Infection hazard of exposure to intestinal parasites, *H. pylori* and hepatitis viruses among municipal sewage workers: a neglected high risk population

Original Article

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ABSTRACT

Background: Waste water may contain pathogenic human and animal excreta-derived micro-organisms that can cause infections. Municipal sewage workers are a relevant neglected high-risk population especially in the absence of effective protective equipment and lack of hygienic practices mainly washing hands.

Objective: The present study aims to assess the hazards of infection with micro-organisms among municipal sewage workers as a neglected population, besides those infections that maybe acquired via sources other than their occupational hazard.

Subjects and Methods: A cross-sectional study was conducted on sewage workers from different sectors in Alexandria Governorate, Egypt. Collected stool samples were subjected to the following techniques; Kato-Katz, ether concentration, Jones' Media culture, modified Ziehl-Neelsen, and quick hot Gram-chromotrope staining. Stool samples were also tested for *Helicobacter pylori* antigen (*H. pylori* Ag). Serum was separated for detection of viral hepatitis C antibodies (HCV Ab), and HBV surface antigen (HBVs Ag).

Results: Out of the 410 examined workers, 289 (70.5%) were infected; among them 111 (38.4%) had mixed infections. It was found that 56.8%, and 31.2% harbored intestinal parasitic infections (IPIs) and *H. pylori*, respectively; and 12.2% had hepatitis mainly HCV (9.8%). Protozoal infections amounted to 54.6%, and only 5.9% had helminthic infections. *Blastocystis* spp. was the most prevalent parasite (46.8%) followed by *Cryptosporidium* spp., *Entamoeba histolytica/dispar* and *Microsporidium* spp. (15.6%, 11.7%, and 7.8%, respectively). Almost equal percentages were recorded for single IPI and multiple infections (28.3%and 28,5% respectively). Significantly higher rates of IPIs and *H. pylori* were observed among workers who were in frequent contact with sewage. Also, IPIs were statistically higher among young workers (<40 years), while hepatitis was significantly more prevalent among those from rural areas.

Conclusion: Although almost all the detected microbiological infectious hazards can affect sewage workers via sources other than their occupational hazard, our findings call for the importance of self-protection measures that should be in association with regular medical investigation and treatment.

Keywords: Egypt, *H. pylori*, intestinal parasites, neglected population, sewage workers, viral hepatitis.

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INTRODUCTION

Water-borne diseases are associated with lack of safe sanitation practices[1]. Waste water treatment plant (WWTP) workers are obliged to work in harsh and dirty conditions as it is difficult to maintain good hygienic practices and very difficult to avoid accidental contact with sewage[2]. Hazards include chemicals that enter sewage treatment plants as industrial effluents, as well as pathogenic microorganisms found in sewage sludge. Waste water treatment (WWT) results in the generation of aerosols containing chemicals, microorganisms, and solvent vapors[3]. Related symptoms have been reported among sewage workers, including eye and nose irritation, lower airway and skin symptoms, headache, fatigue, and dizziness[4]. An increase in the risk of asthma as well as decrease in lung function values, chronic bronchitis, toxic pneumonitis, cardiovascular degeneration, and musculoskeletal disorders have been also reported[5,6].

Sewage pathogenic microorganisms are derived from human and animal feces. The presence of protozoal cysts and helminthic eggs in waste water and sludge

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is well documented[7,8]. These cysts and eggs are highly resistant to destruction in humid environments and can last for a long time up to years as in the case of *Ascaris* eggs[9]. Most protozoal cysts are directly infective while helminthic eggs, with exception of *E. vermicularis* and *H. nana*, are only infective after a period of maturation in the environment. Their embryonic development requires oxygen thus growth is limited in sludge due to the lack of aeration[10]. However, the time and conditions in which helminthic eggs are present in certain WWT facilities can allow this embryonic development as indicated by the detection of infective stages of *A. lumbricoides* and *T. trichiura* eggs in sludge samples[9]. Contact with sewage is therefore associated with a risk of IPIs, resulting in augmentation of gastrointestinal symptoms[11].

Viral hepatitis is a growing concern of public health especially in developing countries. Both hepatitis viruses B and C are associated with chronic infections in addition to considerable morbidity and mortality. Both have been implicated as leading causes of hepatocellular carcinoma in up to 78% of the hepatitis-infected cases around the world[12]. HBV is stable on environmental surfaces for at least seven days, while HCV can be detected in liquid environment for up to five months[13]. Thus, exposure of sanitary workers to occupational injuries may expose their wounds to viral hepatitis. Those in low-waged employments in which occupational safety is compromised are more liable to infection than in high-waged professions[12]. In contrast, hepatitis A virus (HAV) causes a self-limited acute inflammatory liver disease[14]. The virus is shed in high concentrations in the stool of acutely infected individuals and it can survive in moist environments for weeks to months. Data regarding the risk of association of HAV and sewage exposure were conflicting, with the majority denying such an association[15-17]. Hepatitis E virus (HEV) is the most common cause of acute viral hepatitis, with a wide range of clinical manifestations, but asymptomatic infections are the most common[18]. Drinking contaminated water is the main mode of transmission especially in developing countries[19]. The virus can be detected in raw sewage and secondary effluent but it was not present in the tertiary effluent samples. Several studies concluded that sewage was not a source of infection with HEV for sewage workers[19-21].

On the other hand, Friis *et al*. described the increased risks for various cancers among sewage workers; one of them was stomach cancer[22]. *H. pylori* is suspected because it has been associated with several types of gastric diseases, for example: chronic gastritis, atrophic gastritis and peptic ulcers[23], thus favoring its association with an increased risk for cancer of the stomach. Recently the International Agency for Research on Cancer[24] classified it as a human class I carcinogen. Thus, exposure risks for *H. pylori* among sewage workers may possibly predispose them to cancer stomach.

Municipal waste water workers are considered as a high risk population and they are a neglected subpopulation as there is minimal data available regarding their health status in the last decade in Egypt. Therefore, the present work aims to assess the prevalence of different microbial hazards among this group in Alexandria Governorate.

SUBJECTS AND METHODS

A cross-sectional study was conducted between April and September 2016. The study was carried out in WWTPs draining four main sector sites of Alexandria Governorate, Egypt.

Study sites: 1) Middle sector with an area of 68 km^2 and a population size of 545,833. About the third of its land constitutes farming lands and slums. 2) Western sector with an area of 20.7 km^2 and a population size of 532,097, has no farming lands but has many slums areas. 3) El- Montazah sector with an area of 92 km^2 and a population size of 1,190,287; the largest part of its area constitutes farming land with some slums. 4). Eastern sector with an area of 35 km^2 and a population size of 985,786; farming lands constitute a large part of its area (most of Abis rural areas) in addition to some slums.

Study design: All day-shift workers were asked to participate in the study. Those who agreed to give a blood sample and two stool specimens (collected on alternate days) were included in the study (410 workers). An interviewing questionnaire including socio-demographic and disease history data, was fulfilled for every worker. Collected stool and blood samples were transported to the Parasitological Laboratory of the High Institute of Public Health, Alexandria University for processing.

Stool samples: Fresh stool samples were subjected to Kato-Katz technique for detecting intestinal helminthes[25] and Jones' media culture for blastocystosis[26]. A thin film was prepared for staining using the quick hot Gram-chromotrope method for microsporidiosis[27]. Fresh stool samples were also tested by chromatographic rapid technique for detecting *H. pylori* antigen (Ag) using the Ecotest® *H. pylori* antigen kit (Assure Tech Co., Hangzhou, China) according to the manufacturer's instructions[28]. Formalin (10%) preserved stool samples were processed using the formalin-ether concentration technique[29]. The sediment was examined for intestinal parasites, and then a thin film was prepared for staining by Modified Ziehl-Neelsen for intestinal coccidia[25].

Blood samples: As HBV and HCV were the main two viruses responsible for fulminant and chronic hepatitis and due to limitation in funding resources, the sewage workers were screened only for these two viruses.

Separated sera were tested for HCV antibodies and HBVs Ag using an enzyme-linked immunosorbent assay (ELISA) [ACON Laboratories, Inc., San Diego, USA] according to manufacturer's instructions[30,31]. All cases above the cut-off value (0.168 for HCV antibodies and 0.1344 for HBVs Ag) were considered positive.

Statistical analysis: Data were entered, verified, and analyzed using SPSS version 20.0 (IBM, Armonk, USA). Pearson' chi-squared or Fisher's exact tests were used and were considered statistically significant at $P<0.05$.

Ethical considerations: An ethical approval was obtained from the ethical committee of the High Institute of Public Health. A written permission was also obtained from the Chairman of Directors of the Sewerage Company in Alexandria. A signed, written consent was written by every participant after the aim of the research was explained and after strict confidentiality was ensured. All participants were personally informed about their stool and blood test results. Parasitic infections were treated, while HCV Ab and HBs Ag positive workers were referred to a specialist.

RESULTS

The age of workers examined ranged from 20 to 60 years with a mean age of 46.87±8.325. Most of them were urban dwellers (58.5 %). The duration of their work in the WWTPs ranged from 2 to 44 years with 68.5% of them having worked subterranean for >20 years. The majority (75.4%) were frequently in contact with sewage during their work, without the use of any protective tools. Among the WWTP the Western sector (site 2) included the highest number of workers (222; 54.1%). Gastroenteritis was the most frequent complain (34.4%), followed by eye, skin, and chest allergies (Table 1).

Table (2) showed that out of 410 examined workers, 289 (70.5%) were infected with pathogens. Mixed infections were diagnosed in 111 workers (27.1%). IPIs, *H. pylori* infection and viral hepatitis were detected as single infection in 31.5%, 8.5% and 3.9%, respectively.

The protozoal infection rate was higher than the helminth infection rate (54.6% vs 5.9%). *Blastocystis* spp. was the most prevalent protozoa (46.8%) followed by *Cryptosporidium* spp. (15.6%), *E. histolytica/dispar* (11.7%), *Microsporidium* spp. (7.8%), and *G. lamblia* (5.4%). Lower rates were detected for *C. cayetanensis*, *D. fragilis*, and *I. belli* (1.7%, 1.2%, and 0.2%, respectively). With regards to helminth infections, *S. mansoni* showed the highest rate of infection (3.7%) followed by *A. lumbricoides*, and *H. nana* (1% each), then *E. vermicularis* (0.2%) (Table 3). Furthermore, 43 workers (10.5%) had *E. coli* cysts while only 6 (1.5%) showed *I. butchlli* cysts.

Table 1. Characteristics and complaints of municipal sewage workers, Alexandria, Egypt.

Characteristics		Total No. = 410	Frequency (%)
Age	20 - >40	149	36.3
	40 - 60	261	63.7
Area of residence	Urban	240	58.5
	Rural	170	41.5
Contact with sewage*	Rare	101	24.6
	Frequent	309	75.4
Duration of the work	<20	129	31.5
	≥20	281	68.5
Work location	Site 1	77	18.8
	Site 2	222	54.1
	Site 3	79	19.3
	Site 4	32	7.8
Compliant	Gastroenteritis	141	34.4
	Eye allergy	79	19.3
	Skin allergy	56	13.7
	Chest allergy	52	12.7
	Arthritis	30	7.3
	Others**	22	5.4
Total		**239**	**58.3**

*Rare: once or twice weekly. Frequent: daily exposure
**Fatigue, headache, cardiovascular symptoms and urinary tract complaints.

Table 2. Rates of microbial infections among sewage workers.

Microbial infections		Positive	%
Single infection	**IPIs**	127	31.0
	H. pylori	35	8.5
	Viral hepatitis	16	3.9
Mixed infection	**IPIs and *H. pylori***	77	18.8
	IPIs and hepatitis	18	4.4
	***H. pylori* and hepatitis**	5	1.2
	IPIs, *H. pylori* and hepatits	11	2.7
	Total	111	27.1
Total		**289**	**70.5**

N.B.: Total IPIs 233 (56.8%), total *H.pylori* 128 (31.2%), total viral hepatitis 50 (12.2%):HCV (9.8%) and HBV (2.9%).

Table 3. Infection rates of different parasites among sewage workers.

Parasitic infections		Positive	%
Protozoa	***Blastocystis* spp.**	192	46.8
	***Cryptosporidium* spp.**	64	15.6
	E. histolytica/dispar	48	11.7
	***Microsporidium* spp.**	32	7.8
	G. lamblia	22	5.4
	C. cayetanensis	7	1.7
	D. fragilis	5	1.2
	I. belli	1	0.2
	Total	224	54.6
Helminthes	***S. mansoni***	15	3.7
	A. lumbricoides	4	1.0
	H. nana	4	1.0
	E. vermicularis	1	0.2
	Total	24	5.9

Total IPIs detection rates were significantly higher among workers <40 years old and among those frequently exposed to sewage water during their work (63.8% and 62.8 %, respectively) than among those aged 40–60 years and those rarely exposed to sewage water (52.9% and 38.6%, respectively) (*P*=0.032 and *P*>0.001, respectively). Moreover, a significantly higher IPIs detection rate was observed among workers in sites 2, 3, and 4 than those in site 1 (63.1%, 63.3%, and 65.6 % vs 28.6%, *P*<0.001). Although the IPIs detection rate was higher among workers with a history of > 20 years of work and among those residing in rural areas, the differences were statistically insignificant. For *H. pylori* infection, a significantly higher rate was detected among sewer-men who came into frequent contact with sewage water than among those with infrequent contact (34% vs 22.9%, *P*=0.035). Viral hepatitis infection rates were significantly higher among workers residing in rural areas (16.5%) than among those from urban areas (9.2%) (*P*=0.026). Concerning total infection, significant higher rates were observed among workers in frequent contact with waste water and among those aged <40 years old compared to workers rarely contacting sewage and those aged > 40 years old (77% and 77.9% vs 50.5% and 66.3%, with *P* values <0.001 and =0.013, respectively). Moreover, a statistically significant difference (*P*<0.001) was detected between infection rates of workers from different sites with the highest rate (77.2%) in site 3) and the lowest rate (46.8%) in site 1 (Table 4).

Table (5) shows that 28.3% of examined sewage workers presented with single IPI and an almost equal total percentage (28.6%) were suffering from two or more IPIs. Double infections amounted to 18.8% while three or more infections percentage recorded 9.8%.

Table 4. Percentage of different microbial infections among sewage workers in relation to socio-demographic factors.

Variable		No.	IPIs		*H. pylori*		Viral hepatitis		Total infections	
			No. (%)	*P* value	No. (%)	*P* value	No. (%)	*P* value	No. (%)	*P* value
Age	20 - >40	149	95 (63.8)	**0.032***	49 (32.9)	0.582	23 (15.4)	0.130	116 (77.9)	**0.013***
	40 - 60	261	138 (52.9)		79 (30.3)		27 (10.3)		173 (66.3)	
Sewage contact	Rare	101	39 (38.6)	**<0.001***	23 (22.9)	**0.035***	10 (9.9)	0.417	51 (50.5)	**<0.001***
	Frequent	309	194 (62.8)		105 (34.0)		40 (12.9)		238 (77.0)	
Work duration	<20	129	70 (54.3)	0.477	34 (26.4)	0.150	12 (9.3)	0.225	86 (66.7)	0.250
	≥20	281	163 (58.0)		94 (33.5)		38 (13.5)		203 (72.2)	
Residence	Urban	240	132 (55.0)	0.374	76 (31.7)	0.816	22 (9.2)	**0.026***	167 (69.6)	0.633
	Rural	170	101 (59.4)		52 (30.6)		28 (16.5)		122 (71.8)	
Site	Site 1	77	22 (28.6)	**<0.001***	15 (19.5)	0.075	28 (11.3)	0.277	36 (46.8)	**<0.001***
	Site 2	222	140 (63.1)		73 (32.9)		25 (16.2)		170 (76.6)	
	Site 3	79	50 (63.3)		30 (38.0)		9 (11.4)		61 (77.2)	
	Site 4	32	21 (65.6)		10 (31.3)		2 (6.3)		22 (68.8)	
Total		**410**	**233 (56.8)**		**128 (31.2)**		**50 (12.2)****		**289 (70.5)**	

Percentages were compared using Chi square test or Fisher Exact test
*Statistically significant at $P \leq 0.05$
** Out of the 50 cases of viral hepatitis, 40 (9.8%) were HCV and 12 (2.9%) were HBV, i.e. 2 (0.5%) were co-infected.

Table 5. Multiplicity of IPIs in relation to the different socio-demographic factors of sewage workers

Variable		No.	Single		Double		Triple or more	
			No. (%)	*P* value	No. (%)	*P* value	No. (%)	*P* value
Age	20 - >40	149	50 (33.6)	0.074	29 (19.5)	0.789	16 (10.7)	0.613
	40 - 60	261	66 (25.3)		48 (18.4)		24 (9.2)	
Sewage contact	Rare	101	19 (18.8)	**0.015***	14 (13.9)	0.145	6 (5.9)	0.137
	Frequent	309	97 (31.8)		63 (20.4)		34 (11.0)	
Work duration	<20	129	34 (26.4)	0.555	24 (18.6)	0.951	12 (9.3)	0.834
	≥20	281	82 (29.2)		53 (18.9)		28 (10.0)	
Residence	Urban	240	69 (28.8)	0.807	40 (16.7)	0.193	24 (10.0)	0.843
	Rural	170	47 (27.6)		37 (21.8)		16 (9.4)	
Site	Site 1	77	16 (20.8)	0.444	5 (6.5)	**0.020***	1 (1.3)	**0.019***
	Site 2	222	66 (29.7)		47 (21.2)		28 (12.6)	
	Site 3	79	24 (30.4)		19 (24.1)		6 (7.6)	
	Site 4	32	10 (31.3)		6 (18.8)		5 (15.6)	
Total		**410**	**116 (28.3)**		**77 (18.8)**		**40 (9.8)**	

Percentages were compared using Chi square test or Fisher Exact test
*Statistically significant at $P \leq 0.05$

The studied sample of workers who had frequent contact with waste water presented with significantly higher single infection when compared to those who had rare contact with the water (31.8% vs 18.8%, *P*=0.015). Workers with a work history of ≥ 20-year showed higher infection rates with single (29.2%) and double (18.9%) infections compared to those who worked for < 20 years but without statistical significance. Concerning the area of residence, those living in both urban and rural areas presented with a high rates of single and double infections (28.8% and 27.6% respectively), but the differences were not statistically significant. Double infections (24.1%) and triple or more infections (15.6%) were significantly higher among workers in site 3 and site 4 respectively than among workers in other sites (*P*=0.020 and 0.019, respectively). The WWTPs from these two sites drain waste water from areas which are mostly rural (Table 5).

DISCUSSION

Working as sewer-men involves several occupational hazards that expose them to harmful conditions. In the present study, 58.3% of workers were suffering from several complaints, mainly gastroenteritis (34.4%) followed by eye, skin, and chest allergies, in addition to arthritis. These appeared to be common complaints, as they were similarly reported by other studies worldwide[4,5,10,32]. A study conducted in Menoufiya Governorate, Egypt, reported a more significant prevalence of abdominal pain, body aches, respiratory symptoms (asthma and dyspnea), and left ventricular hypertrophy among sewage workers than in non-exposed workers (49%, 30%, 19%, and 30%, respectively, vs 21%, 7%, 5%, and 9% respectively in controls)[33]. About half (47%) of sewage workers from Cairo suffered significantly higher rates of abdominal pain and body aches (29.4%), as compared to the controls (20% and 2.9%, respectively)[34]. Another Egyptian study conducted in Mansoura sewage treatment plant revealed that 43.3% of workers suffered from heartburn, which was the only significant gastrointestinal symptom detected when compared to controls[35]. Saad *et al*.[36] reported that respiratory symptoms (either acute or chronic), headache, fatigue, eye and skin irritations were highly prevalent among sewage workers as compared to the control group[36]. Viruses such as Norwalk agent, other microorganisms, or even endotoxins have been suggested as possible causes for most of these observed symptoms[3]. The possible exposure of workers to gases such as hydrogen disulfide, methane, ammonia, and carbon monoxide could be another explanation for such symptoms since hydrogen sulfide, even at low concentrations, has irritating effects on eyes and respiratory tract[37]. In our study, the workers claimed that arthritic pains, including lower back and knees pains, may be related to their work in confined pipes spaces.

Sewage workers are subjected to other biological hazards due to dirty hands while eating, drinking, smoking, and waste water splashing on their faces. Therefore, there is subsequently a higher risk of IPIs although the infective doses of these parasites may be minimal[34]. In our study 233 out of 410 sewage workers (56.8%) were infected with IPIs. It is worth mentioning that frequency of contact with sewage water and young age of workers was significantly associated with IPIs; the latter group being more active during their work rendering them at higher risk of exposure. Our results were higher than those reported in other studies from Egypt, in which the recorded rates of IPIs ranged from 30% to 43.5%, among other neglected populations such as immunocompromised[38] and mentally handicapped patients[39]. Related to our study on a neglected population, a rate of 21.7% was detected among street sweepers and waste collection workers from Beni-Suef. The main parasites detected were *E. histolytica*, *G. lamblia*, and *H. nana*[40]. Another study conducted in Alexandria revealed that about half of the solid-waste handlers were infected with *Cryptosporidium* spp. (23.4%) followed by *Microsporidium* spp. and *S. mansoni* (20.25% and 13.3%, respectively)[41]. Hammouda *et al*.[42] reported that sewage workers from Alexandria were at a higher risk of developing IPIs especially ascariasis and amoebiasis than the control group. Nail detritus examination from the workers proved they were at high risk for *E. vermicularis* infections[42]. Surveys conducted in different countries worldwide also emphasized the occupational risk of IPIs among workers exposed to sewage[43-48]. A study conducted in Rennes, France reported significant difference in *E. histolytica* detection rate among municipal sewer-men versus non-sewage workers (11% versus 2%)[43]. The mean prevalence of IPIs among sewage employees from Paris, France was 11.8%, with predominance of *G. lamblia* and *T. trichiura*[44]. In New Zealand, Mitchell *et al*.,[45] identified sewage exposure as a significant risk factor mainly for *Giardia*sis. Similarly, an increased risk of hookworm infections[46] and *Giardia*sis[47] were reported among waste water farmers in Pakistan compared to farming households using non-waste water irrigation water. Also, in a study performed in Kampala to evaluate IPIs prevalence in adult population groups with different exposures to waste water . Sewer-men, whether those collecting fecal sludge from houses or those maintaining channel drainage, presented with lower IPIs detection rates than those in our study (36% and 42%, respectively)[48].

However, there is much controversy regarding association of IPIs and municipal working. Clark *et al*.[49] revealed that IPIs were not frequent among sewage workers when compared to control group over a 12-month period study conducted in USA (5.4% vs 14.5%). Results of a Kampala study revealed that sewer-men presented with lower detection rates than farmers who used untreated waste water to grow their crops (76%)[48]. Also, a study conducted by

Fuhrimann *et al*.[50] in different communities exposed to waste water in urban and peri-urban transition zones in Hanoi, Vietnam, showed that waste water exposure was not directly associated with IPIs. The investigators explained their conclusion by the high level of awareness of the population to the different health risks[50].

Our results revealed predominance of protozoa infections (54.6%, vs 5.9% for helminthic infections). The highly detected protozoa was *Blastocystis* spp. (46.8%), followed by *Cryptosporidium* spp., *E. histolytica/dispar*, *Microsporidium* spp. and *G. lamblia* in descending order of frequency (15.6%-5.4%). A high protozoa burden was observed among sewer-men from Mansoura, and rates of 65% and 20% were detected for *E. histolytica* and *G. lamblia*, respectively[35]. A positive correlation between protozoa infection among sewage workers and the duration of exposure to sewage was also reported in an earlier German study. Their results revealed that *E. histolytica* antibody rate was significantly higher among the sewage workers compared to the control[51]. The study conducted in Kampala also confirmed our results. Rates of 27% and 30% were recorded for protozoa infections among workers dealing with fecal sludge and those maintaining sewage channels, respectively, while infection with helminths was 12% and 17%, respectively[48].

In our study, only 5.9% of workers harbored helminth worms. Schistosomiasis, the only pathogen that may not be acquired due to exposure to sewage, was the most prevalent helminth infection in the present study (3.7%). Thirteen out of the fifteen cases of schistosomiasis (87%) were residing in rural areas where most probably they got infected. In addition, the other low records of helminth infections with *A. lumbricoides*, *H. nana*, and *E. vermicularis* suggested that helminth infections are not related to sewage exposure (i.e. not an occupation hazard). The low rate of helminth infection was also recorded in Egypt, but for other neglected populations. A rate of 1.5% was reported among mentally handicapped individuals with *E. vermicularis* being the only helminth found[39]. The study conducted in Sohag Governorate revealed that only 4% of the examined school children were infected with helminth parasites with predominance of *H. nana*. This could be a result of increase in the general awareness about personal hygiene and ways of parasites transmission or could be a result of anthelminth campaign carried out in Egypt[52].

A debate about the association of *H. pylori* prevalence and working in WWTPs was evident from results of different studies worldwide in spite of the higher prevalence of stomach cancer recorded among these workers (the relative risk was about 2 to 2.5)[22], and in spite of the higher risk for gastric carcinoma (up to six fold) among *H. pylori*-infected individuals compared to uninfected persons[53]. Our results revealed a total *H. pylori* rate of 31.2%. This rate was found to be significantly higher among sewer-men who were in frequent contact with sewage than among those with infrequent contact (34% versus 22.9%, respectively). Our result agreed with two other Egyptian studies. The investigators detected *H. pylori* IgG seropositivity in 47% of sewage workers in Cairo compared to the controls (23%). Seropositivity rates increased in workers' aged >40 years and with the increase in the duration of work (>20 years of work). However, no statistical significance was observed[34]. In Mansoura sewage treatment plant, the prevalence of *H. pylori* among workers (56.7%) was statistically higher than in unexposed individuals (16.7%). The risk of infection was significantly higher among workers with poor personal protective equipment, those who worked under these conditions for >20 years, workers older than 45 years, and poorly educated workers[35]. In 2004, the higher percentage of *H. pylori* IgG seropositivity was also reported in Zurich among workers exposed to waste water compared to non-exposed workers (50% vs 34%)[54]. Similarly, Flemish municipal sewage workers presented with a higher rate of *H. pylori* IgG antibodies compared to controls (16.7% vs 13.6%). In addition, no significant association was found between the *H. pylori* infection and gastrointestinal symptoms, duration of occupational exposures, or with hygienic practices[55]. It is worth mentioning that the previously mentioned rates detected in the present study (34% and 22.9%) are higher or similar to other detection rates reported in other neglected populations; school children and mentally challenged patients in rehabilitation centers in Alexandria (24% and 27.1%, respectively)[56,57].

In contrast, Swedish sewer-men did not reveal any increase in the risk of *H. pylori*-associated sero-positivity when compared to control[58]. The prospective cohort study carried out in Zurich (Switzerland) in 2009 revealed that *H. pylori* IgG and IgA seroconversion (incidence rates) were very close in control and waste water exposed subjects. Although *H. pylori* was reported in waste water , the investigators attributed their results to its coccoid form in water that is not able to colonize human stomach[59].

Hepatitis B and C continue to be long-term major health problems on the African continent, especially in Egypt. Workers exposed to occupational injuries could expose themselves to greater risks for viral hepatitis, especially if occupational safety is compromised[60]. The present study revealed that 12.2% of sewer-men showed seropositive results either to HCV Ab (9.8%) or HBs Ag (2.9%) or both (0.5%). Our detected rates are within the range of rates reported by several studies from Egypt and are similar to the general population prevalence. HBV Ag prevalence in Egypt was reported to be of intermediate endemicity (2%–8%), and about 2 to 3 million Egyptians were chronic HBV carriers[61]. In 2015, the Egyptian Health Issue

Survey estimated that HCV antibody among individuals aged 15–59 years was 10%, which was about a 30% decline from what was reported (14.7%) in 2008 by the Egyptian Demographic Health Survey. This significant reduction in HCV prevalence was explained by the aging of the group of individuals infected during the mass schistosomiasis treatment campaign due to syringe reuse (1960–1980) (older than 59 years) and by application of the prevention control measures concerning injection safety and awareness[60]. Similarly, no differences were found in the prevalence of antibodies against HBV between sewage workers from Denmark and either Danish landscape gardeners or office workers[62]. Furthermore, the American Conference of Governmental Industrial Hygienists in 2001 reported that no cases of HBV were linked with sewage exposure, most likely due to substantial dilution of the virus in the waste water [63].

In contrast, a higher rate of HBV Ag (38.2%) among sewer-men compared to control group (17.2%) was reported in a study carried out in Cairo. Higher rates were also recorded among workers younger than 40 years and among those working for more than 20 years. However, both results were not significant[34]. The study conducted in Alexandria in 2015, reported a high HBV seroprevalence (36.1%), but lower HCV seroprevalence (8.4%) among municipal solid waste workers[64]. Worldwide, only three studies reported an increase in exposure risk to HBV and HCV among sewage workers[2,12,65]. Two studies were carried out in Greece, the first reported a high prevalence of HBV markers (43.9%) among employees of a sewage company, and only 6.6% of them were HBV Ag carriers[65]. Similarly, the second study reported a significantly higher anti-HBs antigen percentage among waste water workers compared to controls (32.4% versus 5.8%; P <0.0001). The investigators observed that increasing age and sewage contact were significantly associated with HBV infections[2]. Later, high rates for HCV Ab and HBV Ag (36.4% and 33.6%, respectively) were recorded by Sheikh *et al*.,[12] among sewage workers in Pakistan.

In conclusion, high rates reported in the present study (289 out of 410; 70.5%) emphasizes the susceptibility of an important neglected population of sewage workers to infections, especially IPIs. Thus, health education concerning transmission modes and the importance of the self-protection measures should be included with regular medical investigation and treatment. The possible spreading of *H. pylori* through waste water requires further investigation, especially in areas with a high infection prevalence.

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