Revista Prevenção de Infecção e Saúde
The Official Journal of the Human Exposome and Infectious Diseases Network

ORIGINAL ARTICLE DOI: 10.26694/repis.v11i1.6823

Multisectoral Intervention in Occupational and Environmental Health Among Informal Waste Pickers: Experience in Chota, Peru

Intervenção Multissetorial em Saúde Ocupacional e Ambiental com Catadores Informais: Experiência em Chota, Peru

Intervención multisectorial en salud ocupacional y ambiental con recicladores informales: Experiencia en Chota, Perú

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How to cite this article:
Cárdenas Tirado ZI, Avellaneda Yajahuarca RS, Holmes Flores E, Irigoin Vásquez A, Jaimes Velásquez CAA, Freitas DRJ, Jimenez de Aliaga KM. Multisectoral Intervention in Occupational and Environmental Health Among Informal Waste Pickers: Experience in Chota, Peru. Rev Pre Infec e Saúde [Internet]. 2025; 11: 01. Disponível em: http://periodicos.ufpi.br/index.php/repis/article/view/6823. DOI: https://doi.org/10.26694/repis.v11in.1.6823.

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ABSTRACT

Introduction: Occupational health among informal waste pickers in Peru represents a public health issue. The aim of this study was to assess the effectiveness of a multisectoral intervention program focused on occupational safety and environmental health promotion among informal waste pickers in Chota, Peru. **Design**: The study population consisted of 20 informal waste pickers from the municipality of Chota, Cajamarca, Peru. A non-probabilistic quota sampling technique was employed, and the sample was distributed across six districts of Chota. The study was conducted in two phases: pre-test and post-test. **Results**: There was a significant increase in the use of personal protective equipment among participants, in adherence to tetanus vaccination ($p = 0.018 < 0.05$), and in the adoption of safety measures in the workplace ($p = 0.001$). There was also an improvement in participants' understanding of the transmission of infectious diseases by insects and animals ($p = 0.047 < 0.05$), and in the practice of boiling water before consumption to prevent infectious diseases ($p = 0.035 < 0.05$). **Implications**: The program contributed to improving the occupational health of informal waste pickers by preventing infections and occupational diseases and promoting best practices in workplace safety and proper waste handling and disposal.

DESCRIPTORS

Occupational health. Waste pickers. Workplace safety. Intervention program.

Submitted: 29/04/2025
Accepted: 20/06/2025
Published: 25/06/2025

INTRODUCTION

The management of municipal solid waste is a global challenge that directly affects human, animal, and environmental public health, as well as the economy. According to a 2018 report by the World Bank[1], the world generates approximately 2.01 billion tons of solid waste annually, with projections reaching 3.40 billion tons by 2050, mainly due to urbanization and population growth. The global average recycling rate is below 20%, with wide variations between high- and low-income countries[1].

In the European Union, public policies on recycling have driven recycling rates above 50% in countries such as Germany and Austria[2]. In Japan, a model based on public awareness and community participation, combined with incineration technologies with energy recovery, maintains a material recycling rate between 20% and 30%[3]. In the United States, the recycling rate remains around 32%, with a heavy reliance on landfills[4]. In Africa, formal waste collection covers less than 50% of many urban areas, and recycling is primarily carried out by informal waste pickers[5]. Circular economy initiatives and the socioeconomic inclusion of waste pickers have been gaining ground as sustainable strategies. Latin America has been attempting to follow this path but faces structural challenges related to selective collection and sector informality. It is estimated that over one million informal recyclers operate in the region, accounting for a large portion of effective recycling[6,7].

In Peru, informal recycling is marked by health and occupational safety risks, with a lack of work environments that ensure effective health promotion and disease prevention practices for waste pickers and recyclers[8]. In the specific case of Cajamarca, there are three waste picker and recycler organizations Cajamarca Saludable, Recicladores de Jaén, and Jaenos de Corazón which together include only 19 members[9]. Although these organizations contribute to waste reuse, the relatively rudimentary techniques they employ, combined with improper management of secondary contaminants, worsen air, soil, and water pollution[10], exposing these workers to occupational health and safety risks[11]. This reality calls for multidimensional and multilevel interventions that provide sustainable solutions for urban waste management[12], requiring effective institutional formalization processes.

During discussions with waste pickers, many reported that formalization is not attractive, as the basic monthly wage is around USD 233—an amount that, in practice, can be quadrupled through informal activity, though without any health protection and with numerous health risks, including serious infectious diseases. This situation contradicts the Sustainable Development Goals (SDGs) of the 2030 Agenda, of which at least five address environmental health determinants—such as access to safe drinking water, sanitation, hygiene, air quality, chemical safety, and climate action[13] aimed at ensuring healthy lives and promoting well-being for all people at all ages. However, these goals face serious challenges for implementation, particularly in inclusive and equitable public policies for protection against environmental risks. It is noteworthy that, in Latin America, approximately 50% of recycled waste comes from the work of about 2 million informal waste pickers[14,15].

In this context, critical questions emerge: Does the policy of recycling formalization inadvertently encourage informality due to wage disparities? Moreover, does formal recycling policy compromise the safety of informal waste pickers? To address these questions, the development and implementation of an intervention program may serve as an effective tool. Therefore, the objective of this study was to determine the effectiveness of a multisectoral intervention program in occupational safety and environmental health promotion among informal waste pickers in Chota, Peru.

METHODS

Population, Sample, Sampling, and Study Unit

The study population consisted of informal waste pickers from the municipality of Chota – Cajamarca, Peru; the sampling technique adopted was non-probabilistic quota sampling. The sample distribution was carried out as follows: 20 waste pickers from 6 districts were invited and agreed to participate in the study: 4 from Chota, 3 from Cochabamba, 5 from Huambos, 2 from Lajas, 3 from Tacabamba, and 3 from Chalamarca. This sample corresponds to informal waste pickers located in the main districts of Chota province, identified through field visits and direct observation, due to the absence of formal records. Quota sampling aimed to represent the geographical diversity of the study area.

Experimental Design

This was an applied study, where its approximation to reality was considered scientific evidence of a practical social problem. A quantitative approach was adopted, and the study design was pre-experimental, explanatory, and longitudinal, as it was conducted in two distinct stages: pre-test and post-test[16,17].

The study lasted eight months and was divided into three sequential stages:

- Target population: 20 informal waste pickers working without institutional oversight.
- Inclusion criterion: all informal waste pickers of both sexes operating in the defined districts.
- Exclusion criterion: all formalized waste pickers.

Study Stages

a) First stage: In this phase, informal waste pickers were invited to participate in the research through direct communication by the authors, respecting the principles of free and informed consent. The group underwent a questionnaire developed by the authors, based on pre-existing instruments from the literature and previously validated by five experts from institutions linked to the educational intervention program on environmental health promotion and occupational safety for informal waste pickers. The instrument was validated through three rounds of expert consultation to ensure that the proposed items and dimensions adequately measured the defined theoretical constructs. Linguistic clarity, question comprehension, and the relevance of response options for the target audience were also assessed. Instrument validity was determined through expert judgment, and results were subjected to hypothesis testing for proportions to verify whether Aiken's V coefficient was significantly greater than 50%.

A pilot application of the questionnaire was then conducted with waste pickers not participating in the study. Internal consistency of the instrument was assessed using Cronbach's Alpha coefficient, with values equal to or greater than 0.82 considered acceptable.

The final version of the questionnaire, applied before and after the intervention, contained five sections:

- A: Participants' sociodemographic data.
- B: Assessment of prior knowledge.
- C: Perception of occupational safety and environmental health promotion in the informal work context.
- D: Assessment of study variables.
- E: Evaluation of tools and content related to environmental health promotion and occupational safety for waste pickers.

Sections C, D, and E were presented using a Likert scale with the following response options: strongly disagree, disagree, neutral, agree, strongly agree.

b) Second stage: Based on the diagnostic assessment from the previous stage, an audiovisual educational intervention was conducted with the study group (n = 20) via a 60-minute videoconference prepared by the authors as an informational and motivational tool.

c) Third stage: One month after the educational intervention, the questionnaire was reapplied to assess the intervention's effect by verifying increases in knowledge and changes in participants' perceptions.

Subsequently, the data were statistically analyzed using measures of central tendency, variance calculation, standard deviation, range, kurtosis, and skewness coefficient. Both parametric and non-parametric statistical techniques were applied, including normality tests (Kolmogorov-Smirnov and Shapiro-Wilk) and Q-Q normal plots. To analyze differences between pre- and post-intervention moments,

the paired Student's t-test and the Wilcoxon test were used, with assistance from SPSS software version 27.

Ethical Aspects and Scientific Rigor

The individual rights of research participants were respected, particularly regarding the integrity of families and involved institutions. All participants signed a Free and Informed Consent Form (FICF), ensuring voluntary, ethical, and safe participation, as well as the preservation of anonymity.

RESULTS

The study included a total of 20 informal waste pickers. The participants' general sociodemographic characteristics are presented in the following table. Table 1 shows that 65% of waste pickers were male. The most frequent age group was 18 to 30 years, representing 35% of participants, followed by the 31 to 43 years group with 30%. Regarding marital status, 45% of waste pickers reported being single, 40% were in a common-law union, and only 15% were married.

In terms of education level, most participants had completed high school (25%). Another relevant finding was the length of time working as a waste picker, with the categories 1–5 years (35%) and less than 1 year (30%) being the most frequent.

Table 1. Sociodemographic characteristics of study participants. Peru, 2025.

Características	N°	%
Sex		
Male	13	65,0%
Female	7	35,0%
Age group (years)		
Under 18	1	5,0%
18 – 30	7	35,0%
31 – 43	6	30,0%
44 – 56	3	15,0%
57 – 69	2	10,0%
70 or older	1	5,0%
Marital status		
Married	3	15,0%
Single	9	45,0%
Common-law union	8	40,0%
Education level		
Completed elementary school	3	15,0%
Incomplete elementary school	4	20,0%
Completed high school	5	25,0%
Incomplete high school	4	20,0%
Completed higher education	3	15,0%
No schooling	1	5,0%
Length of time working as waste picker		
Less than 1 year	6	30,0%
1 – 5 years	7	35,0%
6 – 10 years	4	20,0%
11 – 15 years	2	10,0%
21 years or more	1	5,0%

Occupational safety among waste pickers was also assessed, focusing on the use of personal protective equipment (PPE) and transportation methods used to carry the collected waste, before and after the intervention program. The data are presented in Table 2.

The personal protective equipment that showed significant differences in use between the pre- and post-intervention periods were: gloves (increased from 60% to 100%; p = 0.002), boots (increased from 25%

to 65%; p = 0.011), cap/hat (increased from 15% to 50%; p = 0.018), and face mask (increased from 60% to 90%; p = 0.028). Regarding the means of transporting recyclable waste, no significant differences were found between the pre- and post-intervention periods (p > 0.05).

Table 2. Use of personal protective equipment (PPE) and transportation methods before and after the multisectoral intervention program. Peru, 2025.

Characteristics	Pre-test		Post-test		p-value
	No n (%)	**Yes** n (%)	**No** n (%)	**Yes** n (%)	
Personal protective equipment					
Gloves	8 (40,0%)	12 (60,0%)	0 (0,0%)	20 (100,0%)	**0,002****
Boots	15 (75,0%)	5 (25,0%)	7 (35,0%)	13 (65,0%)	***0,011****
Coverall	18 (90,0%)	2 (10,0%)	16 (80,0%)	4 (20,0%)	0,376
Cap/hat	17 (85,0%)	3 (15,0%)	10 (50,0%)	10 (50,0%)	***0,018****
Protective goggles	18 (90,0%)	2 (10,0%)	14 (70,0%)	6 (30,0%)	0,114
Face mask	8 (40,0%)	12 (60,0%)	2 (10,0%)	18 (90,0%)	***0,028****
None	14 (70,0%)	6 (30,0%)	20 (100,0%)	0 (0,0%)	**0,008****
Means of transportation for solid waste collection					
Tricycle	18 (90,0%)	2 (10,0%)	18 (90,0%)	2 (10,0%)	1,000
Wheelbarrow	17 (85,0%)	3 (15,0%)	19 (95,0%)	1 (5,0%)	0,292
Motorcycle taxi	15 (75,0%)	5 (25,0%)	16 (80,0%)	4 (20,0%)	0,705
Pickup truck	12 (60,0%)	8 (40,0%)	15 (75,0%)	5 (25,0%)	0,311
Others[a]	13 (65,0%)	7 (35,0%)	9 (45,0%)	11 (55,0%)	0,204

[a] Truck, cargo motorcycle, sack, on foot.
* Significant at 5%.
**Significant at 1%.

Occupational health was one of the topics addressed and studied by the multisectoral intervention program. Data collected during the pre- and post-tests are presented in Table 3.

In the results presented in Table 3, no significant differences (p > 0.05) were observed in the occupational health indicators before and after the program implementation. Working hours as waste pickers showed similar distributions in the pre- and post-tests. Most waste pickers worked 5 to 7 days per week—55% in the pre-test and 70% in the post-test.

Another relevant aspect was the number of family members involved in recycling work. In the pre-test, 45% reported one family member involved, while in the post-test this percentage was 50%. Regarding monthly income, most participants earned up to 1,200 soles. In the pre-test, this totaled 70%; in the post-test, 80%.

Concerning illnesses related to waste picking activities, 15% of participants reported illnesses in the pre-test, increasing to 25% in the post-test. Reported conditions included fractures, lower back pain, abdominal pain, headache, and arm numbness.

Regarding general health status, 35% of waste pickers in the pre-test and 30% in the post-test reported not feeling well. The main complaints included diabetes, hypertension, arm pain, lower back pain, foot pain, leg pain, and pulmonary issues. In terms of discrimination related to their occupation, participants most frequently selected “Never” (40% in both pre- and post-test), followed by “Sometimes” (35% in pre-test and 40% in post-test).

Table 3. Distribution of waste pickers according to occupational health characteristics before and after the multisectoral intervention program. Peru, 2025.

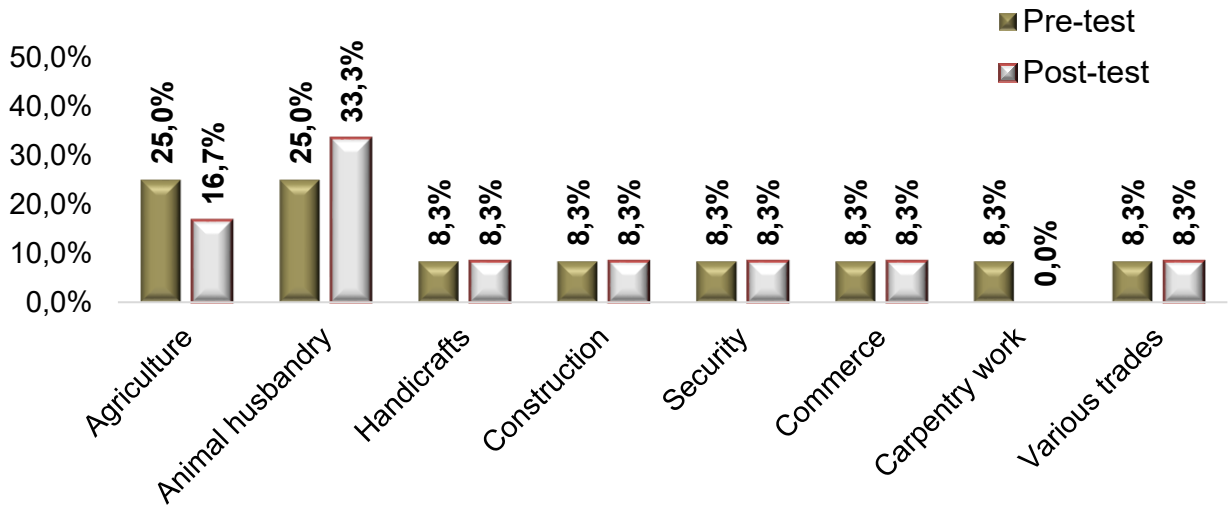
Characteristics	Pre-test n°	Pre-test %	Post-test n°	Post-test %	p-value
Working hours as waste picker: Less than 2 hours	4	20,0%	2	10,0%	0,376
Working hours: 2–4 hours	7	35,0%	7	35,0%	1,000
Working hours: 5–7 hours	3	15,0%	4	20,0%	0,677
Working hours: 8 hours or more	6	30,0%	7	35,0%	0,736
Workdays per week: 1–2 days	7	35,0%	4	20,0%	0,288

Workdays: 3–4 days	2	10,0%	2	10,0%	1,000
Workdays: 5–7 days	11	55,0%	14	70,0%	0,327
Number of family members working as waste pickers: 1	9	45,0%	10	50,0%	0,752
Number of family members: 2	3	15,0%	4	20,0%	0,677
Number of family members: 3	6	30,0%	5	25,0%	0,723
Number of family members: 4 or more	2	10,0%	1	5,0%	0,548
Additional work besides waste picking: Yes	12	60,0%	11	55,0%	0,749
Additional work besides waste picking: No	7	35,0%	9	45,0%	0,519
Additional work besides waste picking: No response	1	5,0%	0	0,0%	0,311
Monthly income (in soles): Less than S/. 900	7	35,0%	8	40,0%	0,744
Monthly income (in soles): S/. 900 - S/. 1200	7	35,0%	8	40,0%	0,744
Monthly income (in soles): More than S/. 1200	6	30,0%	4	20,0%	0,465
Illness due to waste picking: Yes[a]	3	15,0%	5	25,0%	0,429
Illness due to waste picking: No	17	85,0%	15	75,0%	0,429
Currently feels healthy: Yes	13	65,0%	14	70,0%	0,736
Currently feels healthy: No[b]	7	35,0%	6	30,0%	0,736
Feels discriminated due to work: Never	8	40,0%	8	40,0%	1,000
Feels discriminated: Almost never	2	10,0%	3	15,0%	0,633
Feels discriminated: Sometimes	7	35,0%	8	40,0%	0,744
Feels discriminated: Almost always	1	5,0%	0	0,0%	0,311
Feels discriminated: Always	2	10,0%	1	5,0%	0,548

[a]Fracture, back pain, stomach pain, headache, numbness in the arm.
[b]Diabetes, lower back pain, foot pain, leg pain, pulmonary pain, hypertension, arm discomfort.

Informal waste pickers' additional income-generating activities were also assessed before and after the intervention program. In the pre-test and post-test, 60% and 55%, respectively, reported engaging in additional work beyond waste picking. Among these activities, agriculture (25% in pre-test and 16.7% in post-test) and animal husbandry (25% in pre-test and 33.3% in post-test) were most frequently reported. Other occupations included handicrafts, construction, security services, among others. The data are represented in Figure 1.

Figure 1. Distribution of waste pickers according to complementary activities performed before and after the multisectoral intervention program. Peru, 2025.



Occupational health data were also collected regarding whether participants had health insurance, received tetanus vaccination, adopted protective measures, or had any history of work-related accidents, insect bites, or handling materials from healthcare facilities. The data are summarized in Table 4.

Regarding tetanus vaccination at healthcare facilities, a significant difference was identified (p = 0.018 < 0.05), with an increase from 65% in the pre-test to 95% in the post-test. The adoption of protective measures at work also showed a significant difference (p = 0.001), demonstrating the effectiveness of the program, increasing from 55% in the pre-test to 100% in the post-test. Regarding participants' opinions on disease transmission by insects and animals, a significant difference was observed (p = 0.047 < 0.05) in the "Always" category: in the pre-test, 50% of waste pickers believed these vectors transmitted diseases, and in the post-test this percentage rose to 80%. For the remaining indicators, no significant differences (p > 0.05) were observed after the implementation of the multisectoral occupational safety and environmental health promotion intervention program.

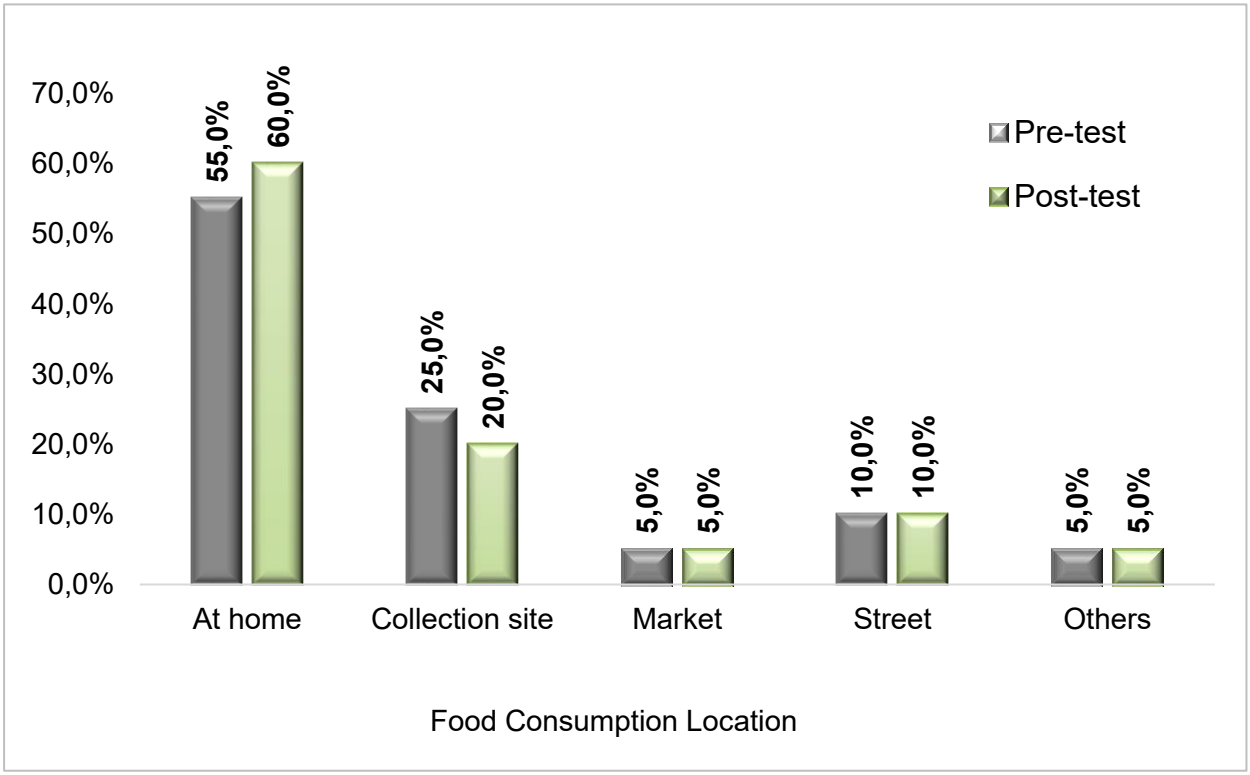
Table 4. Distribution of waste pickers according to occupational health characteristics before and after the multisectoral intervention program.

Characteristics	Pré-teste		Pós-teste		p-value
	n°	%	n°	%	
Has health insurance[1]	17	85,0%	17	85,0%	1,000
No	3	15,0%	3	15,0%	1,000
Receives tetanus vaccine at health facility	13	65,0%	19	95,0%	**0,018***
No	5	25,0%	1	5,0%	0,077
No response	2	10,0%	0	0,0%	0,147
Adopts protective measures at work[2]	11	55,0%	20	100,0%	**0,001****
No	9	45,0%	0	0,0%	**0,001****
Seeks medical care when ill	17	85,0%	20	100,0%	0,072
No	3	15,0%	0	0,0%	0,072
Work-related accidents[3]	6	30,0%	10	50,0%	0,197
No	14	70,0%	10	50,0%	0,197
Seeks medical care after accident	19	95,0%	20	100,0%	0,311
No	1	5,0%	0	0,0%	0,311
Insect bites or animal bites[4]	4	20,0%	3	15,0%	0,677
No	16	80,0%	17	85,0%	0,677
Insects and animals transmit diseases					
Never	3	15,0%	0	0,0%	0,072
Almost never	2	10,0%	0	0,0%	0,147
Sometimes	4	20,0%	1	5,0%	0,151
Almost always	1	5,0%	3	15,0%	0,292
Always	10	50,0%	16	80,0%	**0,047***
Handles materials from healthcare facilities[5]	9	45,0%	11	55,0%	0,527
No	11	55,0%	9	45,0%	0,527
Frequently lifts, carries or drags heavy objects					
Almost never	2	10,0%	2	10,0%	1,000
Sometimes	3	15,0%	5	25,0%	0,429
Almost always	5	25,0%	7	35,0%	0,490
Always	10	50,0%	6	30,0%	0,197

[1] *Includes coverage by SIS and EsSalud (Peru).
[2] *Includes use of gloves, hand hygiene, masks, boots, goggles, and helmets.
[3] *Such as falls, fractures, cuts on hands and feet, limb ruptures.
[4] *Includes contact with dogs, spiders, flies, and ants.
[5] Examples: syringes, needles, IV bottles, papers, and chlorine bottles.
* Significant at 5%
** Significant at 1%

The location where waste pickers consumed their meals was also investigated. In the post-test, 60% reported having their meals at home, followed by 20% who reported eating at the collection site. These distributions were quite similar to those of the pre-test, indicating stability in this behavior. The data are shown in Figure 2.

Figure 2. Location where waste pickers consume meals before and after the multisectoral intervention program. Source: The Authors, 2025.



Still within the theme of environmental and sanitary promotion, a series of questions were raised by the researchers using a Likert scale to assess participants' responses, as shown in Table 5. In the post-test, the “Always” category was most frequent in the following statements:

- “Believes that recyclable waste collection helps prevent soil contamination” – 100%.
- “Believes that the soil is contaminated when materials from healthcare facilities (needles, syringes, gloves, gauze, or others) are discarded” – 95%.
- “Believes that river waters contain contaminants from mining waste” – 100%.

For the other items, the "Never" category prevailed, with percentages ranging from 60% to 100%. Questions 1, 3, 5, and 6 showed significant differences ($p < 0.05$), while questions 2, 7, and 8 showed even stronger differences ($p < 0.01$) between pre- and post-tests, indicating that the program had a positive impact, promoting favorable changes in the waste pickers' attitudes after the intervention.

Still within the theme of environmental and sanitary promotion, a series of questions were raised by the researchers using a Likert scale to assess participants' responses, as shown in Table 5.

Table 5. Distribution of waste pickers according to environmental health promotion questions before and after the multisectoral intervention program. Peru, 2025.

	Pre-test					Post-test					
QUESTIONS	**N (%)**	**AN (%)**	**Somet (%)**	**AA (%)**	**A (%)**	**N (%)**	**AN (%)**	**Somet (%)**	**AA (%)**	**A (%)**	**p-value**
P1. Consumes food at the collection site due to access to handwashing with soap and water	6 (30%)	3 (15%)	4 (20%)	3 (15%)	4 (20%)	12 (60%)	0 (0%)	5 (25%)	1 (5%)	2 (10%)	0,014*
P2. When finding oil, grease, or other chemicals in bottles or gallons, pours the contents onto the ground	10 (50%)	2 (10%)	5 (25%)	1 (5%)	2 (10%)	20 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0,004**
P3. Believes that recyclable waste collection helps prevent soil contamination	0 (0%)	0 (0%)	0 (0%)	5 (25%)	15 (75%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	20 (100%)	0.025*
P4. Believes that the soil is contaminated by materials from healthcare facilities	0 (0%)	0 (0%)	0 (0%)	2 (10%)	18 (90%)	0 (0%)	0 (0%)	0 (0%)	1 (5%)	19 (95%)	0.564
P5. Disposes of waste (bags, cardboard, bottles, etc.) into bodies of water	14 (70%)	4 (20%)	1 (5%)	1 (5%)	0 (0%)	20 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0.024*
P6. Urinates or defecates in rivers or other water sources	15 (75%)	2 (10%)	2 (10%)	1 (5%)	0 (0%)	20 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0.041*
P7. Believes river waters contain contaminants from mining waste	0 (0%)	1 (5%)	4 (20%)	6 (30%)	9 (45%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	20 (100%)	0.003**
P8. Burns solid waste during work	10 (50%)	2 (10%)	4 (20%)	1 (5%)	3 (15%)	14 (70%)	5 (25%)	0 (0%)	0 (0%)	1 (5%)	0.007**

N = Never; AN = Almost Never; Somet. = Sometimes; AA = Almost Always; A = Always.
*Significant at p < 5%.
**Significant at p < 1%

Other sanitary promotion criteria are included in Table 6. These criteria refer to the handling of organic materials, food leftovers, and food storage for consumption. In Table 6, the practice of boiling water before consumption showed a significant increase ($p = 0.035 < 0.05$) after the program implementation, rising from 80% in the pre-test to 100% in the post-test.

Other indicators showed no significant variation; however, the following were notable in the post-test: 70% reported perceiving strong odors; 40% stated they used lime to neutralize odors; 100% adopted measures to prevent food contamination (e.g., eating at home, using sealed containers, handwashing, fruit washing); and 80% of families consumed water directly from the public supply system.

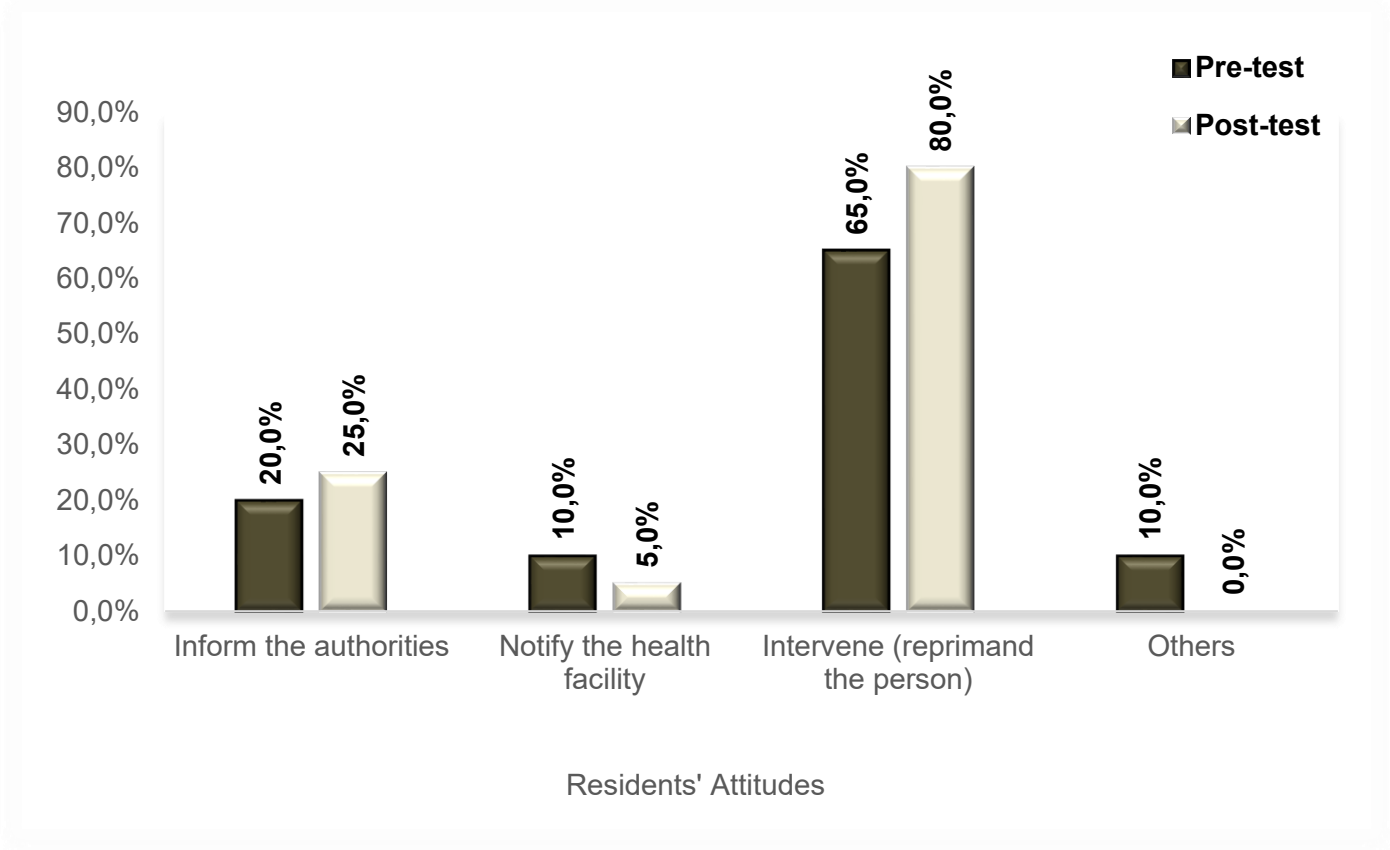
Table 6. Distribution of waste pickers according to environmental health promotion criteria before and after the multisectoral intervention program.

Criteria	Pre-test (n/%)	Post-test (n/%)	p-value
Perception of strong and unbearable odors			
Yes	13 (65,0%)	14 (70,0%)	0,736
No	7 (35,0%)	6 (30,0%)	0,736
Actions towards waste emitting strong odors			
Buries	6 (30,0%)	5 (25,0%)	0,723
Covers with lime	6 (30,0%)	8 (40,0%)	0,507
Others[a]	8 (40,0%)	7 (35,0%)	0,744
Leaves food near recyclable waste during work			
No	20 (100,0%)	20 (100,0%)	—
Takes measures to prevent food contamination			
Yes[b]	18 (90,0%)	20 (100,0%)	0,147
No	1 (5,0%)	0 (0,0%)	0,311
No response	1 (5,0%)	0 (0,0%)	0,311
Actions when encountering hazardous chemicals			
Reports to health facility	1 (5,0%)	4 (20,0%)	0,151
Buries	8 (40,0%)	9 (45,0%)	0,749
Takes home	1 (5,0%)	0 (0,0%)	0,311
Others[c]	9 (45,0%)	7 (35,0%)	0,519
No response	1 (5,0%)	0 (0,0%)	0,311
Actions before drinking from natural water sources			
Boils water	16 (80,0%)	20 (100,0%)	*0,035
Drinks directly	2 (10,0%)	0 (0,0%)	0,147
Others	1 (5,0%)	0 (0,0%)	0,311
No response	1 (5,0%)	0 (0,0%)	0,311
In your community, families drink directly from the public water supply			
Yes	13 (65,0%)	16 (80,0%)	0,288
No	5 (25,0%)	4 (20,0%)	0,705
No response	2 (10,0%)	0 (0,0%)	0,147

[a] Ex: deposit in container, fumigation, thinner application.
[b] Ex: eating at home, use of sealed containers, handwashing, washing fruit.
[c] Ex: discarding in container, taking to landfill, bagging for truck collection.
*Significant at $p < 0.05$.

Regarding community reactions to burning solid waste, Figure 3 shows that reports to authorities increased from 20% to 25%, and direct reprimand of offenders increased from 65% to 80%. However, these differences were not statistically significant ($p > 0.05$) between the pre- and post-intervention assessments.

Figure 3. Distribution of waste pickers according to community residents' attitudes towards burning solid waste at home. Source: The Authors, 2025.



DISCUSSION

The role of waste collection and recycling is socially, environmentally, and economically important in large cities. Therefore, there is a need to train waste pickers to promote their formalization and inclusion in municipal solid waste management, as well as their integration into the economic market. It is also necessary to facilitate partnerships for sustainable productive development, promoting improvements in working conditions and preserving the overall well-being of waste pickers and their families[2].

The data in Table 1 show that most participants were men, young (aged 18–30 years), and had completed high school. The majority were single or in a common-law union and had been working as waste pickers for less than five years. These data may indicate that this young population has not yet had access to formal employment, being pushed into informal and low-income jobs. Their monthly income is around 1,200 soles (Table 3), a low income that often needs to be supplemented with other work, such as agriculture or animal husbandry, as shown in Figure 1. Table 3 also shows that they work many hours consecutively, seven days a week. Supporting this idea, a 2022 study in Mashaeng, South Africa, involving 20 female waste pickers, showed that these workers faced constant risks in their occupational environment and lacked the training and education that would enable them to access more stable and better-paying jobs[18].

The comparative analysis between pre- and post-test assessments demonstrated significant behavioral changes among participants, especially regarding the use of Personal Protective Equipment (PPE) (Tables 2 and 5), adoption of sanitary protection measures, and recognition of environmental risks. A significant increase was observed in the use of PPE such as gloves ($p = 0.002$), boots ($p = 0.011$), masks ($p = 0.028$), and caps/hats ($p = 0.018$), along with a reduction in the practice of not using any protective equipment ($p = 0.008$). These findings corroborate the data of Jiménez-de-Aliaga et al.[8], who identified poor compliance with occupational health standards among informal waste pickers and a positive correlation between environmental awareness and protective practices. Thus, educational interventions may directly

influence the improvement of both individual and collective protection in informal recycling activities.

In interviews, waste pickers also reported using, in most cases (55%), alternative transportation methods for the collected material, such as trucks, cargo motorcycles, carrying sacks, or even transporting materials on foot. It was also mentioned that they frequently or almost always (35% always; 30% almost always) drag heavy objects (Table 4). This practice may also affect their occupational health, leading to ergonomic diseases[19].

Participants' perceptions of biological and environmental risks also changed significantly. The vast majority reported eating meals at home (Figure 2), a condition that remained unchanged in the post-test. However, a significant portion admitted to consuming food at the collection site due to having access to handwashing with soap and water (Table 5). This habit, however, increases the risk of bacterial, parasitic, and viral infections. The belief that insects and animals transmit diseases (Table 4) increased from 50% to 80% ($p = 0.047$), and the practice of boiling water before consumption (Table 6) increased from 80% to 100% ($p = 0.035$), indicating greater sanitary awareness[20]. The intervention program also resulted in an increase in the number of waste pickers who received tetanus vaccination (Table 4). These findings align with the conceptual framework proposed by Alam et al.[(21)], which highlights factors associated with occupational safety such as knowledge, attitudes, socioeconomic conditions, sociodemographic profiles, and work environment. The fact that waste pickers possess limited knowledge about the risks their daily activities pose to the environment and human health has a profound impact.

The study also promoted an understanding of rights and responsibilities related to recycling activities. The work of these professionals is often undervalued and involves the participation of women and children. In this context, formalization emerges as a mechanism for poverty reduction, overcoming social stigma, and achieving professional recognition [21,22]. This is particularly relevant in the Peruvian context, where Law No. 29419, regulated by Supreme Decree No. 005-2010-MINAM [23,24], aims to formalize and protect waste pickers. However, its effectiveness remains limited due to precarious working conditions and a lack of institutional recognition [(25,26)]. Although informal work may often be more lucrative, it exposes workers to physical, chemical, biological, and psychosocial risks (Table 5), as reported in the literature [18,27].

Rodero and colleagues conducted a comparative analysis of the prevalence of dermatological diseases and use of safety measures among waste pickers and non-waste pickers at the municipal landfill in Asunción. They found that 63.7% of waste pickers presented three or more skin lesions compared to 16.6% of non-waste pickers. The most common infections were fungal (50%) and bacterial (31.8%), along with lesions such as cuts (59.1%), boils (59.1%), *Tunga penetrans* infestation (40.9%), and cutaneous larva migrans (36.4%). This study highlighted failures in safety measures and health protection[27], representing a critical public health challenge requiring greater attention from responsible institutions.

Similarly, in our study, waste pickers reported experiencing accidents and contact with dangerous insects or disease vectors; however, following the intervention, they demonstrated better understanding and identification of risk situations, with a significant increase in reports of incidents involving animals or infectious agents. In this regard, the intervention program contributed to their awareness of risks and fostered greater dialogue on infection prevention and control in their daily activities.

The role of healthcare professionals—particularly nursing—proved essential in this process. As emphasized by Peru's National Environmental Policy (Supreme Decree No. 012-2009-MINAM)[25,28], intersectoral actions are crucial for mitigating environmental risks and promoting worker health in vulnerable contexts. In this sense, the educational strategy adopted in this study, centered on videoconferencing and validated educational materials, not only transmitted information but also empowered waste pickers.

From an occupational perspective, the findings reaffirm that waste pickers remain exposed to multiple risks (physical, chemical, biological, psychological, and accidental), as previously described by Karki and colleagues[29], reinforcing the need for public policies that ensure dignified working conditions. Despite the observed improvements, aspects such as accident frequency, health perception, and working conditions still require ongoing attention.

Waste pickers' actions regarding community residents' attitudes toward burning solid waste also revealed that greater awareness among waste pickers can be multiplied (Figure 3). It became evident that after the intervention program, participants became more conscious of waste disposal and the harms caused by burning solid waste. In the pre-test, 65% of participants reported intervening or reprimanding residents when witnessing waste burning; in the post-test, this number increased to 80%. The Peruvian Ministry of Health achieved significant progress by incorporating the implementation of a Comprehensive Health Care

Model as part of the Sectoral Policy guidelines[30]. This model is directly related to Education for Sustainable Development, understood as a continuous educational process that raises environmental awareness and fosters the formation of citizens committed to sustainability[31].

Finally, it is worth emphasizing that improvements in health and safety indicators were achieved through a simple, low-cost intervention, suggesting that well-structured educational programs can serve as effective tools for social transformation. As noted by Kain and colleagues[15], collaboration between local governments, waste picker organizations, and educational institutions is essential for building sustainable strategies in the solid waste sector.

CONCLUSION

The results of this study demonstrated the effectiveness of a multisectoral intervention focused on occupational and environmental health for informal waste pickers in the municipality of Chota, Cajamarca – Peru. In a simple and low-cost manner, the program helped waste pickers better understand the importance of caring for their occupational health and of infection prevention and control, thus avoiding serious and preventable illnesses. The implementation of programs like this may serve as an alternative for Peruvian state agencies to address issues related to the quality of life of these professionals. However, further efforts are still needed to advance the process of labor formalization for these workers.

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AUTHOR CONTRIBUTIONS

Velásquez CAJ contributed to the study conception and design, literature review, manuscript writing, and assisted with data analysis. Vásquez KAI, Flores EH, and Yajahuanca RDSA performed statistical data analysis and interpretation and reviewed the content. Tirado ZIC, Freitas DRJ, and Aliaga KMJ contributed to the study conception, design, and critical intellectual content review. All authors reviewed and approved the final version to be published and declare full responsibility for all aspects of the work, ensuring accuracy and integrity.

Ethical Approval

The research project was approved by the Research Ethics Committee of the Universidad Nacional Autónoma de Chota.

FUNDING

This research was funded by: "Recursos de Canon," under the "VII Scientific and Technological Research Project Competition for Faculty of the Universidad Nacional Autónoma de Chota (UNACH)." RESOLUCIÓN DE COMISIÓN ORGANIZADORA N° 005-2023-UNACH, dated January 6, 2023.

CONFLICT OF INTEREST

The authors declare no conflict of interest.