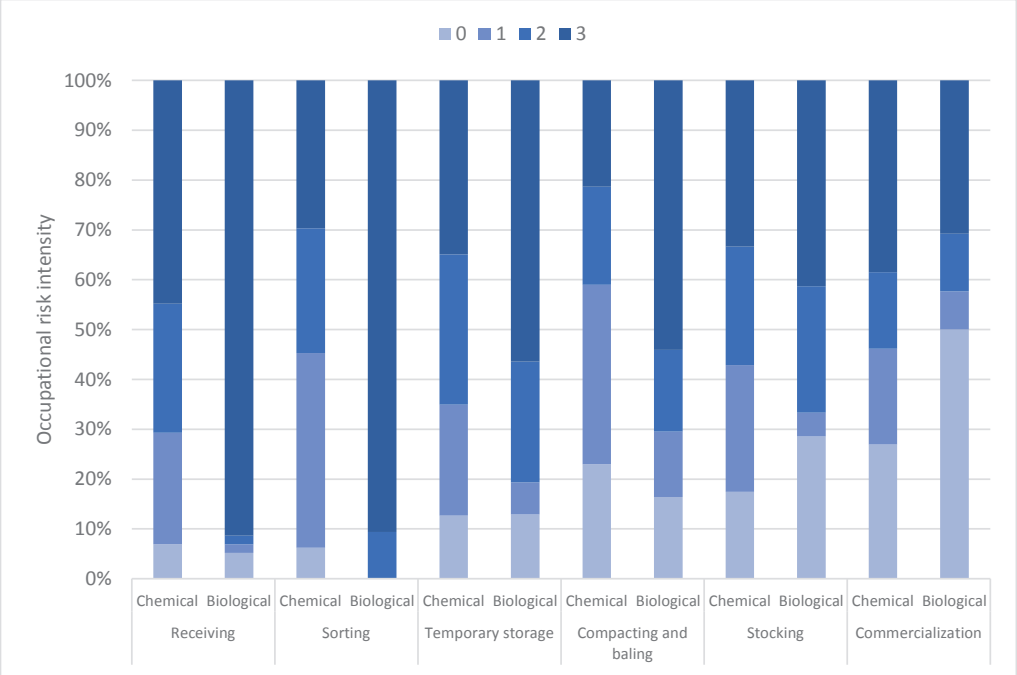


FIGURE 2: Frequency of biological and chemical risks occurrence in the WPO operating activities and biological and chemical risks intensity in the WPO operating activities.

of bacteria and endotoxins are directly associated with the temperature inside the waste containers and the frequency of exposure to endotoxins and fungi during collection and sorting.

According to review findings performed by Silva and Amaral (2019), there is a lack of epidemiological data analysis and epidemiological indicators integrated into occupational safety, as well studies with emphasis on the questions involving worker health.

It is noted in Figure 2 (B) that the occupational risk intensity varied in relation to operating activities, especially for biological risks. A predominance of activities with bio-

logical risk intensity 3 was observed. There is an emphasis on receiving and sorting with 91% and 90%, respectively, because heat and humidity promotes pathogenic organism proliferation on the municipal solid waste. In this respect, inhalation is generally the major route of exposure of waste pickers (Odewabi et al., 2013), being more intense in the initial operating activities.

In addition, other risk behaviors of waste pickers regarding hygiene and the absence of PPE corroborates the high biological risk intensity, and these behaviors include consuming non-filtered water, eating food from the garbage, having contact with animal and human feces, among other wastes, and low use of gloves, as reported by Martins et al. (2014).

With regard to chemical risk, regular distribution of risk was observed in all operating activities, reinforcing that dust is generated in all activities of waste transfer, as reported by Bleck and Wettberg (2012).

One of the main concerns about dust-filled environments is that it can often take decades for a waste picker to develop any symptoms of the illness (Kontogianni & Moussiopoulos, 2017), and it can then be difficult to associate health problem with work conditions.

As a measure to mitigate biological and chemical risks Zolnikov et al. (2021) recommends encouraging the use of PPE, such as chemical protective clothing, respiratory protective masks, gloves, and goggles (Occupational Safety and Health Administration, 2022).

3.2.2 Ergonomic risks

The ergonomic risks evaluated in this study were physical effort and excessive pace, and Figure 3 presents the obtained results for frequency of ergonomic risks occurring in the WPO operating activities and presents the ergonomic risks intensity.

In Figure 3 (A), it appears that the risks of physical effort and excessive pace are present in all operating activities (above 87%). In the activities of temporary storage, compacting and baling, and commercialization, the physical effort was a verified risk in all WPO. For excessive pace, likewise, sorting, compacting and baling, and commercialization, all presented risk in all WPO surveyed.

WPO work is strenuous and has a high physical demand. The lifting of loads, repetitive spine movements, prolonged standing, and repetitive movements of the upper limbs, especially during the process of waste sorting, are the main ergonomic risk factors that vary according to the intensity of exposure (Araújo and Sato, 2018).

As shown in Figure 3 (B), the values for physical effort and excessive pace in the ergonomic risk intensities were similar. The high intensity (level 3) of ergonomic risks stands out in all WPO operating activities. The risk perception of intense physical effort was also the most noticeable among waste pickers.

In practice, however, it was observed that waste pickers perform much more physical effort than is compatible with their health. 88.5% of WPO perceive that physical effort has a negative effect on their health, and 76% classified it as "Very Intense/Intense", which was evidenced by the safety advisor assessment.

In the operating activities of receiving, temporary storage, compacting and baling, stocking, and commercialization, according to Gutberlet (2015) and Jeong et al. (2016), ergonomic risks are related to the weight of bags since waste pickers repeatedly bend over to lift and move heavy wastes, suggesting the introduction of suitable machines for handling heavy loads.

During sorting, most waste pickers sort recyclable waste while standing or sitting on cans, piles of newspapers, or low chairs. The Brazilian labor legislation (Consolidation of Labor Laws (CLT), 1943), article 199, establishes that for the individual who works while sitting, it mandatory they use a seat that ensures good posture in order to avoid uncomfortable or forced positions. On the other hand, workers that stand must have a seat available to be used during breaks.

Gutberlet (2015) noted the reduction of ergonomic risks through classification in tables according to ergonomic standards. A study performed by Araújo et al. (2019) compared postures between manual sorting on a fixed work surface and the use of conveyor belts, and the results showed that the implementation of a conveyor belt did not result in postural overload and might be considered for ergonomics intervention.

Rebehy et al. (2018) also suggested ergonomic intervention through the use of ergonomic vehicles to allow for the inclusion of women in the collection process.

3.2.3 Accident risks

Figure 4 shows the frequency of accident risk occurrence due to improper physical arrangement, unguarded machines, poor lighting, poor electrical connections, inappropriate tools, and inadequate use of PPE in WPO operating activities and presents accident risk intensity.

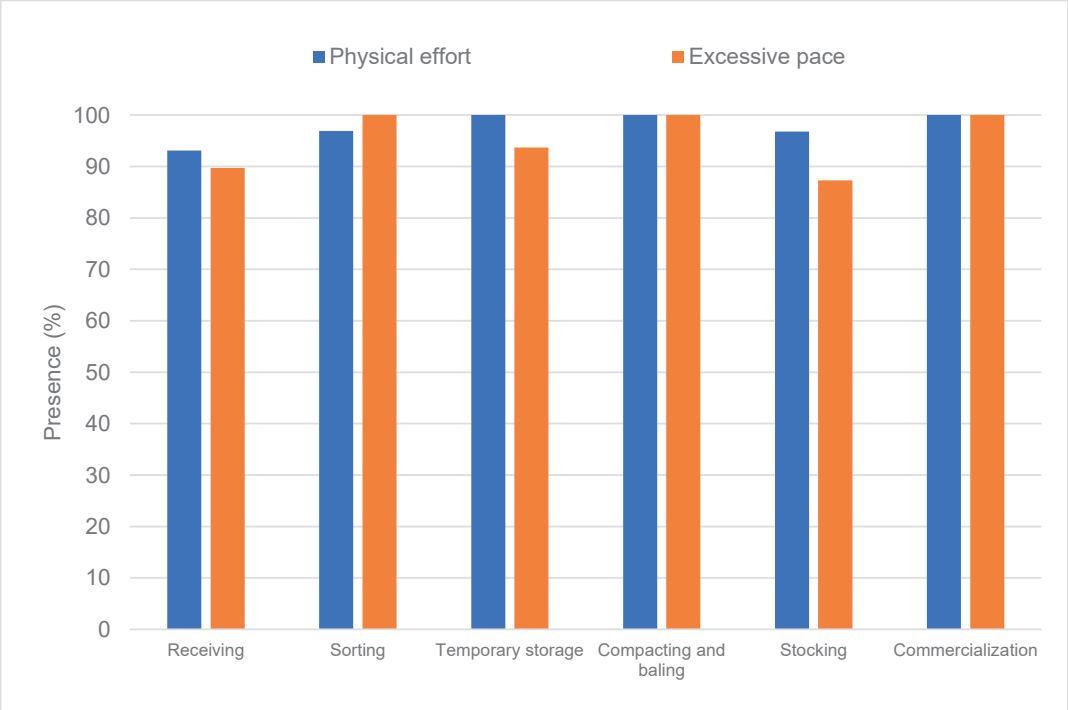
As can be seen in Figure 4 (A), the frequency of accident risks occurrence due to improper physical arrangement and inadequate use of PPE was above 80% and 73%, respectively, for all operating activities. The risk attributed to inappropriate use of PPE is clearly observed and also does not comply with labor laws, but the improper physical arrangement can easily be underestimated.

Improper physical arrangement hinders the transit of people, vehicles, and equipment within the WPO, increases the space required for storage, lengthens the receiving and sorting process, causes ergonomic and accident risks, and favors the contamination of recyclable materials with organics, thus reducing the quantity and quality of the product (Castilhos Junior et al., 2013; Zon et al., 2019).

One of the main reasons for improper physical arrangement is the waste accumulation and random storage, which causes problems such as: excess inventory, unnecessary movement and transportation, non-continuous flow, additional work due to the addition of waste to already sorted materials, underutilized and disorganized areas, and mismanagement. In this sense, Gutberlet et al. (2013) mentions unstable piles and unsafe surfaces as sources of accidents, noting that some WPO carry out collection on the street, which can result in traffic accidents.

In the activity of compacting and baling, the possible causes of accidents are also related to unguarded ma-

(A)



(B)

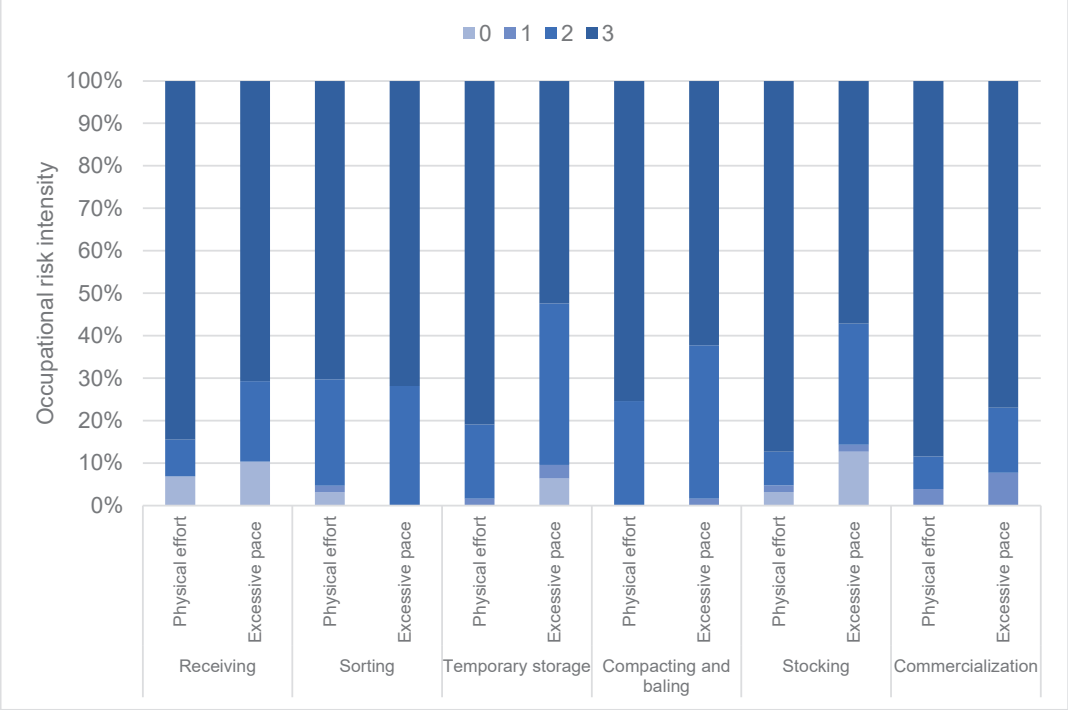
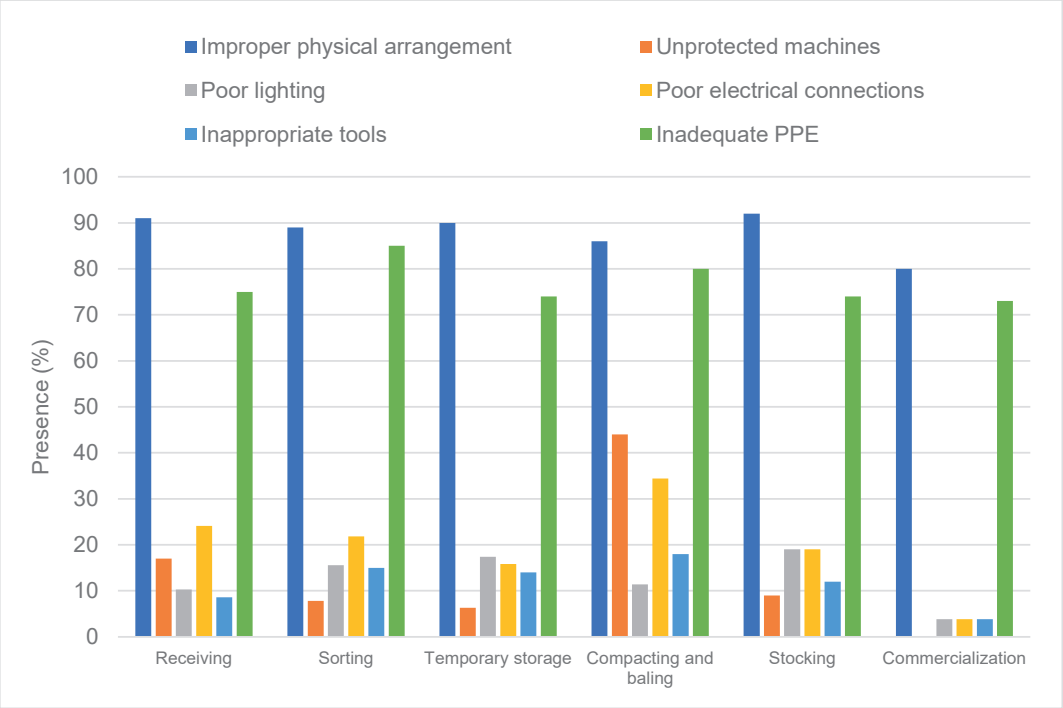


FIGURE 3: Frequency of ergonomic risks occurrence in the WPO operating activities and ergonomic risks intensity in the WPO operating activities.

chines (44%) and poor electrical connections (34%). Inadequate electrical connections can result in risk such as electric shock, sparks that can cause a fire, and even cause the compressor to malfunction. While in operation or idle, the compressor can also present risk if it is not properly guarded, since it can be started accidentally.

Regarding the existence of risk, the other possible causes analyzed (i.e. poor lighting and inappropriate tools)

(A)



(B)

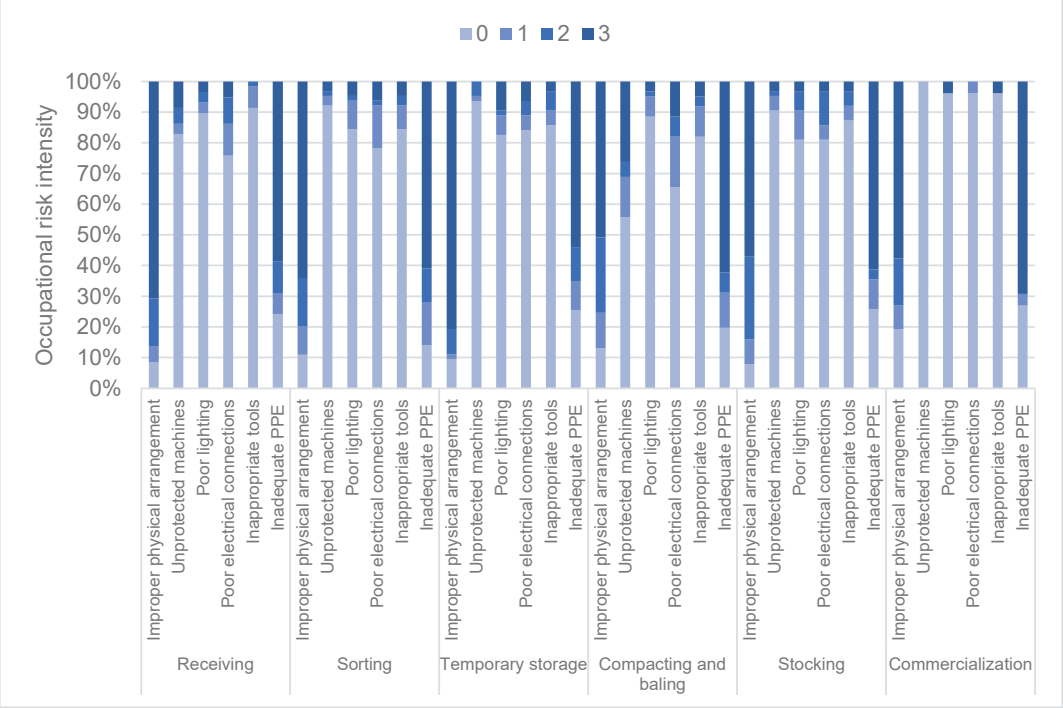


FIGURE 4: Frequency of accident risks occurrence in the WPO operating activities and accident risks intensity in the WPO operating activities.

did not present significant risks among the operating activities (less than 19%), meaning that there is little probability of accidents occurring.

Figure 4 (B) shows that unguarded machines, poor lighting, poor electrical connections, and inappropriate tools are similar in that they do not show level 3 accident risk intensity (less than 26%).

However, the results demonstrated that improper phys-

ical arrangement offer higher accident risks intensity in all operating activities, mainly in temporary storage and receiving. This fact is evidenced when comparing with the waste picker perception, since 50% of minor injuries that occurred occasionally were "slips and trips", due to many obstacles in the circulation area.

Waste pickers probably perceive the disorganized bags in WPO areas as normal and do not give importance to a workplace layout that causes an unsafe work environment with many obstacles. Even though they perceive obstacles as a hindrance, waste pickers do not perceive them as a high risk for accidents, nor are they present in all operating activities.

Changing the layout and organization of the circulation area of a WPO, in addition to reducing the risk of accidents, can also prevent the presence of vectors and reduce physical effort. Other suggestions include: reorganization of stocks to bring them closer to the place of use, change in the compressor position, and the acquisition of more equipment.

While the improper physical arrangement can be considered an easily solved problem, inadequate use of PPE is a concerning factor, as it involves behavioral change and awareness on the part of waste pickers. Among the main barriers are low schooling, lack of resources to acquire PPE in quantity and of required quality, lack of inspection, and discontinued support from city halls, among others. The protection that PPE confers is already known and reported in several studies. For comparison, the study performed by Zolnikov et al. (2018) reported that injuries due to lack of personal protective equipment are frequently observed in informal waste pickers working in dumpsites, and these events were caused by cuts with syringes (85.6%), followed by 8.1% that suffered from slips and falls.

Comparing with the present study, small cuts only happen "occasionally" in 21% of WPO due to the use of gloves, which demonstrates that the work of formal waste pickers in WPO is safer, and the use of PPE considerably reduces the risks of accidents such as cuts. However, the WPO studied presented inappropriate use of PPE and was observed in all operating activities, inferring a high degree of risk (above 54%). For Gutberlet & Baeder (2008) cuts and fractures could be minimized if there was better source separation, providing clean and safe materials for the WPO.

The waste pickers understand the importance of protecting themselves, but in spite of legislation and PPE offered by the WPO, some resistance is still observed. This is probably because of waste picker perception, the use of PPE hinders performance of activities, and productivity/gains are considered the priority (Gutberlet & Uddin, 2017).

Corroborating these findings, Zolnikov et al. (2018) cited incorrect usage of PPE, lack of orientation, discomfort, and decreased productivity as the main reasons, which all lead to loss of income. Changing the waste pickers behaviors involves continuous awareness programs and investments in PPE that consider particularities of waste pickers activities and the high turnover existing in the WPO (Gutberlet et al., 2013).

4. CONCLUSIONS

The simple technical evaluation without input of people who actually work in a WPO would not allow for the identification of important issues. These include noise not being perceived as a risk by waste pickers and physical effort being considered a characteristic of the work and a health synonym. There is also less perceived risk, as there is no ergonomic consideration of the working position (sitting or standing) during sorting, inadequate use of PPE is related to productivity and is a priority, and lack of organization layout of WPO directly affects the number of accidents that have occurred.

Risk intensity is unprecedented data and allowed for important observations about the occupational risks of waste pickers from WPO. The qualitative assessment indicates only the existing risks, while the quantitative assessment showed that noise, an underestimated risk by waste pickers, is frequent in all operational activities (below 27%). In the compacting and baling activity, it is present in 65% WPO and presented high risk intensity in 38% WPO, which is well above the others.

It was observed, in general, that in the scale of risk intensity, there were no considerable differences between the operational activities of the other risks classified with maximum degree, such as biological risks, physical effort, excessive pace, improper physical arrangement, and inadequate use of PPE. This reflects the precarious working conditions, due to the short time since acknowledging the profession and the work environment being a structure adapted to receive informal waste pickers removed from dumpsites.

The obtained data in the risk assessment by occupational safety technicians allowed to identify occupational risks, but the results are limited to the 64 WPO from Espírito Santo State. It is possible that additional occupational risks have not been identified in this investigation.

The main limitation of this research, as already mentioned, was the scale of 0 to 3 adopted by occupational safety technicians in Brazil which indicated the predominance of maximum risk intensity to the occupational risks evaluated limiting the hierarchization of the risks.

As suggestions for future research we recommend periodic evaluations of the WPO to compare the evolution (increase or decrease) in the intensity of the risks observed in this research and the development of new studies that propose practical solutions to reduce those risks, such as investments in the infrastructure of WPO, improvements in the work flow and training of waste pickers.

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