Compliance of e-cigarette refill liquids with regulations on labelling, packaging and technical design characteristics in nine European member states

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ABSTRACT

Objective To evaluate electronic cigarette (e-cigarette) product compliance with European regulations (Tobacco Products Directive (TPD), Implementing Decisions), with a focus on labelling/packaging practices and technical design/safety features.

Methods Before the implementation of the TPD, in early 2016, we randomly selected e-cigarette refill liquids from the five top-selling companies in France, Poland, Germany, Netherlands, UK, Spain, Romania, Hungary and Greece. Identical products were purchased after the implementation of the TPD (early 2018) and assessment of compliance was performed on self-matched samples (n=107) using a prospective cohort design. Compliance with the Classification, Labelling and Packaging (CLP) regulations was also evaluated.

Results Following the implementation of the TPD, improvements were noted with regards to the existence of text-only warnings (32.7% pre vs 86.0% post, p<0.001), child-resistant fastenings (93.3% pre vs 100.0% post, p=0.016), tamper-proof vials (58.9% pre vs 86.9%, post p<0.001) and maximum refill volume ≤10 mL in vials (86.9% pre vs 94.4% post, p=0.008). Lower compliance was noted with regards to the inclusion of a leaflet (26.2% pre vs 53.3% post, p<0.001), refilling instructions (28.0% pre vs 51.4% post, p<0.001) and health warnings on the box, vial or leaflet (32.7% pre vs 86.0%, p<0.001). Overall, 86.0% of products had a warning label in the post-TPD phase in comparison to 32.7% of products before the implementation of the TPD (p<0.001). Compliance with the CLP regulations, also increased in the post TPD follow-up phase.

Conclusions This is the first study to evaluate the level of implementation of the e-cigarette regulations in nine EU member states. Our results indicate that refill liquids had substantial but not full compliance in most of the characteristics evaluated. Further effort is needed to ensure complete compliance.

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INTRODUCTION

Over the past decade, there has been a substantial rise in electronic cigarette (e-cigarette) experimentation and use in the European Union (EU), paralleled by a proliferation in product variations, and an expansion in their advertising and marketing.[1 2] The population impact of e-cigarettes has garnered significant interest, with considerable debate positioned around their role as a harm-reduction tool, balanced with concerns of nicotine dependence sustainment, youth initiation[3] and design feature defects which may lead to risks.[4] Design parameters of refill vials are of significant interest, especially in light of the evidence that unintentional exposure to e-cigarette refill liquids were responsible for the majority of reported incidents to poison centres among children.[4] Additionally, the variation of toxicity in several brands in the market along with the lack of regulation of their manufacture, raised several concerns with regards to e-cigarette refill production[5 6] which led to the necessity of product regulation.[7]

In the 28 EU member states (MS) e-cigarettes and their refill vials are regulated by the Tobacco Products Directive (TPD)[8] under Article 20 which was put in force in May 2016. The implementation of the TPD is mandatory for all the EU MS and aims to regulate the European internal market while protecting consumer health through regulations of the volume of the refill container, their nicotine content, the existence of child-resistant refill containers and other technical parameters to reduce the risk of spilling during refill or leaking during use. Additionally, e-cigarettes and refill containers are required through the provisions of the TPD to include text warning labels on the packaging, and to include leaflets with information on instructions for use (including diagrams) and storage, contraindications, possible adverse effects, addictiveness and toxicity, as well as a list of ingredients.[8] The TPD is supported by two Commission Implementing Decisions EU 2016/586 (2016) which sets the technical standards for the refill mechanism of e-cigarettes[9] and EU 2015/2183[10] which established a common format for the reporting requirements of e-cigarette manufacturers to regulators.[10] Moreover, the TPD stipulates that e-cigarettes are also subject to Regulation (EC) No 1272/2008 on the Classification, Labelling and Packaging (CLP) of substances and mixtures.[11] The implementation of these complex regulatory requirements has yet to be assessed, and our hypothesis is that these would impact e-cigarette refill design in the EU.

Hence, the overall aim of the current study was to evaluate compliance with e-cigarette product regulations stipulated by the EU TPD, with a focus on the labelling/packaging practices and the technical design/safety features of the most common e-cigarette refill liquids in nine EU MS, assessed before

(pre-TPD, beginning of 2016) and after the implementation of the TPD (post-TPD, beginning of 2018).

METHODS

Sample selection

Within the context of the European Commission-funded Horizon 2020 project, EUREST-PLUS, we applied a prospective cohort design with e-cigarette samples self-matched, during which the same products were evaluated pre versus post (beginning of 2016–beginning of 2018) the implementation of the EU TPD in nine EU MS. The countries selected represented the countries of the partners of the EUREST-PLUS consortium (France, Poland, Germany, Netherlands, UK, Spain, Romania, Hungary and Greece). At baseline (pre-TPD), Euromonitor Reports on sales data were used to identify the top-selling companies in each EU MS. For two EU MS (the Netherlands and Romania) the Euromonitor Report did not contain detailed data regarding the top-selling e-liquids, and hence the top-selling companies were identified based on ALEXA rankings (website traffic rankings), as a proxy of their popularity in those national markets. After identifying the five top-selling companies per EU MS, we randomly selected three products from each top-selling company (15 products from each EU MS), and hence a total of 135 samples were randomly selected for purchase in these nine EU MS. Out of the 135 products randomly selected, 122 were available for purchase at the pre-TPD phase. These same products were identified during the post TPD period, of which n=107/122 matching products were still on the market, identified and purchased. The remaining 15 products (from Spain, UK, Poland and Romania) were discontinued from production and not available for purchase in the post-TPD phase. With regards to the distribution of the 107 self-matched samples, 15 were from France, 15 from Germany, 15 from Greece, 15 from Spain, 14 from the UK, 11 from Poland, 10 from the Netherlands, 7 from Hungary and 5 from Romania. Due to the differences in follow-up across EU MS and as our hypothesis was not to assess differences between countries (which would reflect differences between companies), but to assess changes in compliance within the same products, the data were pooled.

Evaluation of parameters noted under TPD Article 20.3

All products were evaluated based on the provisions of Article 20 including: (1) their refill volume (≤10 mL); (2) the reported nicotine content on the vial (≤20 mg/mL); (3) the existence of child-resistant fastening and a tamper-proof system; (4) the inclusion of a leaflet containing information about use and storage of the product, indications that it is not appropriate for young people, not for non-smokers, a list of contraindications, warnings for specific risk groups, possible adverse effects, addictiveness and toxicity, contact details of the manufacturer or importer; (5) a list of ingredients showing in descending order by weight); (6) information on nicotine delivery per dose; and (7) existence of text only health warnings (mentioning either 'This product contains nicotine which is a highly addictive substance. It is not recommended for use by non- smokers.' or 'This product contains nicotine which is a highly addictive substance.'). Assessment of discrepancies in the measured versus reported concentrations of nicotine, as well as composition, chemical health hazards and respiratory irritants, has been previously reported.[12 13] Compliance with the ban on cross border sales was evaluated through the attempted purchase of the product via the web using an international address. Extensive details on the parameters and the methodology followed for product evaluation are provided in online supplementary table 1.

Evaluation of the refill mechanism requirements

We also assessed compliance with the Commission Implementing Decision 2016/586 that outlines the minimum refill mechanism requirements, including whether the product contained refilling instructions with diagrams and a securely attached nozzle at least 9 mm long, that is narrower than and slots comfortably into the opening of the tank (online supplementary table 2). We also evaluated additional criteria such as indication to wear gloves, actions to be taken in an emergency and whether the product had leaked during shipping.

Evaluation of hazard warnings and compliance with the CLP regulations

Compliance with the CLP rules were evaluated for all products.[11] Evaluation was conducted initially on the vial and continued on the external package and leaflet, if included. Furthermore, the existence of hazard warnings was assessed on the whole product as received, on the vial of the e-liquid, the box and the leaflet, if available. Individual checkpoints included the existence of a hazard sign, hazard information, hazard text and the use of a hazard tactile warning for the vial and the outer package (online supplementary table 3).

Statistical analysis

Continuous variables were expressed as mean values (SD) or as median values. Categorical variables are expressed as absolute and relative frequencies. For the comparison of pre and post proportions McNemar tests for paired data were used. Wilcoxon test was used for paired comparison of continuous variables among pre and post measurements. All reported p values are two-tailed. Statistical significance was set at $p<0.05$, and analyses were conducted using SPSS statistical software V.22.0.

RESULTS

Evaluation of the technical features and refill mechanism requirements

Following implementation of the TPD, compliance with refill volume (≤10 mL in vials) increased from 86.9% to 94.4%, p=0.008, as did the existence of a child-resistant fastening (93.3% vs 100.0%, p=0.016) and the existence of a tamper-proof sheath (58.9% vs 86.9%, p<0.001). Compliance with maximum nicotine concentration levels post TPD was also noted (100.0%), while the percentage of products reporting nicotine delivery per dose increased from 0.9% to 43.9%, p<0.001.

The percentage of products including a leaflet in the packaging also increased (26.2% vs 53.3%, p<0.001), as did the types of information that should be included on the leaflet. The categories of information with the largest increase were: instructions regarding use and storage, recommendation that the product is not for non-smokers, warnings for specific risk groups, possible adverse effects and information on addictiveness and toxicity.

Finally, the inclusion of refilling instructions and/or with diagrams also increased during the post TPD period (28.0% vs 51.4%, p<0.001) while the ability to purchase the products via a cross-border sale reduced from 42.1% vs 14.0% (p<0.001). Additional criteria were also assessed, such as the existence of leakage during shipping and handling (3.7% of products had an evident leak during the post TPD period), actions to be taken in an emergency (90.7% post TPD) and

Table 1 Compliance of e-cigarette refill liquids with the EU TPD, in nine EU member states

	Pre-TPD		Post-TPD		
TPD parameters	**N**	**%**	**N**	**%**	**P values***
Refill volume ≤10 mL in vials	93	86.9	101	94.4	**0.008**
Nicotine content ≤20 mg/mL	102	95.3	107	100.0	0.063
Child-proof	98	93.3	107	100.0	**0.016**
Tamper-proof ring	63	58.9	93	86.9	**<0.001**
Tamper-proof plastic wrap (sheath)	43	40.2	24	22.4	**<0.001**
Recommendation to keep out of reach of children	104	97.2	88	82.2	**0.001**
Inclusion of a leaflet that includes references for†	28	26.2	58	54.2	**<0.001**
Instructions on use and storage	28	26.2	58	54.2	**<0.001**
Not recommended for young people	14	15.7	40	37.4	**0.002**
Not recommended for non-smokers	11	10.3	45	42.1	**<0.001**
Contraindications	28	26.2	55	51.4	**<0.001**
Warnings for specific risk groups	28	26.2	58	54.2	**<0.001**
Possible adverse effects	25	23.4	55	51.4	**<0.001**
Information on addictiveness and toxicity	23	21.5	55	51.4	**<0.001**
Contact details of the manufacturer or importer	28	26.2	55	51.4	**<0.001**
List of ingredients	107	100.0	107	100.0	1.000
Nicotine content	104	97.2	104	97.2	1.000
Nicotine delivery per dose	1	0.9	47	43.9	**<0.001**
Batch number	91	85.0	94	87.9	0.549
Information regarding ingredients:					
Yes, any	71	66.4	101	94.4	**<0.001**
Yes, detailed	29	27.1	6	5.6	
No	7	6.5	0	0.0	
Text only health warnings on vial, box or leaflet	35	32.7	92	86.0	**<0.001**
Text health warnings on the box	3	2.8	77	72.0	**<0.001**
Text health warnings on the vial	21	19.6	35	32.7	**0.022**
Text health warnings on the leaflet	14	13.1	45	42.1	**<0.001**
Cross-border distance sale was possible	45	42.1	15	14.0	**<0.001**

Bold values are statistically significant (p<0.05)
*McNemar test.
†Calculated among those products that did have a leaflet.
EU, European Union; TPD, Tobacco Products Directive.

also the indication to wear gloves, which reduced after TPD implementation (from 36.4% to 22.4%, p<0.009).

Moreover, the percentage of products with health warnings on the vial, box or leaflet increased significantly from pre to post TPD. The existence of the text only health warning labels on the box increased from 2.8% to 72.0% (p<0.001), on the vials from 19.6% to 32.7% (p=0.022) and on the leaflet from 13.1% to 42.1% (p<0.001). Overall, 86.0% of products had some form of warning label in the post TPD phase in comparison to 32.7% of products before the implementation of the TPD (p<0.001). Table 1 depicts the findings for the technical features and refill mechanism requirements before and after TPD implementation.

Evaluation of the technical design requirements

Table 2 presents the compliance with EU technical design requirements (COM2016/586) before and after TPD implementation. In the post TPD phase there was high compliance for the minimum nozzle length of 9 mm (81.3%), as well as with the requirement that the e-cigarette refill liquid should need pressure to flow when placed upside down (87.9%). Moreover, the percentage of products with a thin nozzle increased during the post TPD evaluation period from 81.3% to 94.4% (p<0.001) while a product user guide was included in a significantly higher percentage of products during the post TPD period (31.8% vs 84.1%, p<0.001), as was the existence of refilling instructions (28.0% vs 51.4%, p<0.001).

Evaluation of hazard warnings and compliance with the CLP regulations

In addition to compliance to the TPD Article 20, and the Commission Implementing Decision 2016/586, the samples were also evaluated for their compliance with the overall European CLP parameters as noted in table 3.

The existence of hazard warnings on the vial, leaflet and box overall increased after TPD implementation, with the most common area for the placement of CLP hazard warnings being the refill liquid vial, followed by the box and then the leaflet. Overall, the percentage of products with tactile warnings on the vial increased significantly (86.9% vs 93.5%, p=0.016) as did the existence of any hazard information on the product leaflet (22.4% vs 32.7%, p=0.003). The most notable changes were identified on the product external packaging (box) as the existence of any hazard information from 51.4% to 72.0% (p<0.001), hazard pictograms increased from 51.4% to 68.2% (p=0.001) and hazard statements similarly from 51.4% to 72.0% (p<0.001) of the sampled e-liquids in the post TPD period.

Table 2 Compliance of the e-liquid samples with the EU technical requirements (COM2016/586) before and after TPD implementation in nine EU member states

	Pre-TPD		Post-TPD		
	N	%	N	%	P valuest
Refill mechanism requirements					
Securely attached nozzle at least 9 mm long	84	78.5	87	81.3	0.700
The nozzle is narrower than and slots comfortably into the opening of the tank	84	78.5	87	81.3	0.700
Thin nozzle	87	81.3	101	94.4	**<0.001**
Nozzle outer diameter (mm), mean (SD)	2.30 (0.69)	2 (2–3)	2.43 (0.50)	2.2 (2–3)	0.364*
Nozzle length (mm), mean (SD) median	9.43 (3.23)	10 (9–10)	10.19 (1.12)	10 (10–10)	0.069*
Refilling instructions, including diagrams	30	28.0	55	51.4	**<0.001**
User guide included (yes)	34	31.8	90	84.1	**<0.001**
Needs pressure to flow	96	89.7	94	87.9	0.500
Additional criteria					
Indication to wear gloves (yes)	39	36.4	24	22.4	**0.009**
Actions to be taken in an emergency (yes)	92	86.0	97	90.7	0.359
Leaked during shipping	7	6.5	4	3.7	0.549

Bold values are statistically significant (p<0.05)
*Wilcoxon test.
† McNemar test
EU, European Union; TPD, Tobacco Products Directive.

DISCUSSION

We evaluated the labelling/packaging practices and the technical design/safety features of e-cigarette refill vials in nine EU MS before and after the implementation the TPD. We identified that for the technical parameters evaluated, products had substantial, but not full, compliance with most of the characteristics evaluated. Some of the most significant improvements were recorded in child-resistant packaging, tamper-proof vials, the inclusion of a leaflet and the inclusion of the text only health warnings, however, additional improvement in implementation still remains.

Table 3 Additional compliance with the e-liquid samples to the European CLP parameters* before and after the TPD implementation in nine EU member states

	Pre		Post		
	N	%	N	%	P valuest
Name, address and telephone number of the supplier(s)	93	86.9	97	90.7	0.125
The nominal quantity of the substance or mixture in the package	103	96.3	107	100.0	0.125
Product identifiers	90	84.1	100	93.5	**0.021**
Hazard pictograms	72	67.3	90	84.1	**0.001**
The relevant signal word usually accompanying the hazard pictogram	56	52.3	57	53.3	1.000
Hazard statements	89	84.0	92	86.0	0.754
Hazard warnings on the vial					
Any hazard pictogram, statements or text	90	84.1	94	87.9	0.503
Hazard pictogram	90	84.1	91	85.0	1.000
Hazard statements	90	84.1	94	87.9	0.503
Hazard text	46	43.0	48	44.9	0.815
Tactile warning	93	86.9	100	93.5	**0.016**
Hazard warnings on the leaflet					
Any hazard pictogram, statements or text	24	22.4	35	32.7	**0.003**
Hazard pictogram	24	22.4	24	22.4	1.000
Hazard statements	24	22.4	35	32.7	**0.003**
Hazard text	21	19.6	20	18.7	1.000
Hazard warnings on the box					
Any hazard pictogram, statements or text	55	51.4	77	72.0	**<0.001**
Hazard pictogram	55	51.4	73	68.2	**0.001**
Hazard statements	55	51.4	77	72.0	**<0.001**
Hazard text	27	25.2	37	34.6	**0.031**
Tactile warning	14	13.1	24	22.4	0.112

*In addition to the parameters already included in the TPD, such as child-resistant fastenings, etc.
†McNemar test.
CLP, Classification, Labelling and Packaging; EU, European Union; TPD, Tobacco Products Directive.

Although 86% of products included the required warnings, this was mostly found on the box (outside packaging) and less frequently for the actual refill vial (less than one in three refill vials). This may have implications for consumer awareness, as the external packaging may be discarded after purchase, thus it may be warranted for mandatory inclusion of the warnings on the actual refill vial as the vial is accessed frequently by the consumer whenever the product is refilled. Our results are corroborated by cross-sectional population-data reported by cigarette smokers who also use e-cigarettes from six EU MS from which we obtained samples in the current study indicating that prior to implementation of the TPD, the majority of e-cigarette users had not noticed or read the health warnings on e-cigarette outside packaging or pamphlet inserts.[14] It would be important to monitor the impact of health warning parameters after the TPD implementation, now that the health warnings and leaflets are required.[8] This is of paramount importance as health warnings on tobacco products are among the most direct and prominent means of communicating with tobacco product users, whereas health warnings on the product are considered as a source of health information for smokers and non-smokers that can increase health knowledge and perceptions of risk and promote smoking cessation.[15 16]

Informational leaflets are also a potential prominent source of conveying information to consumers. Our analysis indicated that although there was an increase in the percentage of e-cigarette refills containing a leaflet, only half of our samples were compliant with this requirement, among which only half of those leaflets actually included information on instructions for use and storage, instructions for young people, instructions for non-smokers, contraindications, warnings for specific risk groups, possible adverse effects and addictiveness and toxicity. As the design of a leaflet as well as the information included have been found to be effective in providing information to patients and in facilitating informed decision making and to use the product appropriately, the inclusion of leaflets in e-cigarette refill packaging may also have a similar impact—an area in which there is still limited compliance by the industry.[17]

Our study also revealed already high implementation of child-proof resistant caps of refill liquids before the TPD, but even higher compliance after the TPD implementation. Cross sectional research has also showed that e-liquid caps were easy for a child to open.[18–22] Compliance with the design parameters set form TPD as well as with the technical requirements (COM2016/586) such as secure and thin nozzle and leakage of the products, are of paramount importance for populations health. European data have shown that unintentional exposure, was the most frequently cited incident in EU poison centres of which, e-cigarette refill vials were responsible for the majority of the reported incidents. Two-thirds of the incidents occurred as ingestion and more frequently among children.[4] The report of the European Commission to the European parliament had indicated risk of poisoning as a primary risk—a risk which now is mitigated.[6]

We also conducted a detailed compliance evaluation on the e-liquids based on the CLP regulation. Although there was already a good level of implementation during the pre TPD phase, several improvements were also recorded during the post TPD phase, mainly related to the existence of product identifiers, hazard pictograms and obligatory and non-obligatory information and other factors which were statistically significant, primarily the existence of hazard warning labels, pictograms and statements on the external packaging of the refill liquids. We must note that we recorded a high compliance with the tactile existence mostly on the vial or the box both before and after the implementation of TPD, in contrary with a previous study where the level of the products' compliance with tactile warnings was low.[23]

Furthermore, while cross border distance sales are not permitted by the TPD[8] there were still some products that were able to be purchased and shipped to a cross-border address during the post TPD evaluation. This finding raises attention to the need for regulatory action on cross-border e-liquid purchasing, with continued and future monitoring to ensure full compliance.

To our understanding this study is the first comprehensive evaluation of e-cigarette manufacturers compliance with the TPD. Moreover, our prospective study design and follow-up allowed us to be able to assess the same products available before and after the implementation of the TPD so as to identify whether the products' design had evolved in order to be compliant with the Directive. However, while we focused on the random selection of top-selling brands so as to reflect those products that would have the largest population-based impact, it is possible that compliance may not be identical among products with a smaller market shares which is an area for future research. Indeed, as manufacturers and importers of e-cigarettes are mandated to submit a notification within the EU Common Entry Gate (EU-CEG) when a product is intended to be placed on the market and when a modification is made, such notifications could be used for product monitoring across the entire EU, an approach which may be warranted (European Commission, implementing decision). Furthermore, due to the small sample size of the samples per country and the fact that most companies on the EU market sell their products across different EU countries we were not able to assess between country differences as they may reflect cross company results. This is an area in which routine monitoring must be established at the national level. Furthermore, the results of our study are based on products purchased from nine EU MS, which may not be entirely generalisable to the EU market, however they provide a first insight on product compliance to EU regulations across a number of EU markets. Moreover, while the EU legislation is likely to be the leading factor driving product change in design and packaging,

What this paper adds

- E-cigarettes are regulated in the European Union (EU) by the Tobacco Products Directive (TPD) with the goal to protect consumer health through the harmonisation of policies across nation states that address safety and quality.
- Design parameters of refill vials are an important risk mitigation measure as evidence from several European countries showed that unintentional exposure to e-cigarette refill liquids was responsible for the majority of reported incidents to poison centres.
- Through this manuscript, we evaluated for the first time, the compliance of the most commonly used e-cigarette refill products in nine European countries with the regulations of the EU TPD before and after its implementation.
- Child-resistant packaging, the existence of text only health warnings, the product's nicotine content and volume were in compliance with TPD regulations, with minor exceptions.
- Although there was a general increase in the adoption of all other parameters outlined there is still room for full implementation through compliance improvements.

further research is needed to investigate the possibility of other external causes (ie, market research) which may contributed in changing the behaviour of manufacturers.

Overall, our findings provide evidence on the level of compliance and parameters that need full implementation, in preparation for the European Commission 2021 report on the impact of the application of the TPD within which new, supplementary or improved European legislation may be proposed. Our research indicated that in general compliance with specific parameters outlined in the TPD, such as child-resistant packaging, the product's nicotine content and volume were implemented. The existence of text only health warnings was suboptimal while their placement was either on the vial, box or leaflet—an aspect in need of regulatory clarification with regards to the warning labels positioning. On the contrary, although there was a general increase in the adoption of all other design parameters outlined in the TPD, its accompanying implementing acts and CLP regulations, implementation was sub-optimal and as such there is still room for improvements in e-cigarette product compliance so as to protect consumer health and safety in the EU.

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