Waterpipe device cleaning practices and disposal of waste associated with waterpipe tobacco smoking in homes in the USA

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ABSTRACT

Objectives To quantify postsmoking waterpipe tobacco (WPT) waste and describe postsmoking waterpipe (WP) device cleaning practices and disposal of associated waste in home settings.

Methods We analysed data from a US convenience sample of 50 exclusive WPT smokers, mean age 25.3 years. Data were collected at a home visit during which participants smoked one WPT head and completed a self-administered questionnaire on WP cleaning practices and disposal of waste associated with WPT use. Research assistants provided and prepared a WP for participants by weighing and loading 10 g of WPT in the WP head and placing 470 mL of water in the WP bowl. At the completion of the smoking session, research assistants measured the remaining WPT and water. Descriptive analyses were performed.

Results Of the 10 g of fresh WPT used for each smoking session, 70.1% (mean=7.01 g) was discarded postsmoking as waste; for each 470 mL of water used in the WP bowl, 94.3% (mean=443 mL) was discarded. WP device cleaning practices ranged from never cleaning the device to cleaning it after each smoking session. Respondents reported discarding smoked WPT residue in the trash (81.6%) or the kitchen sink (14.3%) and discarding postsmoking charcoal in the trash (57.6%), the kitchen sink (27.3%) or backyard soil (9.1%). Respondents reported discarding smoked WP water in the kitchen sink (76.5%), bathroom sink (14.7%), toilet (2.9%) and backyard soil (5.9%).

Conclusions Interventions and regulations are needed to inform proper WP device cleaning practices and disposal of waste associated with WPT use.

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INTRODUCTION

Global efforts to mitigate the adverse impact of postconsumption tobacco waste on the environment are on the rise,^{1–9} prompted by concern over the 1.69 billion lbs (720 million kg) of cigarette butts that end up as toxic waste annually.^{3 10} While regulatory efforts to reduce the environmental effects of tobacco product waste have been focused on cigarettes,^{1–10} similar attention is warranted for other tobacco products. Waterpipe tobacco (WPT) use is currently considered a global health problem, particularly among youth and young adults in several eastern Mediterranean, eastern European and western countries, including the USA.^{11–20} Prevalence estimates among adults in 68 countries are highest in the eastern Mediterranean, and among

youth are about equal in the eastern Mediterranean and European regions.¹² In the USA, a nationally representative sample (2013–2014) showed that 13% of 15–17-year olds have ever used WPT, and 2.9% have used WPT in the past 30 days; among 18–24-year olds, 44.4% have ever used WPT and 18.2% are current WPT users.²⁰

WPT is smoked using a waterpipe (WP) device (also known as hookah, argileh, nargile, shisha or galyan) in which smoke passes through water. The WP consists of a head (bowl), a stem (body) which is a vertical tube that passes into a partially filled bowl (water jar) and a flexible hose with a mouthpiece. Burning charcoal heats the WPT, which produces the smoke that the user inhales via the hose.

The majority of WPT smokers use flavoured WPT.^{11 21–27} Flavoured WPT, known as ‘Moassel’ (also known as Mu’assel or Maassel), is a mixture of about 30% tobacco and natural/artificial flavourings, sweeteners (eg, molasses, honey, sugars) and humectants (eg, propylene glycol).^{23–28} WPT smoking has been associated with increased risk for lung and oral cancers, coronary heart and pulmonary diseases.^{29–31} The growing popularity of WPT smoking not only increases the number of smokers exposed to health risks^{11–20} but also may lead to increases in environmental contamination due to the disposal of postconsumption WPT waste. Postsmoking WPT waste includes the smoked WPT residue (remnants of the heated WPT found in the WP head at the end of a smoking session), aluminium foil (that covers the WPT by wrapping it around the WP head to avoid burning the WPT), burnt charcoal (charcoal remnants after burning) and smoked WP water (water in the WP bowl through which WPT and charcoal smoke bubble during smoking); other WPT waste includes the packaging of the WPT.

Unlike cigarettes, postsmoking WPT toxic chemicals may be disposed into the environment via waste generated in the various components of the WP device. Toxic chemicals found in fresh (unsmoked) WPT have been found in the smoked WPT residue and to some degree in the smoked WP water.^{25 32–36} For example, 40%±18% of metal content in fresh WPT remained at the end of a smoking session in the smoked WPT residue, and 3%±1% remained as dissolved/suspended metal in the smoked WP water.³² Eighteen toxic elements have been detected in samples of smoked WP water, including arsenic, lead, cadmium, mercury and uranium, which are environmental contaminants.³³ Other harmful

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compounds detected in smoked WP water include carcinogenic furanic compounds, toxic carbonyls (eg, formaldehyde, acetaldehyde and acrolein), phenolic compounds, primary aromatic amines and volatile organic pollutants (eg, toluene).^{25 34–37} Therefore, postsmoking WPT waste should be characterised, quantified and controlled to limit its level of accumulation in the environment.

Homes represent a social setting where WPT smoking frequently takes place.^{38–43} We previously found that WPT smokers smoke at home to relax comfortably, eat and drink while smoking and save money by not going to hookah lounges/cafés.³⁹

To our knowledge, this is the first study to quantify post-smoking WPT waste and describe post-smoking WP device cleaning practices and disposal of waste associated with WPT use in natural home settings. The environmental, consumer and regulatory implications of our findings are discussed.

METHODS

Participant recruitment, screening and consent

Between December 2017 and September 2018, we recruited a convenience sample of 50 WPT smokers (25 men, 25 women) from San Diego County, California, USA via posting flyers on bulletin boards at community colleges, universities and cafes, sharing electronic flyers on social media such as Instagram, Facebook, Snapchat, Reddit and Twitter and encouraging already recruited participants to enlist others by word of mouth. Trained research assistants (RAs) qualified participants by phone via a screening form based on the inclusion/exclusion criteria, invited them to an office visit during which we explained study activities, obtained signed informed consent forms and scheduled a home visit.

Inclusion criteria were as follows: exclusive WPT smoker; aged 21 years or older; who smoked WPT exclusively; smoked at least one WPT head per month; smoked at least one WPT head per smoking session and smoked WPT at home. Exclusion criteria were: major physical/psychiatric illnesses judged by RAs to interfere with providing informed consent or completing an interview; history of chronic health problems (eg, asthma, hypertension); regular use of prescription medication (other than vitamins or birth control) or pregnancy.

A total of 101 respondents were screened by phone; 54 were eligible and were enrolled in the study. Four participants withdrew from the study before the home visit (due to travel or change of mind).

Study design

Data were collected during a single session for each of 50 WPT smoker participants who smoked one WPT head (not shared with other smokers). RAs collected postsmoking WPT waste. Participants completed a self-administered questionnaire that had structured and open-ended questions about demographics, WPT smoking behaviour, WP cleaning practices and disposal of postsmoking WPT waste and received \$75 in cash.

WPT smoking session and materials

The RAs provided the smokers with a medium-sized WP (height=22 inches (55.8 cm); Khalil Mamoon Safari brand, Egypt) and a disposable plastic hose (length=50 inches (125 cm); Fancy Hose, Zebra Smoke brand, Amazon.com). The RAs set up the WP following a standardised protocol. Briefly, the RAs placed a standardised volume (470 mL) of room temperature commercial drinking water (Nestlé Pure Life Purified

Bottled Water brand, USA) in the WP bowl. The metal stem was covered with inch (2.5 cm) of water. The RAs weighed (using an analytical balance) and loaded one head of flavoured WPT (10 g; Exotic Double Apple flavour, Starbuzz brand, USA) in the ceramic head and covered it with a manufacturer preperforated sheet of aluminium foil (Zebra Smoke brand, Amazon.com). The RAs lit a single quick-light charcoal (40 mm; Three Kings brand, Holland) and placed it on the foil-covered WP head (no additional charcoal was added). Participants ended smoking when desired; however, they were instructed that the WP would be available for 45 min.

At the conclusion of the home visit, the RAs returned the WP device and WPT use waste (in sealed Ziploc bags) to our centre; waste was disposed of in our laboratory biohazard trash (disposable hose, smoked WPT residue, aluminium foil, gloves). With permission from the WPT smoker, the burnt charcoal ash was cooled in our study water bucket and was disposed of in the participant's kitchen sink along with the smoked WP water, after which the sink was cleaned with running water.

Measures

Demographics and WPT smoking behaviors

We asked about age, gender, education, race/ethnicity, age at WPT smoking initiation and WP sharing behaviours.

Quantification of postsmoking WPT waste

At the conclusion of the WPT smoking session, the RAs weighed the smoked WPT residue using an analytical balance, measured the volume of water remaining in the WP bowl and recorded session length from first to last puff.

WP device cleaning practices and disposal of postsmoking WPT waste

We asked about WP hose and stem cleaning practices post-smoking WPT and location of usual disposal of postsmoking WPT residue, burnt charcoal and smoked WP water in home settings.

Analyses

Data were double entered and analysed in Excel. Descriptive analyses included arithmetic means and SD, medians and 5th and 95th percentiles and minimum and maximum values. For open-ended questions, participants' responses were manually grouped into themes independently by two coders. Coders discussed the discrepancies and made modifications.

RESULTS

Demographics and WPT use

Participants (mean age, 25.3 years) were 50% men and identified as white (22%), Hispanic (32%), black (10%), Asian (4%), Middle Eastern/Arab, Chaldean, Persian or Kurdish (26%) or multiethnic (6%) (table 1). The majority of participants had either a college degree (50%) or some college (36%) (table 1). About two-thirds (60%) resided in homes and one-third (38%) resided in apartments (table 1). Participants were weekly (62%) or monthly (38%) WPT smokers (table 1). Participants reported smoking an average of one WPT head on the day they smoked (table 1).

Quantification of WPT use waste

WPT smokers smoked for an average of one-half hour (mean=33.1 min) during the observed WPT smoking session at home, using 10 g of WPT, one charcoal (40 mm) and

Table 1 Demographics, WPT use and disposal of WPT use waste by WPT smokers in natural home settings (N=50)

	n (%)
Age (years)	
Mean (±SD)	25.3 (±3.13)
Median (minimum–maximum)	25 (21–35)
Gender	
Male	25 (50)
Female	25 (50)
Highest level of education completed	
High school	7 (14)
College, no degree	18 (36)
College degree	25 (50)
Race/Ethnicity	
White, Caucasian, European	11 (22)
Mexican, Hispanic or Latino	16 (32)
Black or African American	5 (10)
Asian	2 (4)
Middle Eastern/Arab, Chaldean, Persian, Kurdish	13 (26)
Multiethnic	3 (6)
Type of natural home setting	
Home	30 (60)
Apartment	19 (38)
Other: townhouse	1 (2)
Do you currently smoke WPT daily, weekly or monthly?	
Weekly at least once each week but less than daily	31 (62)
Monthly at least once a month but less than weekly	19 (38)
How many WPT heads do you usually smoke on the day you smoke?	
Mean (±SD)	1.3 (±0.56)
Median (minimum–maximum)	1 (0.5–3)
What type of WPT do you currently smoke?	
Only flavoured	46 (92)
Only unflavoured	0 (0)
Flavoured and unflavored equally	0 (0)
Flavoured more than unflavored	3 (6)
Unflavored more than flavoured	1 (2)
How often do you share a WP with someone you know?	
Almost always/often	44 (88)
Rarely/never	6 (12)
How often do you share a WP with someone you just met?	
Almost always/often	10 (20)
Rarely/never	40 (80)
After smoking WPT at home, where do you usually discard the remaining smoked WPT residue?	
In the trash	40 (81.6)
Kitchen sink	7 (14.3)
Bathroom sink	0 (0)
Toilet	0 (0)
In the backyard soil	1 (2)
In the plant pot indoors	1 (2)
After smoking WPT at home, where do you usually discard the remaining burnt charcoal?	
In the trash	27 (55.1)
Kitchen sink	14 (28.6)
Bathroom sink	0 (0)
Toilet	2 (4.1)
In the backyard soil	5 (10.2)
In the plant pot indoors	1 (2)
Smoked WP water	

Continued

Table 1 Continued

	n (%)
After smoking how many WPT heads at home do you replace the water in the WP bowl with fresh water?	
Mean (±SD)	2.1 (±1.36)
Median (minimum–maximum)	2 (0–7)
When you decide to replace the smoked WP water with fresh water, where do you usually discard the water?	
Kitchen sink	36 (72)
Bathroom sink	7 (13.7)
Toilet	2 (3.9)
In the backyard soil	4 (7.8)
In the plant pot indoors	0 (0)
Other places: street storm drain	1 (2)
After smoking WPT at home, when you pour the smoked WP water, do you usually smell anything?	
Yes	24 (52.2)
No	22 (47.8)
After discarding the smoked WP water, do you usually see any material left in the WP bowl?	
Yes	20 (42.6)
No	27 (57.5)
WP hose	
Have you ever cleaned the WP hose that you use at home?	
Yes	33 (68.7)
No	15 (31.3)
If Yes, do you clean the WP hose at home after every WPT smoking session?	
Yes	11 (35.5)
No	20 (64.5)
Where do you usually clean your WP hose that you use at home?	
Kitchen sink	26 (78.8)
Bathroom sink	4 (12.1)
In the backyard	3 (9.1)
How long have you been using the WP hose that you currently smoke at home (months)?	
Mean (±SD)	7.5 (±6.94)
Median (minimum–maximum)	6 (1–24)
Have you ever shared the WP hose that you use when you smoke WPT at home?	
Yes	39 (84.8)
No	7 (15.2)
WP stem	
Have you ever cleaned the WP stem that you use at home?	
Yes	34 (72.3)
No	13 (27.7)
If Yes, do you clean the WP stem that you use at home after every WPT smoking session?	
Yes	16 (50)
No	16 (50)
Where do you usually clean your WP stem that you use at home?	
Kitchen sink	30 (85.6)
Bathroom sink	3 (8.6)
In the backyard	1 (2.9)
Other places: shower	1 (2.9)
How long have you been using the WP stem that you currently use to smoke hookah at home (months)?	
Mean (±SD)	12.9 (±19.95)
Median (minimum–maximum)	6 (1–120)

The response item 'other places' was provided in all location of disposal questions; only those with responses are provided in the table. Due to missing values, some variables do not total the sample size 50.

WP, waterpipe; WPT, waterpipe tobacco.

Table 2 WPT smoking consumption and waste for one smoking session, using 10 g of WPT and 470 mL water in the WP bowl (N=50)

WPT (g)	WPT loaded in WP head presmoking*	WPT consumed	Smoked WPT residue†
Mean (±SD)	10	2.99 (±0.93)	7.01 (±0.93)
Median (5–95 percentile)		3.00 (1.5–4.7)	7.00 (5.3–8.5)
(Minimum–maximum)		(0.5–5.2)	(4.8–9.5)
WP water (mL)	Water placed in WP bowl presmoking‡	WP water loss	Smoked WP water§
Mean (±SD)	470	26.3 (±24.50)	443 (±24.50)
Median (5–95 percentile)		20.0 (0–70)	450 (400–470)
(Minimum–maximum)		(0–165)	(305–470)
Length of time smoked WPT per session (min)			
Mean (±SD)	33.1 (±9.35)		
Median (5–95 percentile)	30.0 (25–54)		
(Minimum–maximum)	(21–64)		
Location of WPT smoking in homes			
Indoors¶ n (%)	28 (56)		
Outdoors** n (%)	22 (44)		

*Research Assistants weighed 10 g WPT using an analytical balance and loaded it in the WP head.

†Smoked WPT residue=WPT remaining at end of a smoking session.

‡Research Assistants measured 470 mL of water and placed it in the WP bowl.

§Smoked WP water = Water remaining in WP bowl at end of a smoking session.

¶Indoors = Participants smoked in the living room, kitchen, or bedroom.

**Outdoors = Participants smoked in the backyard, on the patio, or balcony.

n, number of participants; WP, waterpipe; WPT, waterpipe tobacco.

470 mL water in the WP bowl (table 2). Of the 10 g WPT, smokers consumed an average of 2.99 g WPT/smoking session, discarding the remainder (mean=7.01 g) as waste (smoked WPT residue) (table 2). Of the initial 470 mL of fresh WP water, an average of 443 mL (94%) was discarded postsmoking as waste (smoked WP water) (table 2, figure 1).

Disposal of postsmoking WPT and charcoal waste

The majority of respondents reported discarding the smoked WPT residue in the trash (81.6%) or the kitchen sink (14.3%);

Figure 1 Fresh WPT and smoked WPT (scale: 1 cm). WPT, waterpipe tobacco.

other locations included backyard soil and indoor plant pots (table 1). About half of respondents reported discarding the burnt charcoal in the trash (55.1%) or the kitchen sink (28.6%); other locations included backyard soil, toilet and indoor plant pots (table 1).

Disposal and characteristics of smoked WP water

Respondents reported replacing the smoked WP water with fresh water after smoking an average of two WPT heads. The majority of respondents discarded the smoked WP water in the kitchen sink (72%) or the bathroom sink (13.7%); other locations included backyard soil, toilet and street storm drain (table 1).

When discarding the smoked WP water, about half of the respondents (52.2%) reported an odour (eg, burnt tobacco scent or the flavour of the WPT), and 42.6% usually saw a residue (eg, tobacco or particles/flakes/ashes). The colour of smoked WP water after smoking one WPT head at home ranged from 'black' to 'clear' or the colour of the WPT used (table 3).

WP hose cleaning practices

Participants reported using the same WP hose for about 6 months (table 1). About one-third (31.3%) never cleaned it (table 1). For those who reported ever cleaning their WP hose, most (64.5%) did not clean it after every smoking session (table 1). Instead, cleaning frequency ranged from 'twice weekly' to 'once' or was dependent on frequency of use (eg, 'every other time' or 'every five to six uses') (table 4). Participants most often used water only or water and soap to clean the WP hose (table 4). The majority of respondents reported cleaning the WP hose in the kitchen sink (78.8%); other locations included the bathroom sink and backyard (table 1).

WP stem cleaning practices

Participants reported using the same WP stem for about 6 months (table 1). About a quarter (27.7%) never cleaned it (table 1). For those who reported ever cleaning their WP stem, 50% did not clean it after every smoking session (table 1). Instead, cleaning frequency ranged from 'weekly' to 'rarely' or depended on frequency of use (eg, 'every other time' or 'every five to six uses') (table 4). Water only or soap and water were most often used to clean the WP stem. The majority of respondents cleaned their WP stem in the kitchen sink (85.6%); other locations included the bathroom sink, shower and backyard (table 1).

DISCUSSION

This is the first study to quantify two constituents of post-smoking WPT waste in home settings: smoked WPT residue and smoked WP water. We found that two-thirds (70.1%) of WPT used by one smoker in a smoking session and almost all (94.3%) water used in the WP bowl were discarded as waste. This is also the first study to identify locations of disposal of postsmoking WPT waste associated with using and cleaning WP devices in home settings. We found that WPT smokers who smoke at home usually discard postsmoking WPT waste in both indoor and outdoor environments, including the trash, kitchen sink, bathroom sink, toilet, shower, indoor plant pots, backyard soil and street storm drains.

Indoors, the kitchen may be most affected by disposal of WPT waste. In the USA, trash bins are typically placed in the kitchen area, where smokers reported discarding their WPT

Table 3 Reported description of colour, odour and materials in water in WP bowl after one use (smoked WP water)

n (%)		Quotes
Colour of smoked WP water		
		After smoking 1 WPT head at home, what is usually the colour of the water in the WP bowl? (n=58)
Brown	16 (27.5)	Brown (8). Light brown (2). Tan (1). Colour of tobacco (1). Dirty brown (1). Brown-like soil pieces (1). Just brown liquid (1). Dark brown (1).
White/grey/black	11 (19)	Somewhat clear (1). It is smoky clear (1). White (2). Foggy grey (4). Mostly cloudy (1). It looks a silver colour (1). Black/dark (1).
Yellow	11 (19)	Light yellow (5). Yellow (4). Dark yellow (1). Amber (1).
Clear	9 (15.5)	Clear (7). Pretty clear (1). Pretty clear depending on how long I was smoking (1).
Pink/Red	7 (12.1)	Pink (1). Pinkish clear (1). Reddish colour (2). Orange (3).
Tobacco flavour colour	4 (6.9)	Colour of flavour (1). It is usually the colour of the syrup from the tobacco (1). Colour of tobacco (2).
Odour of smoked WP water		
		After smoking 1 WPT head at home, when you pour the water out of the WP bowl, do you usually smell anything? If Yes, describe the odour: (n=22)
Tobacco/Cigarette/Smoke	10 (45.5)	Somewhat the flavour of the tobacco (3). Burnt tobacco (1). Tobacco smell (2). Smells like charcoal and burned tobacco (1). Cigarettes in water (1). Smells like stale smoke (1). Smoke and flavour (1).
Tar/Burnt/Ash	7 (31.8)	Just tary and burnt (1). Tar-like smell (1). A lot burn with the smell of hookah (1). Burnt sheesh (2). Ashy (2).
Dirty/Harsh	5 (22.7)	Dirty water smell (1). Stinking hookah water (1). Stale charcoal water (1). Dirty hookah water (1). Harsh (1).
Materials in the WP bowl		
		After discarding the water from the WP bowl, do you usually see any material left in the WP bowl? If Yes, describe the material: (n=23)
Tobacco	13 (56.5)	Tobacco residue (1). Small tobacco flakes (1). Leaves (1). Tobacco specks (1). Some pieces of tobacco (1). Sometimes tobacco (1). Tobacco (1). Tobacco leaves (1). Hits of sheesha (1). Burnt sheesh (3). Dark pieces like tar or residue of sheesha (1).
Particles/Flakes/Ash	7 (30.4)	Little particles (1). It's clear particles (1). Small black particles (1). Particulates (1). Black/dark flakes (1). Ash (1). Murky with random pieces in it (1).
Buildup/Residue/Juice	3 (13.1)	Some buildup on the sides of jar (1). Residue (1). Juice (1).

Due to missing values, some variables do not total the sample size 50. Participants provided ≥ 1 response per question. WP, waterpipe; WPT, waterpipe tobacco.

waste and usually remain in the home environment for about a week before being collected by waste management; therefore, there may be continuous lingering emission of post-smoking WPT toxic chemicals in indoor air (ie, thirdhand smoke (THS)),^{44–51} which may be inhaled by smokers and non-smokers residing in the home.

THS (also known as residual or aged tobacco smoke) is an environmental health hazard consisting of tobacco smoke particles and toxicants that accumulate and remain over long periods of time in the smoker indoor home environments.^{44–48} Furthermore, THS constituents react with surrounding chemicals in the air forming secondary toxicants such as the potent carcinogenic tobacco-specific nitrosamines.^{48–49} THS causes DNA damage in human cells,⁵⁰ and in animal studies it stimulated risk factors for inflammation-induced diseases, for example, chronic obstructive lung disease and asthma.⁵¹ We have previously found nicotine in the air and on household surfaces in the living rooms and children's bedrooms in homes of WPT smokers.³⁸ THS studies are focused on cigarettes; however, more studies are needed to characterise and quantify THS levels in homes of WPT smokers to inform interventions to reduce THS exposure from smoking and from discarding of related waste indoors.

Outdoors, the backyard soil may be most affected by smoked WPT residue, burnt charcoal and smoked WP water. This waste may adversely affect children playing outdoors, as well as pets and vegetation. Postsmoking WPT waste discarded in indoor or outdoor home environments will end up in landfills and water resources,^{14–9,32–33} harming the environment.

To reduce the accumulation of postsmoking WPT waste in the environment (eg, smoked WPT residue, aluminium foil and packaging), we suggest tailoring and adopting waste management options based on recommendations and policies enacted for recycling cigarette butts and remnants of smoked cigarette tobacco. The Extended Producer Responsibility (EPR) and Product Stewardship (PS) principles could guide controlling postsmoking WPT waste.^{2–5,52} EPR and PS principles, currently enacted in the USA and other countries on products, such as paint and batteries,^{2–5} can be applied to extend the responsibility and cost of managing postsmoking WPT waste to manufacturers, vendors, WPT smoking commercial venues (eg, hookah lounges/cafes) and consumers.

Approaches could include a WPT waste management tax embedded in the retail price of WPT, a mandatory deposit on WPT packages to provide an incentive to recycle and a disincentive to discard them in indoor and outdoor environments and a recycling programme, such as those that currently exist for cigarette waste.^{52–57} Since postsmoking WPT waste has international implications, health departments, particularly in countries with high WPT prevalence rates, could support the development of recycling programme with upcycling capabilities similar to TerraCycle (active in 25 countries), which does not landfill or incinerate tobacco waste, instead turning it into fertiliser, fuel and energy products for transportation and electricity.^{55–56}

To be effective, these strategies would require a recycling infrastructure as well as consumer awareness campaigns. Simple first steps could include requiring manufacturers to print recycling symbols—which they currently lack—on WPT packages; and requiring owners of WPT retail stores, online point of sale stores and hookah lounges/cafes to display recycling symbols. However, WPT packages may be contaminated with WPT toxic chemicals inappropriate for disposal in drains and landfills and best handled by a recycler of both tobacco waste and packages.

These strategies do not address the safe disposal of smoked WP water or burnt charcoal, which contain toxic chemicals, and cannot be recycled or recollected once discarded in the environment.³³ For WPT, reducing WPT products' ingredients classified by the US Food and Drug Administration (a federal agency authorised by the 2009 Family Smoking Prevention and Control Act to regulate tobacco products including WPT)^{58–60} as harmful and potentially harmful constituents may minimise some of the toxins in WPT waste and thus reduce their adverse environmental impact. For charcoal, strategies to replace it with heating devices to heat the WPT during smoking may reduce charcoal waste.

Proper cleaning practices may reduce some harm to WPT smokers. Most of WPT smokers share their WP with friends and family and at times with strangers,⁶¹ and we found that some smokers never cleaned their WP device. Sharing a WP between smokers is associated with transmission of infectious diseases via saliva and fecal–oral routes.^{62–65} Research is needed to identify levels of WP device contamination in home

Table 4 Reported cleaning practices of WP hose and WP stem

	n (%)	Quotes
WP hose. How often WP hose is cleaned.		
At least once a week	3 (15.8)	Twice a week (1). Once a week (2).
More than once a week	5 (26.3)	Bi-monthly (1). I clean it every month (1). Once every month (1). Every couple of months (2).
Other	11 (57.9)	Once every other hookah head (2). Every couple of times (1). Every third session (1). Every six times (1). I cleaned it only once (1). Rarely (3).
WP hose. How WP hose is cleaned.		
Water only	13 (39.4)	What do you use to clean your WP hose at home? (n=33) Just water (7). Water no soap (1). Hot water (3). Water, air (1). Just run water and blow out (1).
Soap and water	11 (33.3)	Soap and water (8). Water and rinse with soap (1). Water, dawn (1). Soap water (1).
Soap only	2 (6.1)	Soap (2).
Other	7 (21.2)	Blow air through it (1). Water and running alcohol (2). Water, kitchen salt (1). Bleach, water and soap (1). Water, alcohol and salt (1). Water, lemon juice and salt (1).
WP hose. Colour of water when cleaning it.		
Brown	14 (41.2)	When you clean your WP hose at home, what is the colour of the water that comes out of the hose? (n=34) Light brown (4). brown (6). Brownish/darkish colour (2). Brownish red (1). Orange/brown (1).
Clear	8 (23.5)	Clear (5). Normal (2). I think clear (1).
Black	6 (17.6)	Black (4). Black from charcoal (1). Foggy (1).
Yellow	6 (17.6)	Pale yellow (1). Yellow (5).
WP stem. How often WP stem is cleaned.		
At least once a week	1 (7.7)	Do you clean the WP stem that you use at home after every WPT smoking session? If No, describe how often do you clean the WP stem that you use at home? (n=13) Weekly (1).
More than once a week	3 (23.1)	Every couple of weeks (1). Once a month (1). Every couple of months (1).
Other	9 (69.2)	Every other time (1). Every two or three times I use (2). Every three hookah sessions (1). Every four or five sessions (1). Every five to six uses (1). Once or twice (1). Rarely (1).
WP stem. How WP stem is cleaned.		
Water only	10 (29.4)	What do you use to clean your WP stem at home? (n=34) Hot water (1). Water (6). Warm water (1). Just water (1). Run water through it (1).
Water and soap	9 (26.5)	Water and soap (4). Water/soap (3). Water, dawn (1). Run water and soap for the base (1).
Soap only	2 (5.9)	Soap (2).
Other	13 (38.2)	Water and alcohol (4). Water, soap and alcohol (2). Water, soap and bleach (1). Water, salt (1). Water, salt and alcohol (1). Hot water, lemon juice, salt and dish soap (1). Brush and water (3).
WP stem. Colour of water when cleaning it.		
Clear	11 (31.4)	When you clean your WP stem at home, what is the colour of the water that comes out of the stem? (n=35) Clear (10). I think clear (1).
Brown	10 (28.6)	Light brown (1). Brown (7). Orange/brown (1). Brownish/reddish (1).
Yellow	8 (22.9)	Yellow (4). Yellowish (3). Yellowish with black specks (1).
Black	6 (17.1)	Black (3). Dark (1). Black/dark colours (1). Clear with ashes (1).

Due to missing values, some variables do not total the sample size 50. Participants provided ≥ 1 response per question.
WP, waterpipe; WPT, waterpipe tobacco.

settings, recommend and encourage proper cleaning practices of WP devices in homes and investigate cleaning practices in public WPT venues.

Furthermore, as described by the participants, the dark/brownish/yellowish colour of smoked WP water and WP hose/stem cleaning water, the tobacco/tar/dirty odour and the deposited materials/flakes of tobacco in smoked WP water suggest a potential buildup of toxic chemicals, particularly in WP devices that are rarely cleaned. Studies are needed to characterise and quantify components of the buildup of toxic chemicals in hookah devices (eg, tobacco, humectants and flavouring additives) to determine their corresponding health risks; meanwhile tobacco control interventions should develop optimal cleaning strategies for WP devices and communicate findings to the WPT consumer via awareness campaigns.

Limitations

Our findings and recommendations were based on smoking sessions in which participants in our small San Diego US sample, ages 21–35 years, smoked alone in their own home. However, the majority (88%) of participants reported that they almost always smoked with someone else. Therefore, data on smoked WPT residue amount and smoked WP water quality could be underestimated. Future research should collect data from group smoking sessions, sample different populations including older adults with various socio-demographic backgrounds and extend our investigation to commercial WPT smoking venues in the USA and other countries.

While we did ask WPT smokers about cleaning practices of the WP hose and WP stem, we did not ask about the WP bowl; future research should include cleaning practices of the WP bowl, as toxic chemicals may accumulate on its surfaces. We did not ask participants about the disposal location of the empty packages of WPT or the aluminium foil used to cover the WPT during smoking; our recommendations for recycling postsmoking WPT waste are applicable to these components.

Missing responses in some of our open-ended questions is a concern that the data might not represent the population well, given our sample size of 50.

What this paper adds

What is already known on this subject

- Environmental waste is generated from waterpipe tobacco (WPT) smoking.
- Waterpipe (WP) users smoke in home settings.
- Studies have examined neither postsmoking WP device cleaning practices nor the disposal of waste associated with smoking WPT in home settings.

What this paper adds

- About two-thirds of the original weight of WPT smoked in a home setting was discarded as waste.
- Not all WPT smokers clean their WP device components after each use in a home setting.
- Locations where WPT smokers reported discarding waste associated with using and cleaning their WP device in home settings included the trash, kitchen sink, bathroom sink, toilet, indoor plant pots, backyard soil and street storm drains.

CONCLUSIONS

The increasing prevalence of WPT smoking globally warrants including postsmoking WPT waste in programme aimed to control disposal of overall tobacco waste. The WHO and American Cancer Society have provided data on annual cigarette production and volume of associated waste discarded in the environment.^{9 10} Such organisations and individual countries, particularly those with high WPT smoking prevalence, are encouraged to lead similar efforts to estimate global volume of WPT production and associated waste. These data are needed to justify efforts to tailor programme and policies at the city, state, national and international levels to mitigate the adverse environmental impact of WPT waste.

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