

Research

Addressing cigarette butt disposal behaviour on university campus in Portugal

Marta Carrega^{1,2}  · Graça Martinho^{1,2}  · Mário Ramos^{1,2} 

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Abstract

Background The cigarette butt (CB) is often overlooked, despite being an item of waste that has impacts on the environment. Few studies on CB littering are supported with a behaviour framework, and none have been conducted in Portugal in the context of a university campus.

Objective To identify solutions for the prevention of CB dispersion in the environment supported by a behaviour framework, using a Portuguese higher education campus as the study setting.

Methods A questionnaire was applied to a sample of 1933 campus users to understand their behaviour, perceptions and opinions regarding CB disposal. The assessment was based on a literature review regarding smokers' disposal behaviour and on the Behaviour Change Wheel framework. The number and condition of the ashtrays on campus were identified, and the disposal behaviour of people who smoke was observed.

Results People that smoke and people that do not smoke have different perspectives on CB disposal. Most smokers litter more or less frequently, and 80% reported walking up to a trashcan or ashtray to dispose of it correctly, confirmed by observations. Drawing smokers' attention to incorrect disposal of CB seems to be effective, but few engage in this activity.

Conclusions The main components of behaviour to intervene are opportunity (physical and social), and motivation (reflective and automatic), which can be done by reinforcing ashtray infrastructure that allows appropriate disposal of CB, as a starting point for habit formation, and as a base for awareness campaigns, promoting collective and individual responsibility.

Keywords Cigarette butt littering · Social norms · Behaviour Change Wheel · Waste collection · Smokers' behaviours · University campuses

1 Introduction

There have been studies about recycling cigarette butts (CB) and valorising some of its components [10, 41, 42] in an attempt to find a better destination for CB waste than incineration or landfill [23]. However, avoiding the dispersion of CB in the environment and promoting its proper management is highly dependent on the disposal behaviour of people that smoke, reinforcing the need to investigate their actions and attitudes regarding disposal [23]. Proper disposal allows for efficient collection and, if the CB is disposed of in a dedicated container, makes its potential valorisation easier to attain.

✉ Marta Carrega, carrega.marta@gmail.com; Graça Martinho, mgm@fct.unl.pt; Mário Ramos, mario.ramos@fct.unl.pt | ¹Department of Environmental Sciences and Engineering, NOVA School of Science and Technology, NOVA University Lisbon, Caparica, Portugal 2829-516. ²MARE – Marine and Environmental Sciences Centre / Associate Laboratory ARNET – Aquatic Research Network, Caparica, Portugal.



Aside from the impacts that tobacco products have on human health, the waste they generate has several other impacts, including environmental and economic ones. As Conradi and Sánchez-Moyano [14] pointed out, this waste causes double contamination; physical due to the danger of ingestion and as a source of microplastics [2], and chemical as it can leach toxic substances into the environment [2, 16], impacting living organisms in aquatic [16, 17, 33] and terrestrial habitats [6], with the potential to disrupt ecosystems.

Even though CB are not classified as toxic waste on the European List of Waste [18, 35] the European Union (EU) has considered CB filters in the Single-Use Plastics Directive [19]. According to this Directive, Member States are to implement measures to reduce the impacts of this kind of waste in the environment, namely through the Extended Producer Responsibility principle—the producers of tobacco products should cover the costs for clean-ups, ashtrays and consumer awareness campaigns. In 2019, Portugal passed a law forbidding the littering of CB, making it mandatory for universities, restaurants, hotels and other services that have outdoor spaces to provide ashtrays and be responsible for cleaning them and the surrounding area, within a five-metre radius [3]. In the same year, a national health inquiry found that 17% of the Portuguese population aged 15 and over smoked, with a gender balance of two male smokers for every female smoker [26].

This paper presents the results of a research project conducted at a Portuguese university campus, aiming to integrate a behavioural approach to the CB littering problem. As for now, smoking is permitted on campus in outdoors spaces, but there is a possibility that this will change in the upcoming years, as the government recently proposed a new tobacco law that prohibits outdoor smoking within the perimeter of places of public access. This kind of study is important to help inform these kinds of policies, as sometimes they produce undesired effects. For example, the smoking ban indoors might have contributed to CB litter as people started smoking outdoors more frequently [41]. As smoking bans become more prevalent in tobacco control measures and harness a lot of support from universities' campus users [1, 7], it also pushes smoking, and thus potential littering, to the periphery [7]. For this reason, the existence of cessation support for continuing smokers is also relevant, besides the health benefits that it brings, since it could help reduce CB generation at the source.

Universities play an important role regarding the adaptation of students' behaviour, through promoting the understanding of problems from a wider contextual approach. Research conducted in this context is relevant for encouraging behaviour change in students, but also for preparing the campus for the operational requirements and waste management plan that are necessary to support adequate behavioural change and create a more sustainable environment.

The main objective of this study is to address the gaps in scientific literature by contributing to the body of studies that apply a behaviour framework to inform behaviour change interventions. This work also addresses the lack of data on the CB disposal behaviour of Portuguese that smoke. In this case, the Behaviour Change Wheel framework (BCW) was applied to develop a questionnaire and identify solutions for CB littering. The main hypothesis is that people that smoke and people that do not smoke are statistically different regarding CB littering, which can influence future interventions. To the authors' knowledge, it is the first scientific study to use this framework for this purpose regarding CB litter.

2 Literature review

2.1 Littering behaviour

A review on littering behaviour studies identified that situational and psychological factors have been the most commonly used in research, with some of the variables evaluated being the availability of trashcans, environmental cleanliness and anti-littering norms [11]. Others such as demographic factors and reinforcement factors have also been used [11]. Another review identified drivers for both littering behaviours and proper disposal behaviours that can be examined in terms of personal, social, material and habits drivers [9]. Personal drivers relate to personal attributes and influences such as values, attitudes, identity and personal norms, which include feelings of responsibility and a sense of agency; social drivers concern the influence the social context has on a person's thinking and behaviour, including social norms, cultural conventions and shared understandings; material drivers refer to the context in which behaviours are formed and acted out, which include services, infrastructure and technologies; habits drivers relate to patterns of behaviour which individuals carry out almost automatically [9].

During behaviour observations at a university campus, littering rates differed by type of littering (active or passive) and by item [38]. CB were littered more than other kind of items, especially through active littering, and this way of

disposal was harder to change during a feedback intervention [38]. A study in Romania found that 56.6% of cigarettes consumed in public places were littered on the street [27]. Schultz, et al. [34] also observed a higher littering rate for CB, with 65% of all CB disposals being littered, compared to 17% of non-CB litter. According to Cope et al. (1993, cited in [38]), there might be normative differences between CB littering and littering larger and more obvious items. Sagebiel et al. [36] suggested the same in their field experiment on CB littering in littered/clean spaces at another university campus.

Smokers themselves may also have normative differences from people that do not smoke, as they were reported to litter non-smoking related items at higher rates and to have a more relaxed attitude towards littering [9]. Other studies found that, even though people that smoke have knowledge about the negative environmental impacts of CB littering, there is a disconnection between this knowledge and their behaviour [15, 34]. Personal variables were found to have a higher contribution to this behaviour than environmental/context variables (62% vs 38% respectively) [38] and so interventions usually include some kind of information strategy and/or social norming to influence them [11–13, 38]. The content and tone of the messages are important as they can affect the success of an intervention [12, 13].

Regarding other personal factors such as demographic ones, age was the only predictor found for CB littering by Schultz et al. [37] and Nitschke et al. [32], with younger people littering more. Lakatos et al. [27] found that different age groups indicated different motives for littering CB. On the other hand, Taverner Research [40] found no statistical difference between littering and correct disposal rates regarding (observed) age, gender and type of group (i.e., all-male, all-female or mixed). The way people that smoke are perceived by people that do not smoke also influences smoker disposal behaviour, as described by Falsone and Spence [20], where it was seen that CB littering can bring feelings of shame and guilt, prompting people that smoke into littering in a more concealed way.

However, environmental/context variables are easier to control, can help change the perceived social norms of the space and cut disposal cost efforts for individuals, making correct disposal easier than littering, as argued by Castaldi et al. [12] and Falsone and Spence [20]. In fact, the number of ashtrays was found to be a predictor for CB littering [32], as well as the distance to the closest one [37]. It was observed that littering rates were reliant on specific characteristics of the smoking sites, with statistical differences in CB disposal between litter-free areas with proper infrastructure and signalling and littered areas with inappropriate CB infrastructure, where the correct place to dispose of CB was unclear [40]. Gay et al. [22] applied a nudging strategy to change CB disposal behaviour from littering to using an ashtray. It was found that the use of an ashtray with messaging influencing social norms worked better at deviating CB from the ground than normal ashtrays, and that a voting ashtray (where the person uses their CB to vote on a matter or to answer a question) worked even better than the other kinds of ashtrays [22]. They argue that simple modifications in the immediate environment may be sufficient to promote behaviour [22], showing the power of cues in the environmental context on behaviour.

In fact, certain scenarios were identified as being potentially more prone to CB littering: a lack of appropriate containers nearby or those containers being full, dirty or inconvenient to use; when the place is already littered; when it's raining; when it is known or assumed that someone will clean the place; where/when it's unlikely someone will notice; during a break that's not specifically for smoking; on the way to somewhere, especially if smoking at the destination is not allowed; and on certain emotional states [20]. CB littering was also found to be highest when: there was no proper infrastructure; when smokers were in groups; when bins were more than 2 m away from the smoker; at entertainment venues; in areas that didn't cater to smokers' needs and in areas in which smokers felt they had less ownership over [40]. As a smoke-free campus could be more welcoming for non-smokers and protect them from second-hand smoke, the same environment can be considered unwelcoming for a person that smokes, without proper infrastructure for correct CB disposal. This could be one of the reasons why some studies on smoke-free campuses reported that people that smoke engaged in negative behaviour, with respondents still being exposed to second-hand smoke and CB litter still being present, despite the generally positive attitude towards this policy [30]. On the other hand, if planned properly, a smoke-free campus could discourage smokers from such practice, avoiding CB litter altogether.

2.2 Behavioural models applied to littering

Littering interventions developed through theories or models seem to be more effective (Glanz and Bishop, 2010, cited in [11]). However, in their review, Chaudhary et al. [11] found that out of 70 scientific articles about littering, only 30% used a theory or a model. Literature shows that the norms perspective has been popular, although with inconsistent findings when not integrated with situational and personal factors, which is not usually done when a model is not used [11]. Other theories have been applied to waste-related behaviour, but none covers all intervention options available or links to a method for designing interventions in a systematic way [21].

The BCW framework was therefore designed to be a tool for planning effective interventions for behaviour change, being the result of systematic reviews on 19 behaviour frameworks, with the goal being to overcome their limitations [21, 29]. It integrates the COM-B model with nine intervention strategies (restrictions, education, persuasion, incentivisation, coercion, training, enablement, modelling and environmental restructuring) and seven policy strategies (guidelines, environmental/social planning, communication/marketing, legislation, service provision, regulation and fiscal measures) [29]. The COM-B model is at its centre and comprises of three components that interact with and influence behaviour: Capacity, Opportunity and Motivation. The Capacity component is divided into physical capacity (the ability to perform the behaviour) and psychological capacity (having the knowledge to perform said behaviour). The Opportunity component is divided into physical opportunity (resources and physical context to perform said behaviour) and social opportunity (cultural environment and social norms). The Motivation component is split into reflective motivation (goals, decision processes and planning) and automatic motivation (habits and processes that involve impulses or emotions) [21, 29].

The Theoretical Domains Framework (TDF) is another theory resulting from the synthesis of behaviour change theories and has mostly been applied in healthcare and clinical contexts, in qualitative research [5]. However, it can be applied together with other theories and frameworks, namely the BCW/COM-B, allowing for a more elaborate analysis of the behaviours [21], connecting the most important/recurring themes of interviews to the behaviour precursors of COM-B. TDF domains (social influences, environmental resources, social/professional role and identity, beliefs about capabilities, beliefs about consequences, optimism, intention, goals, reinforcement, emotion, knowledge, cognitive and interpersonal skills, physical skills, memory, attention and decision processes, and behaviour regulation) make that connection, being associated with COM-B behaviour precursors [5] and therefore can be associated with the intervention strategies. The application of these frameworks to CB littering on campus thus allows for a quicker identification of deployable strategies that might be effective since they encompass several behaviour-influencing factors. For example, emotion domain is associated with automatic motivation precursor, which means that intervention strategies as environmental restructuring, modelling, enablement, training, coercion, incentivisation and persuasion have the potential to affect emotions associated with CB littering.

3 Methods

3.1 Field and behaviour observations

A field assessment was conducted to assess the number of dedicated containers, such as ashtrays, and the need to substitute some or install more of them, considering the number and location of busy areas.

Observations of CB disposal behaviour were conducted inside the campus, at five locations where trashcans or other proper containers were nearby. They were conducted on four different days when it was not raining. The variables analysed were gender, whether the person smoking was a student or not based on apparent age and the possession of a backpack, whether the person smoking was accompanied or alone—and in case of being accompanied, whether the other person/people were smoking as well, and the method of disposal of the CB: ground, ashtray, trashcan, flower bed, gutter or portable ashtray. Only the ashtray (portable or not) and the trashcan were considered as correct places for disposal. An effort to ensure discretion during observation was made. Since the number of observations was not sufficient for a significant statistical analysis, they were used for fact-checking the self-reported behaviour obtained via questionnaire.

3.2 Questionnaire survey

An online questionnaire was distributed amongst Campus users (presented in appendix). The questions created were inspired by the most relevant findings of Falsone and Spence [20] qualitative study regarding smokers' behaviour, in which the BCW framework and COM-B model were applied. Their results were considered a valid foundation for the present study since such qualitative work has not previously been undertaken in Portugal and both countries are considered developed countries.

Invitations to answer the questionnaire were sent by email to 8078 users. The number of invitations sent was dependent upon the updated contact lists available of students, professors/teachers, non-teaching employees and researchers/fellows, with an effort to get a representative number of answers from each group. The survey period was two weeks, between May and June of 2019. Before answering the questionnaire, respondents were informed that it was anonymous

and that their answers would be used for this study, so only those that gave their consent for their data to be used answered the questionnaire.

The questionnaire was divided into five sections: (1) demographic variables, (2) smoking behaviour and disposal methods (answered just by smokers), (3) attitude towards CB disposal behaviour, (4) behaviour intention and perceived behavioural control of people that smoke (answered just by smokers), and (5) behaviour intention and perceived behavioural control of people that do not smoke (answered just by non-smokers). Questions regarding possible interventions were developed considering the literature reviewed and the authors' perception of what could be feasible at the university campus. The questionnaire included an attitude scale towards CB disposal behaviour with 10 items measured on a 5-point Likert scale, which was validated by a fidelity analysis (Cronbach alfa = 0.808) and an internal validity test (KMO test = 0.889).

Of the 8,078 users who received the invitation, 1,933 valid responses were obtained, which resulted in a 24% answer rate. Considering that the Campus population is around 10,000 people, for a confidence level of 95% the margin of error is 2%, which guarantees that the sample size is sufficient for the accuracy of the data collected to be trusted.

Respondents were divided into smokers and non-smokers, and this was considered the independent variable (categorical). To assess significant differences between the groups, Chi-square tests were applied when dependent variables were also categorical, and ANOVA was applied when dependent variables were quantitative. A confidence level of 0.05 was considered for this. Chi-square tests were accompanied by Cramer's V test (it is considered a weak association when V is lower than 0.10, moderate when V is equal or higher than 0.10 and lower than 0.25, and strong when V is equal or higher than 0.25). Sections of the questionnaire that were targeted to just one of the groups were analysed through the frequencies of the answers in those sections.

4 Results and discussion

4.1 Disposal behaviour and dedicated containers

A thorough campus-wide investigation was conducted to document the placement and variety of smoking receptacles, ultimately identifying 38 distinct ashtrays or designated smoking disposal containers. However, only 4 of these were ashtrays, 10 were combined trashcan/ashtrays—most of which were in a degraded condition—and 24 were plant vases with sand. Thus, there is roughly one container per hectare in the central area of the campus, where services, activities and people are concentrated. A higher density of these containers would be advised, as argued by Nitschke, et al. [32]. Overall, 35 zones were identified as CB hotspots, 12 of which were serviced by one or more container, showing that they are not as effective as desired. A clean-up of these hotspots may help reduce littering behaviour in those areas, even if just a little, as shown by Sagebiel et al. [36] and observed by Taverner Research [40].

As for visual observations of smoker behaviour, 44 acts of CB disposal were registered, however, only 35 were considered valid as the destination given to the rest of CB was not possible to accurately determine by direct observation. Nearly 69% of CB were discarded correctly, with 51% using an ashtray and 17% a trashcan. For incorrect disposal, 23% were dropped on the ground, 6% on flower beds and 3% in the gutter. Most of the individuals observed were male students (69%), followed by female students (19%), male employees (6%) and female employees (6%). There were no female individuals that discarded their CB in an incorrect manner, while 41% of male individuals did so (Table 1).

These behaviour observations are not large enough to be statistically significant, and therefore limit conclusions regarding gender, (apparent) age and job. However, they are aligned with literature findings, which states that males litter more [11]. They also seem in line with other observational studies, regarding littering when in a group [32], especially in a group with other people that smoke [20, 40].

4.2 Questionnaire results

4.2.1 Profile of respondents

Of the 1,933 campus users who answered the questionnaire, 16% declared themselves to be smokers and 84% non-smokers, which is similar to national statistics [26]. Regarding demographic variables, only gender presents statistical differences, although the relation is weak (Table 2), with the smokers group comprising of more men, when compared to the non-smokers group. The proportion of smokers by gender is also similar to national statistics [26].

Table 1 CB disposal by group context and gender of the person smoking

Gender	Group context	Correct disposal	Incorrect disposal
Male	Alone	9	3
	with other smokers	2	6
	with non-smokers	5	2
	Total	16	11
Female	Alone	7	0
	with other smokers	1	0
	with non-smokers	0	0
	Total	8	0

4.2.2 Attitude regarding correct disposal, knowledge, social influence

Regarding the attitude toward the discarding of CB, respondents had to indicate the extent to which they agree with 10 sentences, using a 5-point Likert scale, with 5 being the most positive attitude. Statistical analysis reveals significant differences between these two groups ($F(1, 1931) = 244.931$; $p < 0.001$), with smokers presenting less positive attitudes towards CB disposal, being more permissive towards incorrect disposal albeit still having a positive attitude overall (average attitude score of 3.59 for smokers vs. 4.10 for non-smokers, with standard deviations of 0.58 and 0.51 respectively). This difference indicates different social norms between the groups and is coherent with findings of Rath et al. [34]. The still positive attitude of people that smoke towards a correct disposal of CB seems to support an openness on their part towards a targeted intervention.

Smokers and non-smokers were asked to choose the CB disposal behaviours that are most harmful to the environment. The differences in responses between the two groups are not statistically significant (Table 3). Both groups more frequently selected dropping the CB in a gutter (46%) or dropping it on the ground (44%). The least frequently chosen option was leaving CB in a vase or flower bed on the street (11%). Education regarding the impacts of CB, how marine life is highly susceptible to this litter's toxicity, or that street gutters on campus are connected directly to water bodies might be necessary, since it is important to explain how these impacts occur, as pointed by Falsone and Spence [20]. Dropping the CB on the ground, however, does not necessarily constrain its toxic components [24], which means that it can harm terrestrial life [31] [39] and still be washed into to gutters by wind and rain.

Attracting attention of people that smoke refers to the act of making the litterer notice that their disposal behaviour is not correct. It is not necessarily a critique. However, it is usually conveyed with a critical tone. Regarding this, there

Table 2 Demographic profile of the respondents

Demographic variables		Non-smokers (%)	Smokers (%)	Total (%)	Test statistics
Gender	Male	54.6	65.3	56.2	$\chi^2(1) = 11.947$ $p = 0.001$ $V = 0.079$
	Female	45.4	34.7	43.8	
Occupation	Student	71.1	13.4	84.5	$\chi^2(4) = 1.627$ $p = 0.804$ $V = 0.029$
	Professor	6.2	1.0	7.2	
	Researcher/fellow	4.8	0.7	5.5	
	Non-teaching staff	2.4	0.5	2.8	
Mean age		25.5	25.3	25.5	$F(1, 1931) = 0.123$ $p = 0.725$

Table 3 Respondents' answers to which discarding behaviours that are considered most harmful to the environment

Which behaviour do you consider to be the most harmful to the environment?	Non-smokers (%)	Smokers (%)	Total (%)	Test statistics
Disposal of CB on the ground	36.9	6.8	43.7	$\chi^2(2) = 0.533$ $p = 0.766$ $V = 0.017$
Disposal of CB in gutters	38.3	7.2	45.5	
Disposal of CB in plant vases or flowerbeds	9.3	1.5	10.8	

were no differences between the two groups ($X^2(3) = 10.276$; $p = 0.016$; $V = 0.073$): 47% of respondents never did it, 44% only attract the attention of smokers they know, 7% have done it before, but the person's reaction was not good, so they never did it again, and 3% do it even if they do not know the person. This shows that this kind of social influence is not popular, especially if the litterer is a stranger. This is similar to what Mohmad and Ismail [30] found in literature, where 60% of respondents would not reprimand people that smoke in smoke-free campuses due to the desire to avoid confrontation and to the uncertainty of how to undertake such a reprimand.

Respondents were also asked to choose up to two solutions to be implemented on Campus to change this littering behaviour. From the four solutions presented, only attracting the attention of smokers and reproving their littering behaviour showed no significant difference between the answers of smokers and non-smokers (Table 4). This option was the one with less votes, a result that reinforces how unappealing this action is to campus users. The statistical difference between the groups among the rest of the options shows the presence of normative differences between people that smoke and people that do not. Of these, a smoking ban in places without ashtrays had little support when compared with the other two solutions. This may be an indication of the amount of support the new tobacco law may gather. As shown by Henderson et al. [25], Portugal is among the European countries with higher smoking prevalence and with lower tobacco control performance [25], which may explain this result. In Spain, considered to have similar cultural values to Portugal, it was found that regulations for outdoor smoking at universities' campus only gathered 39% of supports from study participants [28].

As of now, Portuguese law states that it is prohibited to smoke in educational establishments, which includes universities, and specifies that it is applicable predominantly in indoor spaces [4]. It also establishes that whenever possible, smoking areas in outdoor spaces should be defined and should offer protection from the weather. At the time of the field assessment, no such areas were identified. If the new tobacco law is to come into force, universities will need to deal with a total or partial smoking ban on their premises and should take measures to avoid unwanted effects [30].

4.2.3 Reported disposal behaviour

Five discarding behaviours were presented only to smokers, who indicated how frequently they perform each (Fig. 1). Regarding incorrect disposal, 13% of smokers reported to very often and almost always drop their CB on the ground, 14% in gutters and 22% in flower beds or plant vases. On the other hand, 80% report to very often and almost always walk to an ashtray or trashcan to leave their CB. It should be noted that most of the equipment available on campus used by people who smoke to dispose of their CB were plant vases with sand, which might have influenced answers on disposal in ashtrays vs plant vases. When using self-reporting methods, there is always the possibility of respondents lying about their behaviour. Comparing these results with the observations, it can be seen that smokers dispose of their CB correctly most of the time in both sets of data.

Of the smokers that reported dropping the CB in the street gutter, nearly 40% said that it is the most harmful way to dispose of it, showing that, given the knowledge they have, their actions do not correspond to what would be expected, again supporting the findings of Rath et al. [34] and Dehdari [15]. The use of portable ashtrays is uncommon. Indeed, carrying a portable ashtray can reduce the effort cost of correct disposal, as shown by Castaldi et al. [12], but the act of carrying it itself may add to that effort cost.

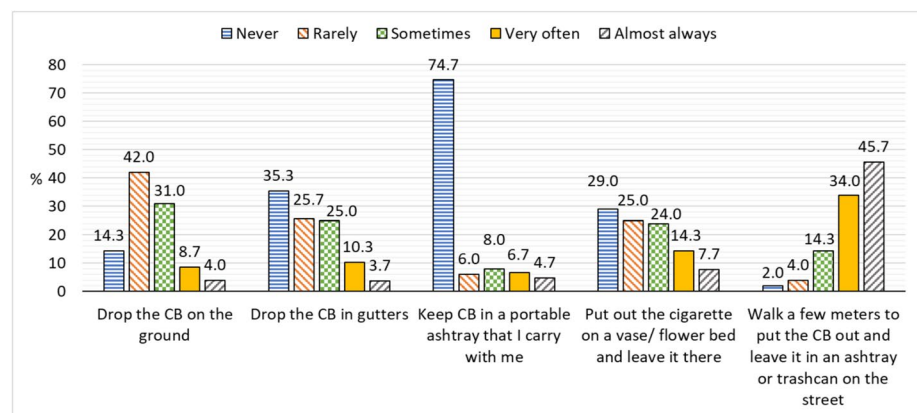
When asked if they look for an ashtray or a trashcan before smoking outdoors, 46% of smokers said "Yes, but If I don't see an ashtray or trashcan I smoke anyway", 42% answered "I rarely have this concern, I only think about it after finishing the cigarette", 7.0% said "Yes, and if I don't see an ashtray or trashcan I don't smoke" and 4.7% "I always carry a portable ashtray with me, so I never do that". It was expected that the majority of smokers would report not reflecting on how to dispose of CB before smoking, as it has been shown that it can be a process involving a low consciousness level [15, 20]. However, over half of smokers reported thinking about the disposal first and then deciding whether or not to smoke after their assessment. When questioned about the motives for dropping it on the ground or in the gutter, 83% of smokers said it happens when they do not find an ashtray/trashcan nearby, while only 17% said it was due to habit, strengthening the previous result. On the other hand, the high percentage of smokers pointing to the lack of nearby ashtrays is not surprising, as their number on campus is low (see Sect. 4.1). Other studies found the same complaint from people that smoke [17, 20, 27].

Regarding the social disapproval that others may have concerning smokers' behaviour, 64% of smokers said that they have never been criticised for dropping a CB on the ground, while 36% stated they have. Of the ones who were criticised, 56% answered that the critique came from friends, 25% from colleagues, 10% from family members and 9% from strangers. Regarding how it affected their littering behaviour, 47% said that they stopped doing it, 33%

Table 4 Respondent's votes on interventions for behaviour change

Solutions	COM-B component	Non-smokers (%)	Smokers (%)	Total (%)	Test statistics
More ashtrays around the campus	Physical opportunity	79.5	92.3	81.5	$\chi^2 (1) = 27.722$ $p = 0.000$ $V = 0.120$
More awareness campaigns targeted towards smokers	Psychological capacity, reflective and automatic motivation	66.0	51.7	63.7	$\chi^2 (1) = 22.377$ $p = 0.000$ $V = 0.108$
Prohibition of smoking in places where there are no ashtrays	Automatic motivation, social opportunity	27.9	10.0	25.1	$\chi^2 (1) = 43.262$ $p = 0.000$ $V = 0.150$
Each one of us attracts the attention of littering smokers that drop the CB on the ground, reproving their behaviour	Psychological capacity, social opportunity, automatic motivation	10.8	11.3	10.9	$\chi^2 (1) = 0.064$ $p = 0.801$ $V = 0.006$

Fig. 1 Frequency that smokers perform these five discarding behaviours



answered that they felt embarrassed but kept littering the CB, and 20% answered that it did not bother them, so they didn't change the behaviour. These results indicate that simply drawing attention to incorrect disposal may be enough to make nearly half of people that smoke stop dropping their CB on the ground or in other inadequate places. However, as discussed in the previous (Sect. 4.2.2), attracting attention to negative behaviour in this context is not perceived as a good solution. This is something that should be better investigated.

Regarding the distance smokers are willing to cover to correctly dispose of their CB, 29.0% chose "up to 20 m" and 23.3% chose "up to 10 m". The third most chosen option was "I'm willing to walk whatever distance is necessary" (18.7%), with 96% of these respondents having answered that they never or rarely drop their CB on the ground in Fig. 1. "Less than 5 m" and "up to 50 m" were each chosen by 12.0% of the respondents, with "up to 100 m" and "I'm not willing to walk any distance for that" comprising the final 5% of the answers. Analysing distance for disposal is important since it was found to be a predictor for littering of CB [32, 37], with statistical differences in littering rates for different distances [40].

When asked about the emotions felt when discarding the CB on the ground (Fig. 2), smokers seem to feel some kind of discomfort and guilt more often, while over half of the respondents admitted being bothered by this action. Shame/embarrassment is something not usually felt by most respondents, which could be due to the normalization of disposing of the CB on the ground. On the other hand, awareness of this issue and the wider critique of smoking in recent years could be behind the more frequent emotions of discomfort, guilt and concern. More research on the cause of these feelings and their impact on behaviour is needed to be able to make conclusions.

4.2.4 Perceived behaviour control

Smokers were asked "If there was an appeal for smokers to stop leaving their CB on the ground or in gutters inside the Campus, how difficult would it be for *you* to comply?" A similar question was made to non-smokers, "If there was an appeal for smokers to stop leaving their CB on the ground or in gutters inside the Campus, how difficult do *you think* it

Fig. 2 How often smokers feel these emotions when disposing their CB on the ground

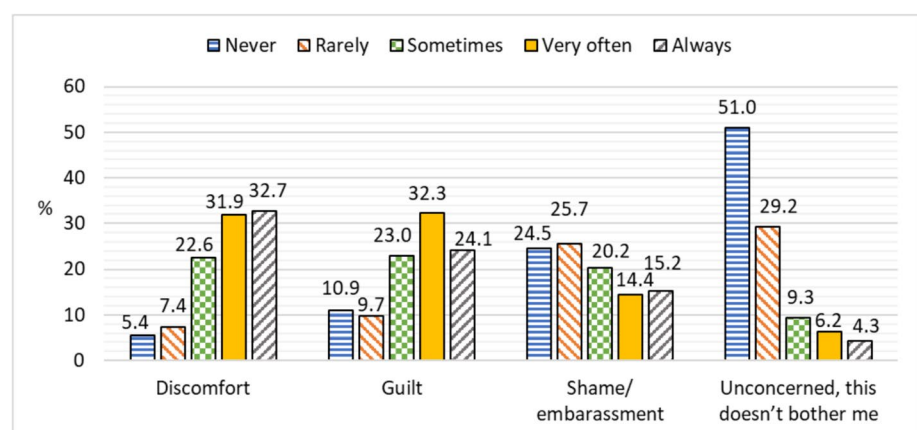


Fig. 3 Respondent's opinion on how difficult it would be for smokers to stop littering CB inside campus

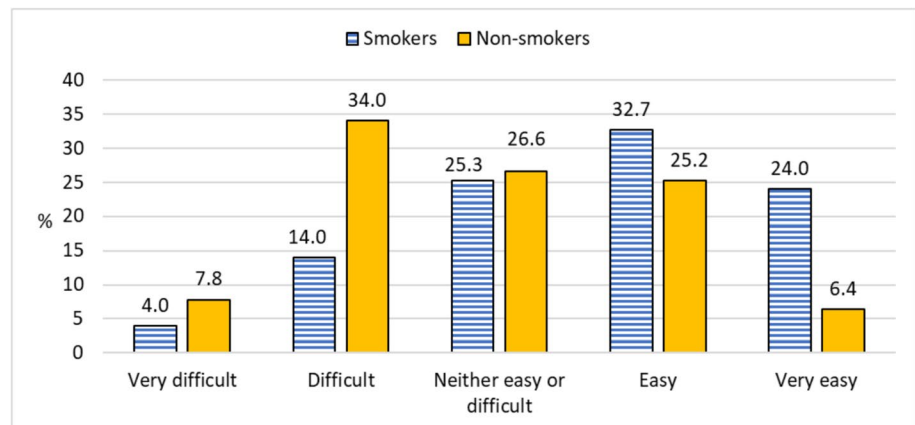
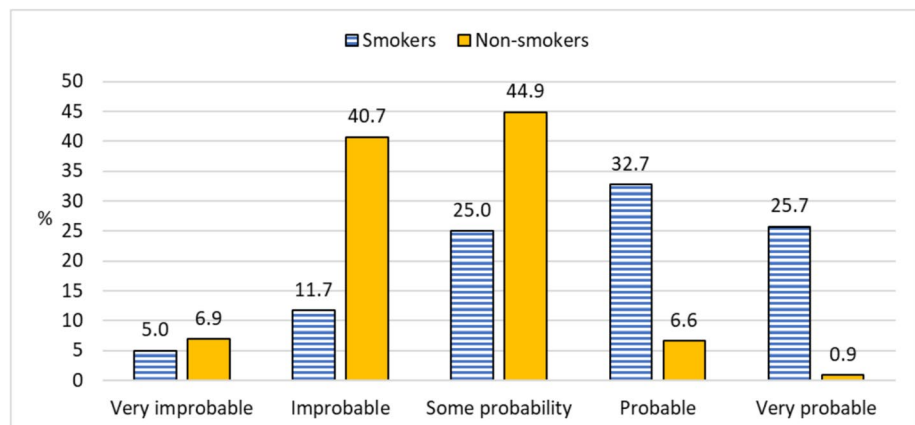


Fig. 4 Respondent's opinion on how probable it would be for smokers to stop littering CB inside campus



would be *for smokers* to comply?" The results obtained for these two questions are presented together in Fig. 3 as they show the perception of different groups in regard the same subject, in this case, the perceived difficulty of people that smoke to stop littering CB. While for about 42% of non-smokers an appeal like this would be difficult or very difficult for smokers, only 18% of smokers considered the change to be difficult.

Non-smokers were also asked how probable it was *for smokers* to stop littering CB inside campus and, in the case of smokers, how probable *for them* it would be to stop littering CB inside campus. Also, for these two questions, the results were presented together as they show the perception of different groups regarding the same subject, the perceived probability of people that smoke stopping littering CB (Fig. 4).

The results (Figs. 3 and 4) indicate that smokers are quite optimistic regarding their own behaviour regulation, while non-smokers seem more sceptical regarding smokers' self-regulation of littering behaviour: more smokers believe that they can change CB littering behaviour with ease and more smokers believe it to be very probable; on the other hand more non-smokers believe it would be hard for smokers to alter this behaviour and more non-smokers believe it to be somewhat probable.

4.3 Discussion on intervention proposals

More ashtrays are needed, as well as greater awareness and conscientiousness during the disposal of CB, which fall under the following BCW intervention strategies: environmental restructuring, enablement, modelling, training, incentivisation, persuasion and education. All these strategies, when combined, affect all components of COM-B, although physical capability is not an issue in this case, as Falsone and Spence [20] noted. Psychological capacity doesn't seem to be critical either, considering that it is a higher education context. However, since these findings are based on data from questionnaires, interviews would be necessary for confirmation.

Enabling and environmental restructuring strategies address the contextual factor in which the behaviour occurs, while modelling, training, persuasion, incentivisation and education strategies address individual factors influencing the littering behaviour. From these, modelling is probably the most difficult one to implement since there are role models for littering behaviour, but there is a lack of role models for correct CB disposal [15, 20]. There is also the possibility that images or videos depicting someone disposing of their cigarette could be interpreted as an encouragement to smoke. As for the training strategy, it could also be tricky and highly dependent on the individual, consisting of training the body to walk up to a receptacle or stop the impulse of flicking the CB, and training the mind to be conscientious in the moment of disposal.

Reinforcing the infrastructure seems to be the best course of action since it can cover several strategies, alongside an awareness campaign. To reinforce the infrastructure, it will be necessary to acquire ashtrays, to replace inadequate ones and increase their numbers across the campus area. The ashtrays should be clearly identifiable as such, so as to prevent other kinds of waste from being placed there, further simplifying the valorisation/recycling processes. They should be easy to clean and maintain, preventing the creation of littered areas around them, as littered areas increase littering behaviour [20, 40]. According to Falsone and Spence [20] the visibility and convenience of ashtrays are influential factors for correct disposal. Since 42% of the respondents reported not searching for one before smoking, placing them in areas that are easy to spot is crucial. Painting them in flashy colours might help. Placing them in convenient areas whilst safeguarding people that do not smoke as much as possible is also of utmost importance. If their location forces users to smoke in areas unsheltered from rain, wind and heat, and/or are too far out of the way they usually travel, they will not be used [20, 40].

In the awareness campaign, initiatives mobilising the campus community should be key, promoting a sense of collective and individual responsibility that can motivate individuals not to litter [8], Roales-Nieto, 1988, cited in [37], e.g. via group clean-ups. This kind of activity might also help change the descriptive norm of CB on the ground and avoid the “litter attracts litter” problem [9] [37]. Another thing that might contribute to community involvement could be the ashtrays themselves. They can be designed to make the action of correct disposal fun [20]—or just requiring less effort to use than littering the CB [12]. One example is ashtrays with questions, in which people that smoke use their CB to vote on an answer. These questions can regard campus matters, interesting topics for the users, bearing in mind that the question itself may have different degrees of efficacy [23]. A designated group could oversee these questions, changing them and divulging results, as feedback was shown to be effective in reducing littering [38]. Social media and other platforms could be used for this and to pool voting on the topic addressed. A more affordable option is traditional ashtrays that could be decorated by each faculty department, sparking curiosity and leading to smokers learning in a fun way where they could dispose of their CB.

Messages should be tested before being disseminated, maybe even using marketing strategies, as recommended by Chaudhary, et al. [9]. This must be done very carefully so as not to oppose the injunctive and the descriptive norm, which may have contrary effects [13]. Schultz, et al. [37] mention the possible advantages of reporting the percentage of people who disapprove of CB littering when changing personal and injunctive norms. Including the perceived behaviour of people that smoke and people that do not in these messages could be an additional incentive for people that smoke to prove to those that do not smoke that their perception of smokers is not correct.

5 Conclusions

Strategies from the BCW framework were identified for an intervention to change CB littering behaviour at a university campus in Portugal. Questionnaire results show that for some variables there are differences between people that smoke and people that do not smoke, namely attitude. Both smokers and non-smokers show a positive attitude towards proper disposal of CB, though smokers have a less positive attitude. Although it is still very frequent for smokers to discard their CB incorrectly, it is also frequent for them to do it correctly, especially considering the lack of proper ashtrays. This was confirmed by the results of behaviour observations. Calling out littering smokers may be an effective strategy, but it is not a popular one in this context. Smokers are more optimistic regarding *their* capacity to change this behaviour than non-smokers are regarding *smokers'* capacity to change. Results also indicate that most people that smoke may change the way they discard their CB given the right conditions. Correct disposal of CB must be easier to enact or at least, be more interesting than littering.

COM-B components to intervene are physical opportunity, social opportunity, reflective motivation, and automatic motivation, which could be attained by reinforcement of ashtray infrastructure that promotes appropriate CB disposal

easily. The ashtrays themselves can be a tool for building the habit but also be used for awareness raising activities that involves students and campus staff, promoting collective and individual responsibility. This provides insight on the path to take in controlling CB litter at university campuses, particularly in Portugal, while a nation-wide smoke ban at such places is not implemented or, in the case of voluntary measures, such a ban will not be well received. It should be noted, however, that a smoke ban, if well implemented, would be a simpler and much cheaper option to deal with CB litter in campus, promoting healthier spaces that benefit everyone and healthier behaviours in people that smoke.

As this study was an initial assessment of the situation at a university campus, there were some matters that were out of scope or that need further development, be it due to time and resources constraints or contextual changes over time. One of those limitations was the low number of observations of discarding behaviour. Another limitation is the small amount of literature regarding qualitative research, conducted either in Portugal or in other regions, on the matter of CB disposal.

Further research should examine the potential impact of drawing attention to incorrect CB disposal in behaviour interventions, with and without the reproving/critical aspect, as well as the cultural influencing factors of different regions. A potential connection between them should also be investigated. Also for future work, an exploration of the dynamics with and without dedicated smoking areas for people that smoke with a wider array of solutions would be useful for implementation strategies. The implementation of the intervention would then be the next step, with evaluation and monitoring, and a selective collection scheme for the CB.

6 Appendix

6.1 Identification

1. Gender

- Female;
- Male

2. Age (open field, numeric).

3. Situation at FCT NOVA.

- Teaching staff;
- Non-teaching staff;
- Research fellow;
- Researcher;
- Student;
- Other situation.

6.2 Smoking behaviour and destination of the cigarette butts

4. Are you currently a smoker?

- No (skip to 13);
- Yes

5. When you smoke outside, how often do you perform these discarding behaviours?

Never Rarely Sometimes Very often Almost always

Drop the cigarette butt on the ground (whoever answers "never" or "rarely" skips the following questions until 5)

Drop the cigarette butt in the gutters

Keep the cigarette butts in a portable ashtray that I carry with me

Put the cigarette out in a vase/flowerbed and leave it there

Walk a few meters to put the cigarette butt out and leave it in an ashtray or trashcan on the street

6. When you are outside, do you look for an ashtray before smoking?

- I rarely have this concern, I only think about it after finishing the cigarette
- Yes, but if I don't see an ashtray or trashcan I smoke anyway
- Yes, and if I don't see an ashtray or trashcan I don't smoke
- I always carry a portable ashtray with me, so I never do that

7. What are the reasons you leave your cigarette butt on the ground or in gutters sometimes?

- It's an old habit, I do it automatically without thinking
- I only do this when I don't see any ashtrays or trashcans nearby

8. What distance are you willing to walk with your cigarette butt to leave it in an ashtray or trashcan?

- I'm not willing to walk any distance for that
- Less than 5 m
- Up to 10 m
- Up to 20 m
- Up to 50 m
- Up to 100 m
- I'm willing to walk whatever distance is necessary

9. When you leave your cigarette butt on the ground, how often do you feel:

Never

Rarely

Sometimes

Very often

Always

Discomfort

Guilt

Shame/embarrassment

Unconcerned, this doesn't bother me

10. Has anyone criticized you for leaving a cigarette butt on the ground?

- No (go to 13);
- Yes

11. If yes, who? (Multiple choice)

- Family
- Friends
- Colleagues
- Strangers

12. If yes, what effects did it have on your behaviour?

- It didn't bother me, I continued to drop cigarette butts on the ground
- I felt embarrassed, but I keep dropping the cigarette butts on the ground
- I stopped leaving cigarette butts on the ground

6.3 Attitudes towards the discarding behaviours of cigarette butts

13. Please indicate your level of agreement with the following sentences:

	I totally disagree	Disagree	Neither disagree nor agree	Agree	I totally agree
Dropping cigarette butts on the ground doesn't do much harm because they are biodegradable in nature					
Whoever leaves cigarette butts on the ground should be fined					
The cigarette butts are very harmful to the environment					
I am indifferent to the amount of cigarette butts on the ground, it doesn't bother me					
Leaving the cigarette butts on the ground is not a big problem because they are removed by the urban cleaning services					
Smoking in the streets should be forbidden, thus solving the problem of cigarette butts on the ground					
Leaving cigarette butts on the ground is uncivilised behaviour					
It is acceptable to leave cigarette butts on the ground when there are no ashtrays nearby					
We should always show our disapproval to smokers who leave cigarette butts on the ground					
Leaving cigarette butts on the ground is more acceptable than leaving packaging or food scraps					

14. Which behaviour do you consider to be the most harmful to the environment? (select only one, which you consider worse).

- Disposal of cigarette butts on the ground
- Disposal of cigarette butts in gutters
- Disposal of cigarette butts in plant vases or flowerbeds

15. When you see someone dropping a cigarette butt on the ground, do you usually say something to them to draw attention to it?

- Yes, even if I don't know the person
- Yes, but only if it's someone I know
- I did it once and the person's reaction wasn't good, so I never did it again
- No, I've never done that

16. Which are the solutions that you consider to be most effective to have a campus free of cigarette butts? (select only one, the one you consider most effective)

- More ashtrays around the campus
- More awareness campaigns targeted to smokers
- Prohibition of smoking in places where there are no ashtrays
- Each one of us call to attention smokers that drop the CB on the ground, reproving their behaviour

6.4 Perceived behavioural control and behavioural intent (for smokers only)

17. If an appeal were made to all smokers to stop leaving cigarette butts on the ground or in gutters on our Campus, how would this be for you?

Very difficult	Difficult	Neither easy or difficult	Easy	Very easy
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18. And how probable would it be for you to stop leaving cigarette butts on the ground?

Very improbable	Improbable	Some probability	Probable	Very probable
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6.5 Perceived behavioural control and behavioural intent (non-smokers only)

19. If an appeal were made to all smokers to stop leaving cigarette butts on the floor or in gutters on our Campus, do you think that for smokers it would be:

Very difficult	Difficult	Neither easy or difficult	Easy	Very easy
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20. And what, in your opinion, would be the likelihood that smokers stop leaving cigarette butts on the ground?

Very improbable	Improbable	Some probability	Probable	Very probable
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Data availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate The online questionnaire and its application followed the Ethics Committee of NOVA School of Science and Technology guidelines, in accordance with the the General Data Protection European Regulation (Regulation (EU) 2016/679, of the European Parliament and of the Council, of 27 April, on the protection of natural persons with regard to the processing of personal data and on the free movement of such data), which is applicable in Portugal through the General Personal Data Protection Law (in Portuguese: *Lei Geral de Proteção de Dados Pessoais*): Law 58/2019, of 8 August. All experimental protocols were approved by Ethics Committee of NOVA School of Science and Technology, Comissão de Ética da Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa (CENOVAFCT).

Informed consent Informed consent was obtained from all individual participants included in the study.

Competing interests The authors declare no competing interests.

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References

1. Al-Jayyousi GF, Shraim M, Hassan DA, Al-Hamdani M, Kurdi R, Hamad NA, et al. University students' and staff attitudes toward the implementation of a "tobacco-free" policy: a view from Qatar. *Preventive Medicine Reports*. 2024;38:102605. <https://doi.org/10.1016/j.pmedr.2024.102605>.
2. Arat SA. A review on cigarette butts: environmental abundance, characterization, and toxic pollutants released into water from cigarette butts. *Sci Total Environ*. 2024. <https://doi.org/10.1016/j.scitotenv.2024.172327>.
3. Assembleia da República. Lei n. 88/2019 de 3 de setembro, Redução do impacto das pontas de cigarros, charutos ou outros cigarros no meio ambiente [Law no. 88/2019 of 3 September on Reducing the impact of cigarette butts, cigars or other cigarettes on the environment] in its current wording. Lisboa, Assembleia da República. 2019.
4. Assembleia da República. Lei n. 37/2007 de 14 de agosto, do Normas para proteção dos cidadão da exposição involuntária ao fumo de tabaco e medidas de redução da procura relacionadas com a dependência e a cessação do seu consumo, [Assembly of the Republic, 2007. Law no. 37/2007 of 14 August, on Standards for the protection of citizens from involuntary exposure to tobacco smoke and demand reduction measures related to addiction and smoking cessation] in its current wording. Lisboa, Assembleia da República. 2007.
5. Atkins L, et al. A guide to using the theoretical domains framework of behaviour change to investigate implementation problems. *Implement Sci*. 2017;12:77. <https://doi.org/10.1186/s13012-017-0605-9>.
6. Bakr Z, Aboulnasr GN, El-Aal MA, Elshimy NA, Said SM. Ecotoxicological effects of cellulose acetate nanoplastic derived from cigarette butts on earthworm (*Allolobophora caliginosa*): implications for soil health. *Environ Res*. 2025. <https://doi.org/10.1016/j.envres.2025.122189>.
7. Braverman MT, Hoogesteger LA, Johnson JA. Predictors of support among students, faculty and staff for a smoke-free university campus. *Prev Med*. 2015;71:114–20. <https://doi.org/10.1016/j.ypmed.2014.12.018>.
8. Bonanomi G, Incerti G, Cesarano GGS, Lanzotti V. Cigarette butt decomposition and associated chemical changes assessed by ¹³C CP/MAS NMR. *PLoS ONE*. 2015. <https://doi.org/10.1371/journal.pone.0117393>.
9. Brook Lyndhurst, n.d. Rapid Evidence Review of littering behaviour and anti-litter policies, Scotland: Zero Waste Scotland. <https://www.zerowastescotland.org.uk/sites/default/files/Rapid%20Evidence%20Review%20of%20Littering%20Behaviour%20and%20Anti-Litter%20Policies.pdf>. Accessed 5 Sep 2024.
10. Cavagnoli S, Pazzaglia A, Fabiani C, Landi FFA, Castellani B, Pisello AL. Sustainable approach to cigarette butts management: From waste to new building material component. *Sustain Energy Technol Assess*. 2024. <https://doi.org/10.1016/j.seta.2024.104039>.
11. Chaudhary AH, Polonsky MJ, McClaren N. Littering behaviour: a systematic review. *Int J Consum Stud*. 2021. <https://doi.org/10.1111/ijcs.12638>.
12. Castaldi G, Cecere G, Zoli M. "Smoke on the beach": on the use of economic vs behavioral policies to reduce environmental pollution by cigarette littering. *Econ Politica*. 2021;38:1025–48. <https://doi.org/10.1007/s40888-020-00205-5>.
13. Cialdini RB. Crafting normative messages to protect the environment. *Curr Dir Psychol Sci*. 2003;12(4):105–9. <https://doi.org/10.1111/1467-8721.01242>.
14. Conradi M, Sánchez-Moyano JE. Toward a sustainable circular economy for cigarette butts, the most common waste worldwide on the coast. *Sci Total Environ*. 2022. <https://doi.org/10.1016/j.scitotenv.2022.157634>.
15. Dehdari T. A qualitative exploration of Iranian smokers' experiences in terms of cigarette butt littering behaviour. *Int J Environ Res Public Health*. 2020. <https://doi.org/10.1080/09603123.2020.1769040>.
16. Dobaradaran S, Salemi A, De-la-Torre GE, Telgheder U, Schmidt TC. The role of different remaining parts of cigarette butts in the transfer of phenolic compounds into the aquatic environment and their ecological risk. *Sci Total Environ*. 2024. <https://doi.org/10.1016/j.scitoenv.2024.177584>.
17. dos Santos NP, Maciel MGR, Guimarães PS, et al. Negative effects of cigarette butt leachate on freshwater phytoplankton communities. *Ecotoxicology*. 2024;33:884–92. <https://doi.org/10.1007/s10646-024-02787-3>.
18. EU. Commission Decision of 18 December 2014 amending Decision 2000/532/EC on the list of waste pursuant to Directive 2008/98/EC of the European Parliament and of the Council. Brussels: EU. 2014.
19. EU. Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment. Brussels: EU. 2019.
20. Falsone, C. & Spence, B., 2017. Qualitative research of cigarette disposal behaviour—full report of research findings, s.l.: Hall & Partners—Open Mind. https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/litter/qual_cigarette-disposal-behaviour-research-report.pdf?la=en&hash=90B8A09B8926B4D44CE2865E0B1712D817C1B3FF. Accessed 5 Sep 2024.
21. Gainforth HL, et al. Developing interventions to change recycling behaviors: a case study of applying behavioral science. *Appl Environ Educ Commun*. 2016;15(4):325–39. <https://doi.org/10.1080/1533015X.2016.1241166>.
22. Gay A, Pascual A, Salanova T, Felonneau ML. What about using nudges to reduce cigarette butts pollution? *J Hum Behav Soc Environ*. 2023;34(4):528–35. <https://doi.org/10.1080/10911359.2023.2219714>.
23. Ghasemi A, Golbini Mofrad MM, Parseh I, et al. Cigarette butts as a super challenge in solid waste management: a review of current knowledge. *Environ Sci Pollut Res*. 2022;29:51269–80. <https://doi.org/10.1007/s11356-022-20893-9>.
24. Green A, Putschew A, Nehls T. Littered cigarette butts as a source of nicotine in urban waters. *J Hydrol*. 2014;519:3466–74. <https://doi.org/10.1016/j.jhydrol.2014.05.046>.
25. Henderson E, Lugo A, Liu X, Continente X, Fernandez E, Lopez MJ, et al. Secondhand smoke presence in outdoor areas in 12 European countries. *Environ Res*. 2021;195:110806. <https://doi.org/10.1016/j.envres.2021.110806>.
26. INE—Instituto Nacional de Estatística (Statistics Portugal, document in portuguese), 2020. Inquérito Nacional de Saúde 2019. https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_destaques&DESTAQUESdest_boui=414434213&DESTAQUESmodo=2. Accessed 20 Aug 2025.
27. Lakatos ES, Cioca LI, Geng Y, et al. Environmental impacts of tobacco product waste: an investigation on littering attitudes. *Circ Econ Sust*. 2024;4:2199–220. <https://doi.org/10.1007/s43615-024-00372-8>.

28. Martínez C, Méndez C, Sánchez M, Martínez-Sánchez JM. Attitudes of students of a health sciences university towards the extension of smoke-free policies at the university campuses of Barcelona (Spain). *Gac Sanit*. 2017;31(2):132–8. <https://doi.org/10.1016/j.gaceta.2016.08.009>.
29. Michie S, van Stralen M, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implement Sci*. 2011. <https://doi.org/10.1186/1748-5908-6-42>.
30. Mohmad S, Ismail A. Smoking behaviors and attitudes towards the smoke-free campus policy: a systematic review. *Malays J Public Health Med*. 2021;21(3):124–35. <https://doi.org/10.37268/mjphm/vol.21/no.3/art.1095>.
31. Montalvão MF, Sampaio LLG, Gomes HHF, Malafaia G. An insight into the cytotoxicity, genotoxicity, and mutagenicity of smoked cigarette butt leachate by using *Allium cepa* as test system. *Environ Sci Pollut Res Int*. 2019;26:2013–21. <https://doi.org/10.1007/s11356-018-3731-2>.
32. Nitschke T, et al. Smokers' behaviour and the toxicity of cigarette filters to aquatic life: a multidisciplinary study. *Microplast Nanoplast*. 2023. <https://doi.org/10.1186/s43591-022-00050-2>.
33. Olah-Kovacs B, White HJ, Tingey T, Boots B, Green DS. The impacts of smoked cigarette butt leachate on a common freshwater gastropod, *Lymnaea stagnalis*. *Environ Pollut*. 2025. <https://doi.org/10.1016/j.envpol.2025.126425>.
34. Rath JM, Rubenstein RA, Curry LE, Shank SE, Catwright JC. Cigarette litter: smokers' attitudes and behaviors. *Int J Environ Res Public Health*. 2012;9(6):2189–203. <https://doi.org/10.3390/ijerph9062189>.
35. Rebischung F, Chabot L, Biauudet H, Pandard P. Cigarette butts: a small but hazardous waste, according to European regulation. *Waste Manag*. 2018;82:9–14. <https://doi.org/10.1016/j.wasman.2018.09.038>.
36. Sagebiel J, Karok L, Grund J, Rommel J. Clean environments as a social norm: a field experiment on cigarette littering. *Environ Res Commun*. 2020. <https://doi.org/10.1088/2515-7620/abb6da>.
37. Schultz PW, et al. Littering in context: personal and environmental predictors of littering behavior. *Environ Behav*. 2013;45(1):35–59. <https://doi.org/10.1177/0013916511412179>.
38. Sibley C, Liu JH. Differentiating active and passive littering: a two-stage process model of littering behavior in public spaces. *Environ Behav*. 2003;35(3):311–453. <https://doi.org/10.1177/00139165030350030060>.
39. Suárez-Rodríguez M, García C. There is no such a thing as a free cigarette; lining nests with discarded butts brings short-term benefits, but causes toxic damage. *J Evolut Biol*. 2014;27:2719–26. <https://doi.org/10.1111/jeb.12531>.
40. Taverner Research, 2023. Butt Litter Index 2022 - Research on cigarette disposal behaviour for the NSW environment protection authority, Australia: Taverner Research. <https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/litter/butt-litter-index-2020.pdf?la=en&hash=328BEFF81F750D7468CD289E243AB3333FCF9FE>. Accessed 5 Sep 2024.
41. Vanapalli KR, et al. Cigarettes butt littering: the story of the world's most littered item from the perspective of pollution, remedial actions, and policy measures. *J Hazard Mater*. 2023;453:131387. <https://doi.org/10.1016/j.jhazmat.2023.131387>.
42. Yousefi M, et al. Challenges on the recycling of cigarette butts. *Environ Sci Pollut Res Int*. 2021;28:30452–8. <https://doi.org/10.1007/s11356-021-14058-3>.

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