

RESEARCH ARTICLE

Effects of infection prevention training on healthcare waste handlers' compliance in hospitals of Gedeo zone, Southern Ethiopia: a quasi-experiment study

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Abstract

Background: Healthcare waste handlers (HCWHs) are at risk of health issues due to exposure to infectious healthcare waste. Infection prevention and control (IPC) training is essential to enhance their knowledge, attitudes, practices, and compliance (KAPC) with standard precautions (SP), thereby reducing the spread of infections. However, the effectiveness of IPC training for HCWHs in low-resource settings like Ethiopia remains under-researched. This study aims to evaluate the impact of IPC training on HCWHs' KAPC regarding standard precautions in public hospitals within the Gedeo zone of Southern Ethiopia.

Methods: A quasi-experimental study design was conducted with 124 HCWHs across four public hospitals from July to December 2022. Each hospital delivered a four-day IPC training program, utilizing a structured and interactive approach that included presentations, hands-on demonstrations, and group discussions to promote participation and understanding. HCWHs' KAPC regarding standard precautions were assessed using structured questionnaires and observational checklists. Data analysis employed descriptive statistics and the Wilcoxon Signed Rank Test, with regression analysis identifying demographic factors associated with KAPC changes post-training. A significance level of $p < 0.05$ was established.

Results: The median score differences between pretest and posttest were statistically significant for knowledge ($z = -8.554$, $p = 0.00$, $r = 0.54$), attitude ($z = -8.356$, $p = 0.00$, $r = 0.53$), practice ($z = -8.696$, $p = 0.00$, $r = 0.55$), and compliance ($z = -8.523$, $p = 0.00$, $r = 0.54$). IPC training resulted in significant improvements: knowledge increased by 46%, attitude by 8.1%, practice by 19.4%, and compliance by 23.7%. IPC-related awareness among HCWHs (AOR: 2.55; 95% CI: 1.16-5.61) and the presence of Environmental Health Officers (EHOs) in hospitals (AOR: 2.53; 95% CI: 1.17-5.43) were significantly associated with positive attitudes toward SP. Additionally, attitudes were significantly linked to HCWHs' practices regarding infection prevention measures (AOR: 2.48; 95% CI: 1.10-5.59), and practices were statistically associated with compliance levels (AOR: 27.02; 95% CI: 9.50-76.87).

Conclusion: IPC training effectively enhanced HCWHs' knowledge, attitudes, practices, and compliance with standard precautions.

Keywords: Compliance, Ethiopia, Healthcare waste handlers, IPC training, Knowledge

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1 Introduction

Globally, the healthcare sector faces significant challenges in healthcare waste management [1]. Ethiopia, like many developing nations, confronts numerous obstacles, including inadequate infrastructure, limited resources, and a shortage of trained personnel [2, 3]. These issues increase the risk of infections among healthcare waste handlers and the general population [4]. Evidence shows that healthcare cleaners and waste handlers are often contracted externally, with little to no consideration given to their training, particularly in infection prevention and control (IPC) [5]. A substantial proportion (55%) of healthcare waste handlers (HCWHs) lack essential knowledge and understanding of safe practices, further heightening the risk of hospital-acquired infections (HAIs) [1, 6].

HAIs significantly impact the quality of patient care and outcomes [7]. They affect approximately 10% of hospitalized patients in developed countries and 25% in developing countries, resulting in adverse healthcare outcomes such as prolonged hospital stays, increased costs, and considerable morbidity and mortality [8, 9]. In developing nations, the prevalence of HAIs is largely due to insufficient knowledge and awareness of healthcare waste management among workers [10]. Certain occupational groups, including hospital cleaners and laundry service workers, are particularly vulnerable to injuries and infections due to their job roles and exposure risks [11].

Existing evidence indicates that training in healthcare waste management can enhance compliance with standard precautions, thereby reducing occupational exposures [12, 13]. This suggests that effective training and education are crucial for managing healthcare waste, lowering the incidence of HAIs, improving patient outcomes, and ensuring safer working conditions for healthcare workers [12, 13]. Moreover, quality healthcare delivery is impossible without effective IPC [14, 15]. The World Health Organization (WHO) asserts that effective IPC methods can reduce HAIs by at least 30% [15-17]. There is an increasing recognition of the need for effective infection prevention practices at all levels

in Ethiopia to enhance HAI prevention [18].

Healthcare waste handlers are often underpaid, undereducated, inadequately protected, and work in hazardous environments with little to no in-service training [12, 19, 20]. They are among the most vulnerable to hospital-acquired infections (HAIs). Infections such as hepatitis B, hepatitis C, and HIV are primarily transmitted by healthcare workers who do not adhere to infection prevention measures [21, 22]. The incidence of these infections may be significantly higher among healthcare waste handlers, who often demonstrate low compliance with standard precautions in their daily tasks.

The importance of IPC training programs in enhancing the knowledge and practices of healthcare workers is well established [23]. However, evidence on the effectiveness of such training specifically for healthcare waste handlers is lacking. This study aims to address this gap by evaluating the efficacy of an IPC training program tailored for healthcare waste handlers in hospitals within the Gedeo zone of Southern Ethiopia.

The results of this study will assess the effectiveness of IPC training for healthcare waste handlers. Findings will provide valuable insights for policymakers, healthcare administrators, and training providers regarding the necessity of specialized training for this group of healthcare workers. The study aims to improve the knowledge, attitudes, practices, and compliance of healthcare waste handlers with standard precautions for infection prevention, particularly in public hospitals in the Gedeo zone and similar settings in developing countries. Ultimately, this research seeks to reduce the incidence of HAIs and enhance patient safety.

2 Materials and Methods

2.1 Study area

This study was conducted in the Gedeo zone of Southern Ethiopia, focusing on healthcare waste handlers in four governmental hospitals. Geographically, the zone is located north of the equator, spanning from 5°53'N to 6°27'N lati-

tude and from 38°8' to 38°30'E longitude. The altitude ranges from 1,500 to 3,000 meters, and the climate is characterized as sub-humid tropical. The zone includes one general hospital (a teaching hospital), three primary hospitals, thirty-five health centers, one hundred forty-six health posts, and seventeen private health facilities. According to current border delineations, the total land area of the region is approximately 1,347.04 square kilometers.

2.2 Study setting

The study was conducted in four public hospitals (three primaries and one general hospital) in Gedeo zone of Southern Ethiopia.

2.3 Study period

This study was conducted at hospitals in Gedeo zone for up to six months from July, 2022 to December, 2022.

2.4 Study design

A pre-post intervention quasi-experimental study was conducted to assess changes in the knowledge, attitudes, practices, and compliance of healthcare waste handlers following IPC training.

2.5 Source population

All healthcare waste handlers employed in healthcare facilities within the Gedeo zone were included as the study population.

2.6 Study population

Healthcare waste handlers employed in public hospitals of the Gedeo zone served as the study population. A comprehensive list of these handlers was obtained from hospital administrative records, ensuring the selection and inclusion of eligible representative participants from the hospitals.

2.7 Eligibility criteria

Inclusion: All workers in public hospitals within the Gedeo zone responsible for healthcare waste collection and transportation, as well as service staff involved in waste treatment and disposal, were included in this study.

Exclusion: Healthcare waste handlers in public hospitals of the Gedeo zone who did not complete all training modules were excluded from the study.

2.8 Intervention

An infection prevention and control (IPC) training program was specifically designed for healthcare waste handlers. The training covers four

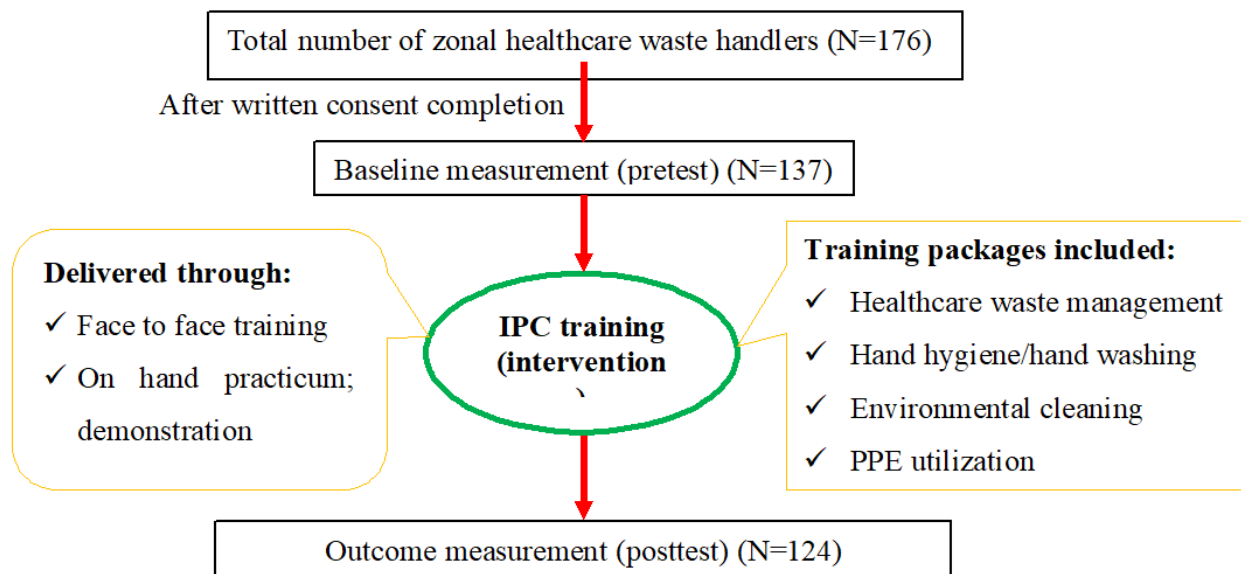


Figure 1 Flow chart for quasi-experiment (pre-post) study

components of standard precautions directly related to their roles: the healthcare waste management system (including waste segregation and disposal procedures), personal protective equipment usage, environmental cleaning, and hand hygiene. The training was delivered using a hands-on, participatory approach, incorporating lectures, demonstrations, group discussions, and practical exercises to enhance understanding and application of the concepts. Post-intervention evaluation included pre- and post-training assessments through structured questionnaires, observation checklists, and periodic follow-ups to measure knowledge retention and improvements in compliance with IPC practices.

2.9 Sample size and sampling procedure

A single population proportion formula was used to determine the sample size, assuming a 48% proportion of healthcare waste handlers with good knowledge based on previously conducted studies in Northern and Eastern Ethiopia [24, 25]. With a 95% confidence level and a 5% margin of error, the calculated sample size, including the non-response rate, was 422. However, due to the small source population size of 176 public hospital staff involved in the healthcare waste management system at the study locations, this interventional study adopted a rule of thumb, utilizing 70% of the population.

As a result, the actual maximum sample size of 137 was determined, accounting for a 10% non-response rate. The number of healthcare waste handlers to be included from each hospital was calculated in proportion to the total number of HCWHs in each facility. A list of each healthcare waste handler was obtained from hospital administrative records. Based on this, a baseline survey was conducted, and the intervention was implemented at each hospital.

2.10 Data collection

The study utilized structured questionnaires that included 16 yes/no questions for assessing knowledge, along with three-point Likert scale questions: 19 for attitude, 14 for practice, and 12 for compliance. These questionnaires were used to evaluate infection prevention measures among healthcare waste handlers and to determine changes following the IPC training.

2.11 Quality assurance

A pre-test of the data collection tools was conducted using 5% of the actual sample size at a healthcare facility in the West Guji zone under similar conditions. The data collection tools were initially prepared in English after a thorough review of relevant literature and guidelines [26-29]. They were later translated into the local language (Amharic) to facilitate easier analysis

and quicker responses from participants. Finally, the tools were translated back into English for data entry and analysis.

The intervention materials included instructions, descriptions, images, posters, and specific examples of recommended practices [16]. Three environmental health professionals, certified as trainers of trainers (TOT), were selected to deliver the IPC training. These health professionals were oriented on how to conduct the training for healthcare waste handlers and were instructed to explain the intervention's implementation to participants. Additionally, all participants received identical training resources, including printed materials and visual aids, to ensure consistency in the content delivered. A monitoring mechanism was established to oversee the training sessions across different hospitals.

2.12 Data analysis

The data was entered into EpiData version 4.2.0 (CDC, Atlanta, GA, USA) and analyzed using SPSS version 26. Descriptive statistics were employed to provide an overview of the characteristics of healthcare waste handlers, including age, gender, years of experience, and baseline scores for knowledge, attitude, practice, and compliance.

To determine significant improvements following the IPC training, the Wilcoxon Signed-Rank Test was used to compare mean or median scores for knowledge, attitude, practice, and compliance before and after the training. The Chi-Square test assessed the association between IPC training and compliance with infection prevention measures among healthcare waste handlers. Regression analysis identified demographic characteristics associated with differences in knowledge, attitude, practice, and compliance following the implementation of IPC training. The significance level was set at $p < 0.05$.

2.13 Operational Definition

Knowledge Level of Healthcare Waste Handlers about Standard Precautions: This refers to the understanding of facts, information, and guidelines related to infection pre-

vention and control (IPC). It encompasses awareness of infection transmission modes, proper procedures, and safety precautions [30]. Knowledge was measured using a tool developed based on WHO universal precautions and previous research [31, 32], consisting of 16 yes/no items. Scores were categorized as a good level of knowledge if they were higher than or equal to the median score (≥ 0.88); otherwise, they were classified as a low level of knowledge.

Attitude of Healthcare Waste Handlers Towards Standard Precautions: This reflects the feelings, beliefs, and perceptions of healthcare waste handlers regarding IPC practices, influencing their behavior and motivation [33, 34]. It was measured using 19 questions on a 3-point Likert scale (1. Not agree, 2. Undecided, 3. Agree), addressing factors that influence healthcare waste handlers' behavior and motivation towards infection prevention. Scores were categorized as "not acceptable attitude" if they were lower than the median score (< 2.74) and "acceptable attitude" if they were greater than or equal to the median score (≥ 2.74).

Practices of Healthcare Waste Handlers Regarding Standard Precautions: This refers to the actual actions taken by healthcare waste handlers to prevent the spread of infections in healthcare settings. Practices were measured using 14 items on a 3-point Likert scale (1. Never, 2. Sometimes, 3. Always), including IPC procedures, PPE usage, environmental cleaning, hand hygiene, and healthcare waste handling [16, 30]. Results were categorized as "poor level of practice" if the score was less than the median score (< 2.50) and "good level of practice" if the score was greater than or equal to the median score (≥ 2.50).

Compliance Level of Healthcare Waste Handlers with Standard Precautions: This measures the extent to which healthcare waste handlers adhere to IPC guidelines consistently and correctly, reflecting the alignment between knowledge, attitude, and actual practices [30, 35]. Compliance was assessed using 12 items adapted from a compliance instrument based on WHO universal precautions and previous re-

search [31, 32], with a 3-point Likert scale (1. Never, 2. Sometimes, 3. Always). Scores were categorized as “good compliance level” if they were higher than or equal to the median score (≥ 2.50); otherwise, they were classified as poor compliance. A good compliance level indicates that safe infection prevention practices have become habitual for healthcare waste handlers [18].

3 Results

3.1 Demographic Characteristics

The study included 124 healthcare waste handlers who had completed training, with a dropout rate of 9.5%. As shown in Table 1, the majority of participants were from Dilla General Hospital (48.4%), followed by Gedeb Primary Hospital (20.2%), Bule Primary Hospital (16.9%), and Yirga-Chefe Primary Hos-

pital (14.5%). A higher proportion of respondents worked in the inpatient department (IPD) (16.1%), followed by the outpatient department (OPD) (13.7%) and the operating room (OR) (8.06%).

Most participants were female (79.8%), with the majority aged 18-30 years (88.9%) and having two to five years of experience in healthcare waste handling (68.7%). The mean age of the respondents was 26.56 ± 5.56 years. Marital status was classified as single (21%), married (75.8%), divorced (1.6%), and widowed (1.6%). Most respondents (71%) had worked at a hospital for two to five years. Regarding educational status, 55.7% held diplomas, while 36.3% and 8% had completed secondary and primary school, respectively. The respondents reported an average monthly income of 1800.87 ± 330 Ethiopian Birr (Table 1).

Table 1 Socio-demographic characteristics of the respondents (n = 124)

Variables		Frequency	Percentage
Gender of the respondents	Female	99	79.8
	Male	25	20.2
Age of the respondents	18-20	13	10.5
	21-30	91	73.4
	31-40	15	12.1
	41 and above	5	4.0
	Mean age	26.56 ± 5.56 years	
Marital status of the respondents	Single	26	21
	Married	94	75.8
	Divorced	2	1.6
	Widowed	2	1.6
Work experience	One year	11	8.9
	Two to five years	88	71
	Six and above years	25	20.1
Educational status	Primary school	10	8.1
	Secondary school	45	36.3
	TVET	61	49.2
	Diploma and above	8	6.4
Monthly income	1296 to 1500 Birr	8	6.4
	1501 to 1600 Birr	20	16.1
	1601 to 1900 Birr	39	31.5
	1901 to 2000 Birr	55	44.4
	2001 and above	2	1.6
	Average monthly income	1800.87 ± 330 Birr	
Exposure to HAIs	No	96	77.4
	Yes	28	22.6
Previous training status on SPs	No	70	56.5
	Yes	54	43.5
Previous training on PPE usage	No	77	62.1
	Yes	47	37.9
Period of last training on PPE	No training at all	77	62.1
	Less than a year	21	16.9
	Two years	16	12.9
	More than two years	10	8
Previous awareness status about the job	No	70	56.5
	Yes	54	43.5
Awareness about the existence of IPC committee	No	71	57.3
	Yes	53	42.7

Many respondents (56.5%) reported that they had not received training on recommended infection prevention measures since their hiring (Table 1). Additionally, there were no environ-

mental health professionals present in the primary hospitals of the Gedeo zone during the study period (Table 2).

Table 2 Participant characteristics across study settings (n = 124)

Variables		Frequency	Percentage
Respondents' corresponding hospital (proportional)	Bule Primary Hospital	21	16.9
	Dilla General Hospital	60	48.4
	Gedeb Primary Hospital	25	20.2
	Yirga-chefe Primary Hospital	18	14.5
Departments of study participants	In patient	20	16.19
	Out patient	17	13.70
	Operation room	13	10.48
	Emergency ward	10	8.06
	Delivery room	9	7.26
	Laundry	7	5.64
	Neonatal Intensive Care Unit	6	4.84
	Obstetrics ward	6	4.84
	Medical Admin	5	4.03
	Medical ward	5	4.03
	Medical laboratory	5	4.03
	Orthopedics	4	3.22
	Surgical ward	4	3.22
	Gynaecology ward	3	2.41
	Pediatric	3	2.41
	Antenatal Care ward	3	2.42
	Intensive Care Unit	2	1.61
	Pharmacy	2	1.61
Is (are) there EHO(s) in the hospital?	No (in primary hospitals)	64	51.62
	Yes (in General hospital)	60	48.38

3.2 Comparison of pre- and post-KAPC scores across study hospitals

During the pre-training assessment, significant gaps were observed among study participants in knowledge, attitude, practice, and compliance with standard precautions across the hospitals

in the study area. Relatively, healthcare waste handlers (HCWHs) at Dilla General Hospital had better scores compared to those at primary hospitals (Figure 2). However, after the training, there was a significant improvement across all hospitals.

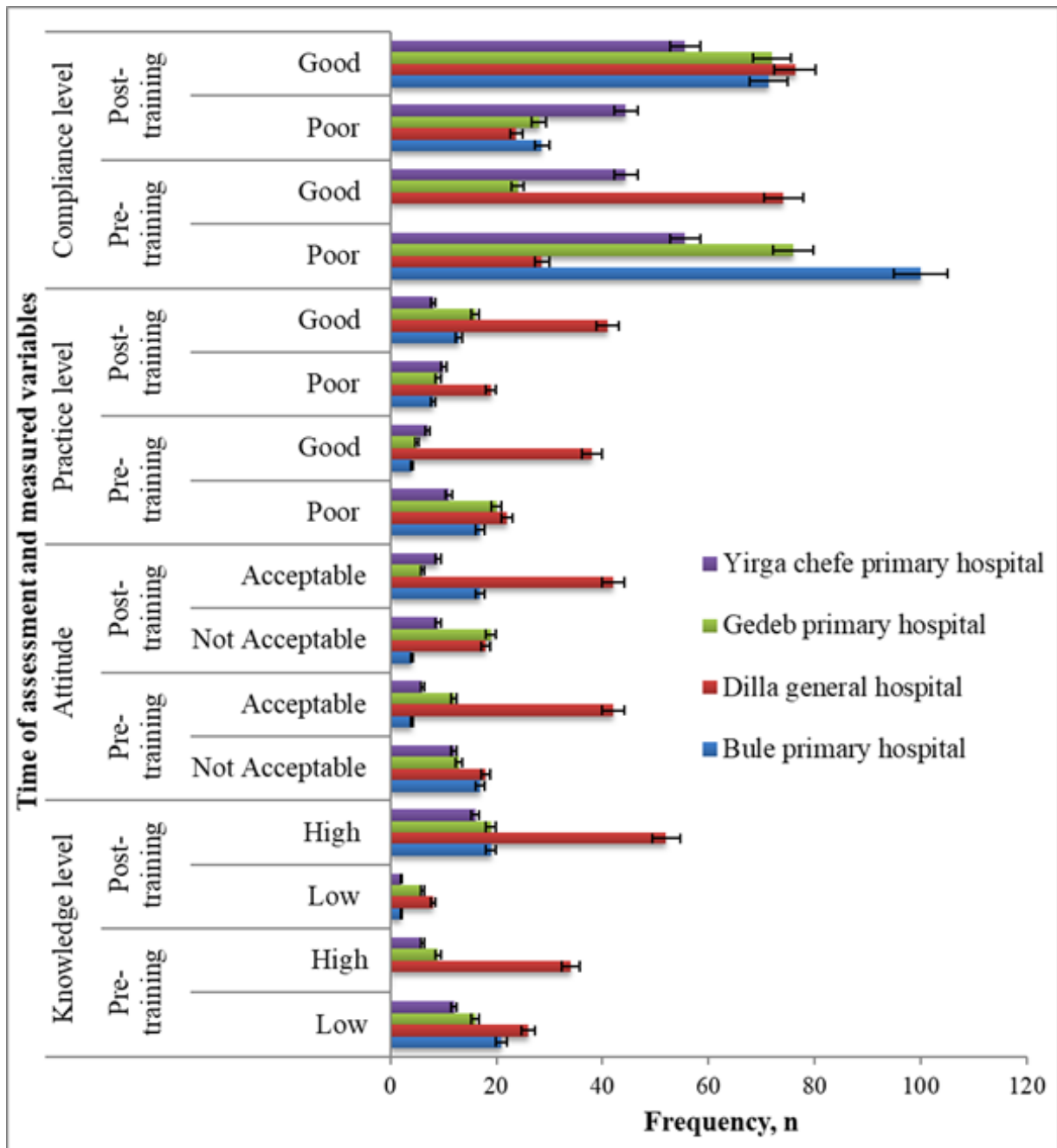


Figure 2 Comparison of HCWHs' KAPC across study sites at pre-and post-training

3.3 Effects of infection prevention training on HCWH's KAPC

There was a statistically significant difference when comparing pre-test and post-test scores at $p < 0.05$. Healthcare waste handlers' (HCWHs) knowledge, attitude, practice, and compliance scores for standard precautions improved positively in Gedeo zone hospitals after IPC training

(Figure 3). The proportion of participants with a good level of knowledge increased significantly by 46% (from 39.5% to 85.5%), while acceptable attitude, good practice, and good compliance increased by 8.1% (from 51.6% to 59.7%), 19.4% (from 43.5% to 62.9%), and 23.7% (from 44% to 67.7%), respectively, following IPC training (Figure 3).

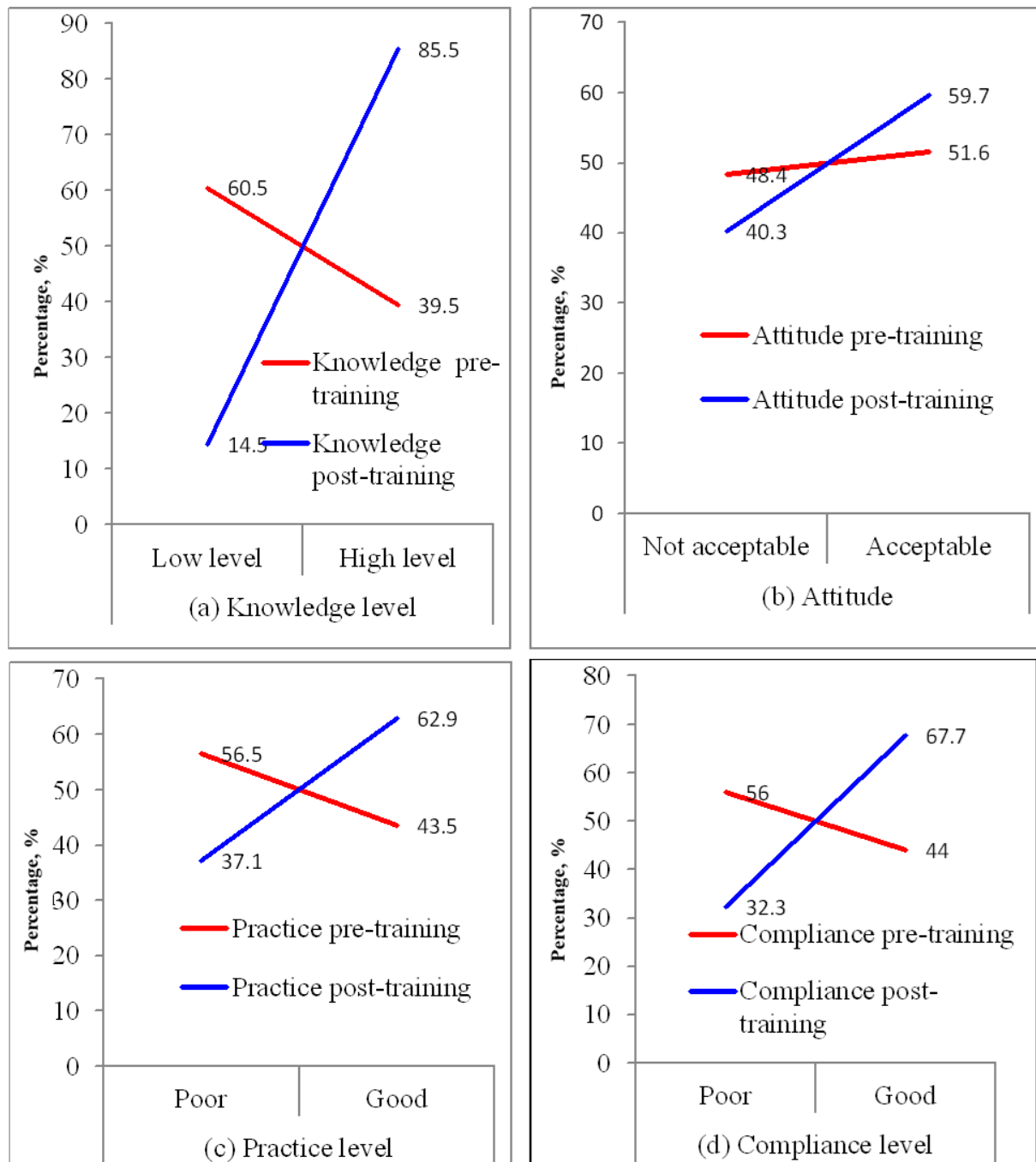


Figure 3 Percentage distribution of subjects according to: (a) knowledge, (b) attitude, (c) practice and (d) compliance level before and after IPC-training

Comparing the optimum knowledge, attitude, practice and compliance mean scores pre- intervention, the post-intervention scores showed a positive significant change at $p < 0.05$ (Table 3).

Table 3 Description of mean and median for KAPC scores at pre- and post-training

Variables	N	Mean	SD	Minimum	Maximum	Percentiles			p-value
						25 th	50 th (Median)	75 th	
Knowledge at pretest	124	.6972	.20118	.00	1.00	.5625	.6875	.8750	0.001
knowledge posttest	124	.8821	.10214	.50	1.00	.8125	.8750	.9850	
Attitude at pretest	124	2.6935	.27196	1.37	3.00	2.5395	2.7368	2.8947	0.001
Attitude at posttest	124	2.9121	.11185	2.47	3.00	2.8421	2.9474	3.0000	
Practices at pretest	124	2.4994	.33447	1.86	3.00	2.2321	2.5000	2.7857	0.001
Practice at posttest	124	2.8376	.12699	2.29	3.00	2.7857	2.8571	2.9286	
Compliance at pretest	124	2.5000	.32752	1.83	3.00	2.3333	2.5000	2.7500	0.001
Compliance at posttest	124	2.8293	.13644	2.42	3.00	2.7500	2.8333	2.9167	

A Wilcoxon signed-rank test revealed that median knowledge scores were significantly higher after the intervention (Md = 0.88, n = 124) compared to before (Md = 0.69, n = 124), $z = -8.554$, $p = 0.00$, with an effect size of $r = 0.54$. The results also indicated that attitude scores significantly improved post-intervention (Md = 2.95, n = 124) compared to pre-intervention scores (Md = 2.74, n = 124), $z = -8.356$, $p = 0.00$, with an effect size of $r = 0.53$. Similarly, practice scores

were significantly higher after the intervention (Md = 2.86, n = 124) compared to the pre-test (Md = 2.50, n = 124), $z = -8.696$, $p = 0.00$, with a large effect size of $r = 0.55$. Additionally, compliance scores towards standard precautions statistically increased after the intervention (Md = 2.83, n = 124) compared to the pre-test (Md = 2.50, n = 124), $z = -8.523$, $p = 0.00$, with an effect size of $r = 0.54$ (Tables 3 and 4).

Table 4 Wilcoxon Signed Ranks Test results for KAP and compliance comparing posttest-pretest

Variables (posttest-pretest)		Ranks			Z	p-value
		N	Mean Rank	Sum of Ranks		
Knowledge posttest- Knowledge pretest	Negative Ranks	6 ^a	32.58	195.50	-8.554	.000
	Positive Ranks	104 ^b	56.82	5909.50		
	Ties	14 ^c				
	Total	124				
Attitude posttest- Attitude pretest	Negative Ranks	7 ^a	26.93	188.50	-8.356	.000
	Positive Ranks	99 ^b	55.38	5482.50		
	Ties	18 ^c				
	Total	124				
Practice posttest – Practices pretest	Negative Ranks	11 ^a	14.27	157.00	-8.696	.000
	Positive Ranks	100 ^b	60.59	6059.00		
	Ties	13 ^c				
	Total	124				
Compliance posttest- Compliance pretest	Negative Ranks	12 ^a	15.25	183.00	-8.523	.000
	Positive Ranks	97 ^b	59.92	5812.00		
	Ties	15 ^c				
	Total	124				

a. posttest (after intervention) < pretest (before intervention)

b. posttest (after intervention) > pretest (before intervention)

c. posttest (after intervention) = pretest (before intervention)

3.4 Factors associated with baseline KAPC of HCWHs towards standard precautions

As indicated in Table 5, regression analysis showed a significant association between baseline knowledge and IPC-related awareness provided to healthcare waste handlers (HCWHs) at the time of employment (AOR: 2.65; 95% CI: 1.04-6.76; $p = 0.041$). Additionally, the presence of Environmental Health Officers (EHOs) in hospitals was significantly associated with knowledge (AOR: 3.14; 95% CI: 1.10-8.95; $p = 0.033$), as was the baseline attitude of HCWHs towards standard precautions (AOR: 6.59; 95% CI: 2.35-18.47; $p = 0.000$). Consequently, HCWHs who received IPC-related awareness during their employment were 2.65 times more likely to be knowledgeable about standard precautions than their counterparts. Similarly, participants working in hospitals with EHOs were 3.14 times more likely to have a high level of knowledge about standard precautions compared to those in hospitals without EHOs.

Moreover, the availability of EHOs was significantly associated with the baseline attitude of study participants towards standard precautions. Participants in hospitals with EHOs were 5.14 times more likely to have a positive attitude towards standard precautions than those without (AOR: 5.14; 95% CI: 1.63-16.23; $p = 0.005$). Additionally, participants with a secondary school education were 10.51 times more likely to exhibit a positive attitude towards infection control standard precautions compared to those with a primary school education (AOR: 10.51; 95% CI: 1.94-56.89; $p = 0.006$).

Similarly, the presence of EHOs was linked to the baseline practices of participants regarding standard precautions ($p = 0.005$). Those working in hospitals with EHOs were 3.78 times more likely to demonstrate good practices related to standard precautions compared to those in hospitals without EHOs (AOR: 3.78; 95% CI: 1.49-9.58).

Additionally, participants' marital status and baseline practices were significantly associated with compliance levels to standard precautions. Married participants were 4.21 times more likely

to adhere to standard precautions than unmarried participants (AOR: 4.21; 95% CI: 1.39-12.76; $p = 0.011$). Furthermore, participants with a good level of baseline practices were 5.21 times more likely to have a good level of compliance with standard precautions compared to those with poor baseline practices (AOR: 5.21; 95% CI: 2.18-12.48; $p = 0.000$).

3.5 Factors associated with post KAPC of HCWHs towards standard precautions

Factors associated with post knowledge of HCWHs about standard precautions

Marital status, work experience, monthly income, previous training attended on standard precautions, and prior awareness of healthcare waste handlers regarding standard precautions were candidate variables associated with the knowledge of HCWHs about infection prevention measures ($p < 0.25$). However, multivariable logistic regression analysis indicated that none of these candidate variables were significantly associated with the knowledge of healthcare waste handlers about standard precautions in this study.

Factors associated with post-attitude of HCWHs towards standard precautions

Work experience, previous training on standard precautions, and the availability of Environmental Health Officers (EHOs) in healthcare facilities were candidate variables associated with the knowledge of healthcare waste handlers (HCWHs) regarding infection prevention measures ($p < 0.25$).

However, as indicated in Table 5, multivariable logistic regression analysis revealed that IPC-related awareness provided to HCWHs at the time of employment and the presence of EHOs in hospitals were significantly associated with the attitudes of HCWHs towards standard precautions for infection prevention ($p < 0.05$). Specifically, healthcare waste handlers who received prior awareness about infection prevention measures during their employment were 2.55 times more likely to have an acceptable attitude to-

wards standard precautions (AOR: 2.55; 95% CI: 1.16-5.61). Additionally, the presence of EHOs in healthcare facilities was linked to the attitudes of HCWHs towards standard precautions. In hospitals with assigned EHOs, HCWHs were 2.53 times more likely to possess an acceptable attitude towards standard precautions (AOR: 2.53; 95% CI: 1.17-5.43).

Factors associated with post-practices of HCWHs with standard precautions

Gender, previous training on standard precautions, attitude, and the availability of EHOs in healthcare facilities were candidate variables associated with the practices of healthcare waste handlers (HCWHs) regarding standard

Table 5 Factors associated with knowledge, attitude, practice and compliance level of HCWHs to standard precautions at baseline and post-training

Variables	Category	AOR (95% CI)	p-value
<i>Factor associated with baseline knowledge about standard precautions</i>			
IPC related awareness provided for HCWHs at employing time	No	Reference	
	Yes	2.65 (1.04-6.76)	0.041*
Availability of Environmental Health Officers (EHOs) at hospital	No	Reference	
	Yes	3.14 (1.10-8.95)	0.033*
Baseline attitude of HCWHs	No	Reference	
	Yes	6.59; (2.35-18.47)	0.000*
<i>Factor associated with baseline attitude towards standard precautions</i>			
Availability of EHOs at hospitals	No	Reference	
	Yes	5.14 (1.63-16.23)	0.005*
Participants' educational level	No	Reference	
	Yes	10.51 (1.94-56.89)	0.006*
<i>Factor associated with baseline practice with standard precautions</i>			
Availability of EHOs at hospital	No	Reference	
	Yes	3.78 (1.49-9.58)	0.005*
<i>Factor associated with baseline compliance to standard precautions</i>			
Marital status of participants	Single	Reference	
	Married	4.21 (1.39-12.76)	0.011*
Baseline practice with standard precautions	Poor	Reference	
	Good	5.21 (2.18-12.48)	0.000*
<i>Factor associated with post-attitude towards standard precautions</i>			
Previous SP training attended by HCWHs	No	Reference	
	Yes	2.55 (1.16-5.61)	0.021*
Availability of EHOs in the hospital	No	Reference	
	Yes	2.53 (1.17-5.43)	0.018*
<i>Factor associated with post-practice with standard precautions</i>			
Attitude towards infection prevention	Not acceptable	Reference	
	Acceptable	2.48 (1.10-5.59)	0.028*
<i>Factors associated with post-compliance level to standard precautions</i>			
Practice of HCWHs towards infection prevention	Poor level	Reference	
	Good level	27.02 (9.50-76.87)	0.000*

precautions ($p < 0.25$). However, multivariable logistic regression analysis revealed that only attitude was significantly associated with the practices of HCWHs towards standard precautions for infection prevention. As shown in Table 5, HCWHs with an acceptable attitude towards infection prevention measures were 2.48 times more likely to perform good practices in accordance with standard precautions (AOR: 2.48; 95% CI: 1.10-5.59).

Factors associated with post-compliance level of HCWHs to standard precautions

Gender, practices of healthcare waste handlers (HCWHs) towards infection prevention, and the availability of Environmental Health Officers (EHOs) in healthcare facilities were candidate variables associated with the compliance of HCWHs to standard precautions ($p < 0.25$). However, multivariable logistic regression analysis revealed that the practices of HCWHs towards infection prevention were significantly linked to their compliance levels with standard precautions. As shown in Table 5, HCWHs with a good level of practices regarding infection prevention measures were 27.02 times more likely to adhere to standard precautions compared to those with a low level of practices (AOR: 27.02; 95% CI: 9.50-76.87)

4 Discussions

This interventional study meticulously examined the knowledge, attitude, practices, and compliance levels of healthcare waste handlers (HCWHs) regarding standard precautions. The findings indicate that infection prevention training significantly improved the knowledge, attitude, practice, and compliance of HCWHs with standard precautions. These results align with previous studies [25, 26, 28, 36, 37], highlighting the crucial role of training in enhancing infection control practices. Our study corroborates findings from a study conducted in Nigeria [38], which reported increases in knowledge and adherence to standard precautions among teaching hospital staff following training sessions. This evidence suggests that structured training programs can positively influence the behavior of

HCWHs, leading to improved healthcare waste management practices.

Furthermore, our study revealed that providing IPC-related awareness to participants during their employment significantly correlated with their knowledge of standard precautions ($p = 0.041$). Specifically, participants who received IPC-related awareness demonstrated superior baseline knowledge compared to those who did not. This may be attributed to the fact that HCWHs who reported receiving adequate awareness and education on IPC issues were more knowledgeable, practical, and compliant with standard precautions [39, 40]. This finding emphasizes the necessity of implementing in-service training to enhance the knowledge and practices of HCWHs regarding standard precautions [41]. Additionally, our study indicates that HCWHs' practices towards infection prevention significantly influenced their compliance with standard precautions ($p < 0.05$), underscoring the critical role of infection prevention practices in adherence to these standards.

The presence of Environmental Health Officers (EHOs) in hospitals significantly influenced both baseline and post-intervention attitudes towards standard precautions ($p = 0.000$). Participants employed in hospitals with EHOs exhibited a more positive baseline and post-intervention attitude compared to those in hospitals without assigned EHOs. This may be due to the primary responsibilities of EHOs, which include disseminating up-to-date information to healthcare staff and advocating for universal precautions to mitigate occupational risks. The environmental health profession, one of the oldest public health fields, is often regarded as the cornerstone of public health [42].

EHOs focus on promoting occupational health and safety, which involves safeguarding health in the workplace by raising awareness among healthcare workers about the importance of adhering to infection prevention guidelines and protocols [43]. They are responsible for developing, promoting, and enforcing guidelines, policies, and laws related to environmental health, as well as addressing environmental health risks

[44]. Additionally, our study found that the availability of EHOs in hospitals was associated with the baseline practices of participants regarding standard precautions, underscoring the pivotal role EHOs play in the healthcare setting.

Participants' educational status was another significant factor associated with baseline attitudes towards standard precautions ($p = 0.006$). In this study, participants with a secondary school education exhibited a more acceptable (positive) attitude towards standard precautions than those with only a primary education. This finding aligns with previous research [45, 46], which indicated that higher educational levels are linked to more positive attitudes towards standard precautions due to increased exposure and access to information. However, high formal education does not guarantee correct knowledge of standard precautions, nor does it necessarily lead to positive behavior. For instance, someone with greater knowledge than hospital waste handlers may still practice poorly with standard precautions [45].

Additionally, the current study revealed that the baseline compliance level of participants with standard precautions was significantly linked to their marital status. Married participants were more likely to have and perform good practices regarding standard precautions compared to their unmarried counterparts. This finding is consistent with a previous study conducted in Hawassa, Southern Ethiopia [47], which found that married participants were more compliant with standard precautions than unmarried healthcare workers.

The evidence from this study emphasizes the crucial role of IPC training in improving the knowledge, attitude, practices, and compliance (KAPC) of healthcare waste handlers (HCWHs). It provides valuable insights for developing targeted, context-specific strategies to address identified gaps and enhance HCWHs' practices. By prioritizing comprehensive training programs and fostering stakeholder engagement alongside supportive institutional frameworks, hospitals can strengthen infection prevention measures, ensure proper waste management, reduce infec-

tion risks, and create a safe environment for both staff and clients.

The implications of the study highlight the need for ongoing training programs to maintain high levels of compliance among healthcare waste handlers. Limitations of the study include a small sample size and potential biases in self-reported data. Future research could explore the long-term effects of infection prevention training on healthcare waste handlers' practices. This underscores the importance of continuous education and reinforcement of best practices to ensure the safety of healthcare workers and patients.

5 Conclusion

This interventional study highlights the significant impact of infection prevention and control (IPC) training on improving the knowledge, attitude, practices, and compliance (KAPC) of healthcare waste handlers (HCWHs) regarding standard precautions. The findings underscore the crucial role of structured training programs in enhancing adherence to infection control practices and promoting effective waste management.

The study also identifies key determinants of KAPC, such as IPC-related awareness, the presence of Environmental Health Officers (EHOs), educational status, and marital status, all of which significantly influence baseline and post-training outcomes. These findings emphasize the necessity of implementing comprehensive and ongoing IPC training, supported by strong institutional frameworks and stakeholder engagement, to foster a safe working environment, reduce infection risks, and ensure sustainable improvements in healthcare waste management practices.

Moreover, hospital management should prioritize recruiting and retaining qualified EHOs to ensure adherence to these standards. EHOs should consistently provide updates and guidance on IPC practices and protocols to reinforce compliance.

Abbreviations

AOR	Adjusted Odds Ratio
CI	Confidence Interval
EHOs	Environmental Health Officers
HAIs	Hospital Acquired Infections
HCWHs	Healthcare Waste Handlers
IPC	Infection Prevention and Control
KAPC	Knowledge, Attitude, Practice and Compliance
Md	Median
PPE	Personal Protective Equipment
SP	Standard Precautions

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Ethical approval and consent to participate

Ethical approval was obtained from the Dilla University College of Health Sciences and Medicine Institutional Review Board, with protocol number DUIRB/029/22-01. Informed consent was secured from all participants, and their confidentiality and privacy were ensured throughout the study.

Consent for publication: Not applicable

Availability of data and materials

The datasets used the study are available from the corresponding author up on request.

Declaration of conflict of interest

There was no conflict of interest among the authors regarding this article.

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