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The Extent of Illicit Tobacco Trade in Low and Middle-Income Countries (LMICs) - a Systematic Review and Meta-Analysis

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Abstract

Introduction

Little is known about the extent of the illicit tobacco trade in low- and middle-income countries (LMICs) where more than 80% of tobacco users now live. We systematically reviewed literature from LMICs to investigate the share of illicit tobacco and the methods studies applied.

Methods

We searched nine electronic databases, three websites, and grey literature published in English from January, 2012 to July, 2023. Studies assessing the extent of illicit tobacco trade within LMICs were included. Two independent reviewers screened titles, abstracts, and full-text manuscripts' and extracted the data from those eligible. Studies were critically appraised using a bespoke framework. We conducted meta-analysis of the share of illicit tobacco and pooled the results with random effects. Analysis was stratified by type of tobacco and funding source. Based on the estimation methods for illicit tobacco, sub-group analysis was conducted. The review was registered in PROSPERO (CRD42023450354).

Results

Among 48 eligible studies from 39 LMICs, 41 disclosed independent (non-industry) funding sources. Only two studies estimated the share of illicit smokeless tobacco. Studies used three estimation methods: i) pack analysis (n=33), ii) gap analysis (n=13), and iii) trade monitoring

(n=2). The pooled share of illicit smoking and smokeless tobacco was 14.4% (95%CI: 10.5-18.9) and 86.9% (95%CI: 51.1-100.0) respectively.

Conclusions

Approximately one in every seven cigarette packs is likely to be illicit in LMICs. The share of illicit smokeless tobacco may be a lot higher, but the estimates were uncertain due to very few studies.

Implications

Since the inception of WHO FCTC Illicit Tobacco Trade Protocol (ITP) in 2012 this review is the first attempt to systematically investigate the share of illicit tobacco in LMICs. We found that the evidence is lacking in many LMICs, even among ITP signatories. The share of illicit smokeless tobacco is considerably higher than the smoking tobacco. Given that there is no fiscal marking (e.g. tax stamp) on the packs, studies in LMICs mainly relied on packaging compliance to detect illicit tobacco products. The findings highlight the lack of evidence in LMICs and the importance of robust estimation of the share of illicit tobacco where the evidence is lacking.

Introduction

Over one in five adults worldwide are tobacco users. Among the 1.3 billion users, more than 80% live in low and middle-income countries (LMICs).¹ Consequently, a high burden of tobacco-related deaths and disabilities is borne in these countries.^{2,3} The illicit tobacco trade evades taxes and keeps these products cheap and accessible, which in turn increases their uptake, especially among youth.⁴ Moreover, the illicit tobacco trade undercuts government revenue and threatens security.⁴

Illicit tobacco trade is a global problem. Since the inception of World Health Organization (WHO) Illicit Tobacco Trade Protocol (ITP) in 2012,⁵ 87 countries have either signed and/or ratified the protocol. According to the protocol, illicit tobacco trade is defined as “*any practice or conduct prohibited by law and which relates to production, shipment, receipt, possession, distribution, sale or purchase including any practice or conduct intended to facilitate such activity*”.⁵ Researchers have observed a shift in illicit tobacco trade patterns; previously, only well-known cigarette brands were smuggled in, but now illegal manufacturing of cigarettes, including counterfeiting, has emerged.⁶ The cumulative revenue loss of Belgium, Bulgaria, Czech Republic, Ecuador, Estonia, Hungary, India, Indonesia, Malaysia, Philippines, Romania, UK and Vietnam owing to illicit trade was three times more than the budget of WHO during 2010–11.⁷ For Indonesia, this loss during 2011–2013 was 4% to 13% of total tobacco excise revenue.⁸ Minimising illicit tobacco trade could generate substantial government revenue and lower tobacco use.^{2,9} Over 3.49 billion illicit cigarettes were seized globally in 2019.¹⁰ The market share of illicit cigarettes was shown to be higher in LMICs than the overall share in high-income countries (HICs) in two previous studies (12.1% vs. 9.8% and 12.3% vs. 10.4%).^{2,9} However, these estimates did not include all forms

of tobacco and did not distinguish between the methods and funding sources of the included studies. These studies were not designed as systematic reviews and hence, the quality of estimates was not assessed. Furthermore, due to the dynamic and contextual nature of the illicit tobacco trade, their estimates need updating regularly.

WHO Framework Convention on Tobacco Control (WHO FCTC) aimed to standardise global tobacco control policies, offers several comprehensive interventions across all governance levels.¹¹ Nevertheless, tobacco control regulation and enforcement differ significantly between LMICs and HICs, with policy stagnancy in most LMICs.¹² The differences are generally based on varying taxation levels, differing comprehensiveness of advertising bans and packaging laws, and varying degrees of industry influence.^{11–13} The governance, border control, licensing procedure and other policy enforcement measures may be a little weaker in LMICs than HICs. Moreover, the illicit tobacco trade undermines effective tobacco control in LMICs, undermining regulation efforts even more than HICs.¹⁴

Research in illicit tobacco trade is skewed to the HICs, while the overall share of illicit tobacco is larger for LMICs.^{2,9} We performed a scoping search and found to date no systematic review on illicit tobacco trade in LMICs. Thus, we systematically reviewed the literature on illicit tobacco in the context of LMICs to explore the prevalence of illicit tobacco and the various methods used in the studies to estimate its extent. We specified the review questions using PerSPECTiF [Perspective (Per), Setting (S), Phenomena (P), Environment (E), Comparator (C), Timing (Ti), and Findings (F)] framework (Supplementary File: Table S1, pp24).¹⁵ The review questions were: What is the share of

illicit tobacco sales and/or consumption in LMICs? And what methods were used by the studies in LMICs to estimate the share of illicit tobacco?

Methods

Search strategy and selection criteria

This systematic review is registered in PROSPERO (CRD42023450354)¹⁶ and it was conducted following PRISMA guidelines.¹⁷ Using a comprehensive search strategy (developed with inputs from the information specialist in the Department of Health Sciences, University of York, UK), we performed the search with a blend of free text and Medical Subject Heading (MeSH) phrases related to the areas of smoking or smokeless tobacco and illicit trade (Supplementary File: Appendix S1, pp 2-20). The main keywords included “illicit”, “smoking tobacco”, “smokeless tobacco”, “sales”, “consumption”, “tax evasion”, “counterfeit”, “smuggle”, “bootleg”, and “packaging compliance”. We searched nine electronic databases (MEDLINE, CINAHL, EMBASE, EconLit, PSYCInfo, Scopus, Web of Science, PubMed, and Cochrane Library), and the websites and registers of three organisations: [Tobacconomics \(University of Illinois at Chicago, US\)](#), [Research Unit on the Economics of Excisable Products \(REEP\) \(University of Cape Town, South Africa\)](#), and [WHO FCTC Knowledge Hub on Tobacco Taxation](#). We accessed the reference lists of eligible papers and performed a guided search in Google Scholar (the first 50 search results were considered) to assess the eligible studies published elsewhere. ProQuest Dissertations & Theses and DART-Europe E-theses Portal were searched for grey literature. The search was conducted in July 2023.

We included studies conducted in LMICs and published between January, 2012 and July, 2023. The search timeline coincided with the enactment of ITP in 2012.⁵ We used the World

Bank's income classification in 2022-23 for country selection (Supplementary File: Table S2, pp 24).¹⁸ Studies published in languages other than English were excluded.

There were two separate stages for study screening: titles and abstract, and full-text screening. Two independent reviewers (SMA and ZS) conducted the screening using a screening form (Supplementary File: Appendix S2 and S3, pp 21) based on the inclusion/exclusion criteria (Supplementary File: Table S3, pp 25). Discrepancies were resolved through discussion and with the intervention of the third reviewer (SK). We conducted the de-duplication of records in EndNote 20.¹⁹ Ineligible studies were removed by manual searching. As a review management tool for screening and data extraction, we used Covidence.²⁰

Data extraction and quality assessment

We adapted the Cochrane Effective Practice and Organization Care (EPOC, 2017)²¹ data extraction tool. It provides an extraction framework suitable for interventional and observational studies with heterogeneous design. EPOC is modified for studies assessing the effect of policy and public health interventions, making it suitable for illicit tobacco, which encompasses fiscal, regulatory, and enforcement measures. Before its implementation, we piloted the data extraction form using five included studies (Supplementary File: Appendix S4, pp 22). Subsequently, we modified the form to include a column for data sources. Besides the estimates, the form included columns for the methods used for measuring illicit tobacco trade, including study design, place and time, sample size, data collection and the methods for analysis, and funding sources. A list of potential outcome domains for different data items and their probable effect measure is given in the supplementary file (Table S4, pp 26). Illicit

tobacco research can include multi-country estimates within a single study, as well as multiple estimates for individual countries. For the meta-analysis, we utilised the country-specific estimates of illicit tobacco. Since studies may report estimates using various methods, all estimates were documented and synthesised into different sub-groups based on the estimation methods. Two reviewers (SMA and ZS) extracted the data independently. For validity and consistency, we cross-matched the following domains: study design, study sample, method(s) of measurement, outcome(s) measured, and findings. Disputes were settled through discussion and with the involvement of a third reviewer (SK).

We assessed the quality of illicit tobacco trade estimates using a novel tool. Ross (2015) suggested a domain-based approach and proposed 20 characteristics for assessing the quality of estimates related to tobacco tax evasion and hence, illicit tobacco.²² We used this approach and combined it with the scale in Crombie's Item (I)²³ ["yes" (score = 1) - meets the characteristics, "no" (score = 0) do not meet the characteristics, "unclear" (score = 0.5), and "not applicable" (no score assigned)]. For consistency and validation, two reviewers (SMA and ZS) appraised independently, involving a third reviewer (SK) for dispute settlement. The critical appraisal form (Supplementary File: Appendix S5, pp 23) mapped characteristics of studies over the seven domains: peer-reviewed, funding, replicability and theory relevance, generalizability and criteria selection, definition and identification of illicit products, result and cross-validation of illicit estimate, and limitation acknowledgment. The proportion of characteristics in each domain was considered as weight. Score for each domain is calculated by multiplying the domain-specific weight with the number of characteristics included in that domain. We calculated the total score for a study by summing up the individual score over the seven domains (Supplementary File: Appendix S5, pp 23). After standardising the score to a scale of ten, the maximum score a study could obtain was 36, with a lowest of zero.

Studies were categorised in terms of risk to the quality of estimates as, i) Low risk (≥ 22), ii) Moderate risk (between 22-11), and iii) Serious risk (≤ 11). Thus, studies meeting less than 30% of the criteria were deemed methodologically weak, rendering their estimates unreliable.²⁴⁻²⁶ We also used the Cochrane Risk of Bias Assessment Tool: for Non-Randomized Studies of Interventions (ROBINS - I) for the visual presentation of the quality assessment.²⁷

Data analysis

We conducted a quantitative synthesis and meta-analysis of the illicit tobacco estimates with 95% confidence intervals (CI) and pooled the results with random effects. Share of illicit tobacco is expected to vary across the type of tobacco, and method for estimation. It can be diverse because of non-comparable proportional data in different studies. Moreover, the observational studies (smokers survey, retailers survey, and pack analysis) can have large sample sizes, generating tighter CI for the share of illicit tobacco. All these could inflate I^2 value in the meta-analysis of studies with the share of illicit tobacco. Accordingly, to minimise the effect of heterogeneity and to make informative inferences from meta-analysis, we applied the random effects model and estimated 95% prediction intervals (PI). Unlike the fixed effects model, the random effects model uses more balanced weighting regardless of study size and allows the effect size to vary across studies, thereby incorporating between-study variance to provide a more realistic estimate of the share of illicit. To explore heterogeneity, we performed subgroup analysis based on the method of estimation. We stratified the analysis by type of tobacco (smoking or smokeless) and funding source of the studies (independently funded or industry funded/undisclosed) for sensitivity. The overall pooled estimate and the estimate of the share of illicit tobacco for each sub-group were presented using the forest plot. The potential publication bias was assessed visually using the

funnel plot. We tested the significance of funnel asymmetry by Egger test and Begg test.^{28,29} All statistical analysis was carried out using STATA V.18.³⁰

Results

Selection process and characteristics of included studies

We identified 1,592 studies (1,436 from database searches and 156 from the websites and grey literature). After the removal of duplicates (771), we considered 821 studies for title and abstract screening. We excluded 728 studies at this stage for being ineligible. Of the remaining 93, full-texts were retrieved and 48 studies were found eligible for the review and meta-analysis (Figure 1). Of these 48 studies, six were reports,^{31–36} and 42 were journal articles (Supplementary File: Table S5, pp 27).^{8,37–77} There were seven multi-country studies (five articles^{37,59,64,69,70} and two reports^{35,36}). Seven studies^{33–36,51,62,63} were either funded by the tobacco industry (three studies)^{34–36} or the funding information was undisclosed by the authors (four studies);^{33,51,62,63} the rest were funded independently.

Figure 1: PRISMA flow diagram and study selection

Alt Text: Figure 1. Presents the study selection process using PRISMA flow diagram. A total of 1,592 studies were identified through database and website searches. After title and abstract screening, 93 studies were selected for full-text review. Eligibility check excluded 45 studies, and thus, 48 studies were included in the review and meta-analysis.

The included studies were conducted in 39 countries (Supplementary File: Figure S1, pp 40): 28 in Asia (Bangladesh,^{64,69} Cambodia,³⁵ China,⁶⁴ Georgia,^{52,53} India,^{60,65,69,70}, Indonesia,^{8,32,35,57} Iran,^{62,63} Jordan,³⁶ Lebanon,³⁶ Malaysia,^{35,55,64,68} Mauritius,⁶⁴ Mongolia,⁴⁵ Myanmar,³⁵ Nepal,⁴⁴ Pakistan,^{35,56,69} Philippines,^{35,54,77} Srilanka,³³ Thailand,^{35,47,64} Turkey,⁵⁸

and Vietnam^{48,49,73,74}), eight in Africa (Egypt,³⁶ Ethiopia,⁶⁶ Gambia,⁶⁷ Ghana,⁴³ Sierra Leone,⁷⁶ and South Africa^{38,39,71}), three in Europe (Albania,^{37,59} Bosnia and Herzegovina,³⁷ Bulgaria,⁵⁹ Montenegro,^{31,37} North Macedonia,³⁷ Romania,⁵⁹ Serbia,³⁷ and Kosovo³⁷), ten in Latin America (Argentina,⁴⁶ Brazil,^{40-42,51,61} Colombia,^{50,75} and Mexico^{64,72}), and one in Oceania (Papua New Guinea³⁴).

Only one study focused solely on smokeless tobacco⁶⁹ and one on both smoking and smokeless tobacco;⁷⁰ the rest estimated cigarette illicit trade. Welding and colleagues considered bidi (cheap smoking tobacco) besides cigarettes for India.⁷⁰ Study from Papua New Guinea discussed Brus (smoking tobacco made from traditionally dried raw tobacco leaf) along with cigarettes.³⁴ Hand-rolled tobacco besides manufactured cigarettes was studied by Vladisavljevic and colleagues in Western Balkan Countries (Albania, Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia, and Serbia).³⁷

Methods applied to estimate the share of illicit tobacco

Three methods were used to estimate the share of illicit tobacco: i) pack analysis (33 studies)^{31-34,37-41,43-46,48-53,56,58-64,66,67,69,70,72,75} -analysing the tobacco pack features collected from different sources e.g. smokers, retailers, littered and waste recycle stores, ii) gap analysis (13 studies)^{8,35,36,42,54,55,57,65,68,71,73,74,76} -comparing the legal tax paid sales with estimated total consumption, and iii) trade monitoring (two studies)^{47,77} -comparing the bilateral exports and imports of the country.²²

Table S6 (Supplementary File: pp 29-37) lists the studies with independent funding. Of these 40 studies, 27 used pack analysis. Twenty-one studies^{31,32,37-41,48-50,52,53,56,58,59,61,64,66,67,72,75} surveyed smokers and either asked them to show their last purchased cigarette pack and directly recorded their packaging features or recorded the smokers-reported packaging features. Four studies^{43,44,60,70} collected empty cigarette packs from retailers or purchased packs from point-of-sale vendors while nine others^{31,40,44-46,56,60,66,72} collected discarded cigarette packs from sources such as street litter, waste recycle bins, household solid waste, and waste recycle stores. Seven studies^{31,40,44,56,60,66,72} analysed pack information using packs from multiple sources (collected pack information (empty packs) from smokers or retailers and packs from discarded sources). Eleven studies^{31,40,43-46,56,60,66,70,72} collected cigarette packs and examined their features while fifteen^{31,32,37,40,48-50,52,53,56,58,59,64,67,75} observed or photographed the last purchased packs from the smokers. Self-reported packaging information from smokers was analysed in twelve studies.^{37-41,50,59,61,64,67,72,75}

Twenty-two studies used pack compliance related to the health warning (graphical and textual – size, content, colour, and design) legitimacy, brand legitimacy, country of origin, price disclosure, under age or country of sale disclosure or duty-free sign as a hallmark of illicit. Fourteen studies scrutinised tax stamp or excise sticker compliance to detect illicit.^{31,32,37,43-46,48,49,52,53,58,59,64} Ten studies used price threshold^{37-41,50,59,61,67,75} approach and four used place of purchase^{31,37,49,59} to detect the illicit products. We found only two studies estimating the share of illicit smokeless tobacco.^{69,70} Both of them were independently funded, applied pack analysis (collected packs from retailers) method and used packaging compliance to categorise the product as illicit.

Among the seven tobacco industry-funded (or undisclosed funding information) studies (Supplementary File: Table S7, pp 38-39), five applied pack analysis method;^{33,34,51,62,63} two^{33,51} collected packs (from littered sources) and examined their features while another two^{62,63} observed the packs (available with smokers) and one study³⁴ did not discuss the method adequately. Three studies^{51,62,63} used packaging compliance to identify illicit packs while none of them scrutinised the tax stamp legitimacy or used price threshold for the purpose.

Among the eleven independently funded smoking tobacco studies that used gap analysis to estimate the share of illicit,^{8,42,54,55,57,65,68,71,73,74,76} eight^{8,42,57,65,68,71,73,74} compared the legal cigarette sales and the estimated total cigarette consumption. Lavares and colleagues used the gap between annual total estimated cigarette consumption and annual legal consumption for Philippines to estimate the share of illicit tobacco.⁵⁴ For Sierra Leone, Gallien and Occhiali used gap between annual total consumption and total legal import.⁷⁶ Koya and colleagues in Malaysia applied gap between actual excise tax payment and due tax payment estimated with total consumption.⁵⁵ All gap analysis studies utilised routine data to gather information on smoking prevalence, smoking intensity, tobacco tax revenue and consumption, sales, population and cigarette trade. There were only two industry-funded studies that applied gap analysis.^{35,36} They used domestic sales and consumption data to estimate the gap and measure the extent of illicit tobacco. However, the method and assumptions were not adequately described.

We found trade monitoring as the least applied method for estimating the illicit tobacco share. Abola and colleagues in Philippines and Pavananunt in Thailand applied this

method.^{47,77} Trade discrepancy was measured using the gap between the reported import and export of tobacco. Both studies were independently funded.

Estimate of the share of illicit tobacco – Meta-analysis

Figure 2 shows the forest plot for independently funded studies. The pooled estimate for the share of illicit smoking tobacco was 14.4% (95%CI: 10.5-18.9). Due to diverse methods of estimation, noticeable heterogeneity was present (Overall $I^2=99.8$). Accordingly, we conducted sub-group analysis and found the pooled estimates with pack analysis studies (29 countries) as 14.0% (95%CI: 10.0-18.6; 95%PI: 0.0-50.0), with gap analysis (eight countries) as 21.1% (95%CI: 11.0-32.8; 95%PI: 0.0-60.0) and with trade monitoring method (two countries) as 9.6% (95%CI: 0.0-49.6; PI could not be estimated for the insufficient number of studies).

Figure 2: Random effects model showing the proportion of illicit smoking tobacco in LMICs with independently funded studies

Alt Text: Figure 2. Forest plot showing the proportion of illicit smoking tobacco in LMICs as 14.4% with independently funded studies. The proportion is 14.0% with a sub-group of studies using the pack analysis method. The estimate was 21.1% and 9.6%, respectively for the sub-groups with gap analysis and trade monitoring methods.

For sensitivity, we conducted the meta-analysis for smokeless tobacco (Figure 3) and undisclosed or industry-funded studies (Supplementary File: Figure S2, pp 41) separately. The pooled estimate of the share of illicit smokeless tobacco was 86.9% (95%CI: 51.1-100.0; 95%PI: 0.0-100.0). We estimated the pooled estimate for smoking tobacco in undisclosed or

industry-funded studies as 13.9% (95%CI: 9.0-19.5; 95%PI: 0.0-40.0). It was 15.6% (95%CI: 9.1-23.4; 95%PI: 0.0-60.0) with the studies applying pack analysis and 14.7% (95%CI: 4.8-27.8; 95%PI: 0.0-70.0) with those applying gap analysis (Supplementary File: Figure S2, pp 41). The insignificance of small study effects in the meta-analysis was confirmed by Egger test [Independently funded studies: $z=1.45$ ($p=0.146$); Undisclosed or Industry-funded studies: $z=1.16$ ($p=0.245$)] and Begg's test [Independently funded studies: $z=1.41$ ($p=0.159$); Undisclosed or Industry-funded studies: $z=0.45$ ($p=0.651$)]. Funnel plots confirming these are given in (Supplementary File: Figure S3, pp 41).

Figure 3: Random effects model showing the proportion of illicit smokeless tobacco in LMICs with independently funded studies

Alt Text: Figure 3. Forest plot showing the proportion of illicit smokeless tobacco in LMICs as 86.9% with independently funded studies. The meta-analysis included evidence from three South Asian countries (Bangladesh, India and Pakistan), and all of them applied the pack analysis method.

Risk of bias and quality of estimates

After assessing the estimates of illicit tobacco for the risk of bias, the average score was 18.2, with a maximum of 30.25 and a minimum of 8.0 (Supplementary File: Table S6 and S7, pp 29-39). Estimate of the share of illicit tobacco in 29 studies (60.0%; average score 17.74) had moderate, 11 studies (23.0%; average score 25.1) had low,^{31,38,39,41,46,48,49,61,64,67,72} and eight studies (17.0%; average score 10.2) had serious risk of bias (Supplementary File: Figure S4, pp 42).^{33-36,47,51,60,62} Of these eight studies, six were either industry-funded or had undisclosed funding (average score 10.04).^{33-36,51,62}

All 11 studies with low risk of bias applied pack analysis. Seventeen studies used this method with a moderate risk of bias, while five studies exhibited a high risk. Among 13 studies with gap analysis, 11 had a moderate risk of bias. Among the two studies that applied trade monitoring, one had moderate, and the other had serious risk of bias in their quality of estimate of illicit tobacco. Risks mainly pertained to the domains, replicability and theory relevance, generalisation and criteria selection, definition and identification of illicit, and results and cross-validation of illicit (Figure 4).

Figure 4: Risk of bias assessments for individual studies

Alt Text: Figure 4. Risk of bias assessments for studies in LMICs on the estimate of share of illicit tobacco. Risks mainly pertained to the domains, replicability and theory relevance, generalisation and criteria selection, definition and identification of illicit, and results and cross-validation of illicit.

Discussion

We found that the extent of the estimates of the share of illicit tobacco for 39 LMICs from 48 studies differed greatly between countries. Furthermore, it differed by estimation method, tobacco type, and funding source. The pooled estimate of the share of illicit smoking tobacco was 14.4% (95%CI: 10.5-18.9) while that for smokeless tobacco was 86.9% (95%CI: 51.1-100.0). The estimate with the pack analysis method was lower (14.0%; 95%CI: 10.0-18.6) than the gap analysis (21.1%; 95%CI: 11.0-32.8). While most of the independently funded studies applied pack analysis (designed as either a cross-sectional survey of smokers/retailers or observational studies), the undisclosed or industry-funded studies applied gap analysis. These studies estimated a relatively larger share of illicit with pack analysis method than the independently funded studies (15.6% vs. 14.0%).

The share of illicit tobacco varied from less than 1% to over 60% between LMICs. We found an extremely high share of illicit tobacco in some LMICs: using pack analysis 62.6% in Montenegro, 47.1% in Brazil, 36.4% in South Africa, 35.3% in Bosnia and Herzegovina and 32.2% in Georgia; using gap analysis 65% in Malaysia, 44.6% in Vietnam, 25.9% in Sierra Leone, 19.3% in Indonesia, and 16.1% in Philippines. Earlier Joossens and colleagues also found high share of illicit tobacco in most of these LMICs.² Although their results are not directly comparable due to differences in methodologies adopted, our pooled estimate (14.4%) is close to the previous pooled LMIC estimates by Goodchild and colleagues (12.3%) and Joossens and colleagues (12.1%).^{2,9} Goodchild and colleagues estimated the pooled share for HICs as 10.4%.⁹ Estimated higher share of illicit tobacco in LMICs reinstated the possible unequal burden of tobacco-related diseases and revenue loss for them compared to HICs. The tax administration capacity and governance level are important determinants of illicit tobacco.^{78,79} Weaker tobacco control law enforcement and tax administration and lower governance levels could be the reasons for underlying differences in the share of illicit tobacco in LMICs and HICs.¹⁴ LMICs encounter multiple challenges in implementing tobacco control intervention.⁸⁰ These include informal tobacco markets, where retailing is unregulated and tobacco control enforcement is poorly coordinated.⁸¹ Additionally, weak tax policies and a lack of digital tracking systems adds to the challenges. Significant interference from the tobacco industry in policymaking is compounded by a lack of awareness and political will to tackle the illicit tobacco issue.^{80,82} Some of the HICs where illicit tobacco is more effectively regulated, include Australia, Austria, Finland, France, Greece, Hungary, Italy, and New Zealand.^{59,83,84} They employ an advanced tracking and tracing system, strictly enforce border control, and impose heavy penalties for illicit trade. LMICs experiencing significant illicit tobacco may adopt strategies from HICs, contextualising them appropriately to decrease the prevalence.

We found that the illicit tobacco research evidence is skewed towards smoking tobacco and focused mainly on cigarettes. However, the illicit trade of novel tobacco such as e-cigarettes is an emerging problem.⁷⁸ Although the use of smokeless tobacco is reported in 127 countries around the world,⁸⁵ only two of the included studies covering Bangladesh, India, and Pakistan reported the share of illicit for smokeless tobacco. The pooled estimate of the share of illicit smokeless tobacco was more than six times than that of smoking tobacco. India, Pakistan, and Bangladesh accounted respectively for 70%, 7%, and 5% of DALYs (Disability Adjusted Life Years) lost in the overall smokeless tobacco disease burden in South and Southeast Asia.⁸⁶ Such high prevalence of illicit smokeless tobacco has adverse implications for the disease burden of these countries.

The ITP was targeted improving coordinated national efforts to curb the illicit tobacco trade problem. Among the 87 current signatories of ITP, 43 fall within the category of LMIC. Of these, we found that only 11 countries (Brazil, China, Colombia, Ghana, India, Mongolia, Montenegro, Pakistan, Serbia, and South Africa) have independently funded evidence on the share of illicit tobacco since the inception of ITP. Thus, the majority of LMIC signatories lack evidence for the estimated share of illicit tobacco. More LMICs should sign and ratify the ITP. Research indicates that implementing track and trace systems and the Global Information-Sharing Focal Point (GSP) is vital for securing the tobacco supply chain.^{78,87,88} Besides these global tools, establishing an effective system to control illicit tobacco would require international collaboration among LMICs.

Tax stamp examination is the direct measure of tobacco tax evasion and illicit tobacco.⁸⁹ Nevertheless, given the unavailability of proper track and trace or fiscal marking (e.g. tax stamp), studies mostly relied on indirect measures (e.g. compliance of packaging features or comparing the purchase price with either estimated or legislated threshold price of tobacco). Of the included 27 independently funded smoking tobacco studies, only 14 scrutinised the tax stamp, and 16 applied tax and/or price information of tobacco along with the pack features as the criteria for detecting illicit and hence tax evaded tobacco. Thus, although in many LMICs an attempt to estimate the share of illicit tobacco is present, robust estimation of this share is lacking. Representative survey data on tobacco-related information and disaggregated bilateral tobacco trade information are lacking for many LMICs. This inherent data challenge resulted in lower number of illicit tobacco studies with gap analysis and trade monitoring method.

The study has several strengths. Our detailed and exhaustive search strategy found 23 independently funded new illicit tobacco studies in 25 LMICs since 2018. Estimation of illicit cigarette consumption in LMICs by Goodchild and colleagues used evidence from 16 LMICs from 2010 to 2018.⁹ However, they did not include six independently funded studies^{47,60,61,64,73,77} published within the period from ten LMICs (Bangladesh, China, Malaysia, Mauritius, Mexico, Thailand, Brazil, India, Vietnam, and Philippines). Unlike the earlier research, we stratified the analysis depending on the type of tobacco and method of estimation for illicit. Additionally, we analysed the undisclosed or industry-funded studies separately whose estimates might be interest-driven and often overestimate the share of illicit tobacco to impede tobacco tax increases.

The application of English as a language restriction is a limitation, nevertheless, we found a good number of studies with a geographical variation. Evidence with a low risk of bias was scarce. However, we did not use the quality ranking of the studies as an exclusion criterion and the findings were free from small study bias. Significant variations in the share of illicit tobacco across studies resulted in higher heterogeneity in the meta-analysis. Additionally, differing definitions of illicit tobacco and various estimation methods may impact the true extent of illicit tobacco. Therefore, the comparability of the included studies and the generalizability of the pooled estimate are limited. Although a subgroup analysis with PI using a random effects model was performed, the results should be interpreted with caution.

In conclusion, we provided the latest estimates of the share of illicit smoking tobacco in LMICs (14.4%) and highlighted the lack of such estimates in many LMICs. We found only a couple of estimates for smokeless tobacco which were high. Besides illicit cigarette trade, future research needs to consider novel tobacco products and smokeless tobacco. Results show that the studies rely mostly on context-specific packaging compliance to categorise tobacco product as illicit. Evidence of scrutinising the tax stamp is limited and thus the assessment for true illicit share might not be robust. Regardless of the type of tobacco LMICs require robust administration of tobacco taxes and implementation of the provisions of ITP (e.g. track and trace system and tax stamp) to combat illicit trade.

Contributors

SMA, KS, MK and RH conceptualized the study. SMA and ZS completed the search and contributed to screening and data extraction. The analysis was undertaken by SMA guided by KS, MK and RH. KS provided inputs on the overall approach and MK guided the technical

analysis. SMA drafted the original manuscript with inputs from all co-authors. All authors provided their feedback and approved the final version. SMA accepts full responsibility for the research work, had access to the data, and controlled the publication decision.

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Competing interests

We declare no competing interests.

Patient consent for publication

Not required

Ethics approval

Not required

Data availability statement

Data collected and extracted for the review can be made available from the corresponding author through reasonable request. It should outline in detail the purpose for which the data are required.

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Figure 1: PRISMA flow diagram and study selection

Alt Text: Figure 1. Presents the study selection process using PRISMA flow diagram. A total of 1,592 studies were identified through database and website searches. After title and abstract screening, 93 studies were selected for full-text review. Eligibility check excluded 45 studies, and thus, 48 studies were included in the review and meta-analysis.

Figure 2: Random effects model showing the proportion of illicit smoking tobacco in LMICs with independently funded studies

Alt Text: Figure 2. Forest plot showing the proportion of illicit smoking tobacco in LMICs as 14.4% with independently funded studies. The proportion is 14.0% with a sub-group of studies using the pack analysis method. The estimate was 21.1% and 9.6%, respectively for the sub-groups with gap analysis and trade monitoring methods.

Figure 3: Random effects model showing the proportion of illicit smokeless tobacco in LMICs with independently funded studies

Alt Text: Figure 3. Forest plot showing the proportion of illicit smokeless tobacco in LMICs as 86.9% with independently funded studies. The meta-analysis included evidence from three South Asian countries (Bangladesh, India and Pakistan), and all of them applied the pack analysis method.

Figure 4: Risk of bias assessments for individual studies

Alt Text: Figure 4. Risk of bias assessments for studies in LMICs on the estimate of share of illicit tobacco. Risks mainly pertained to the domains, replicability and theory relevance, generalisation and criteria selection, definition and identification of illicit, and results and cross-validation of illicit.

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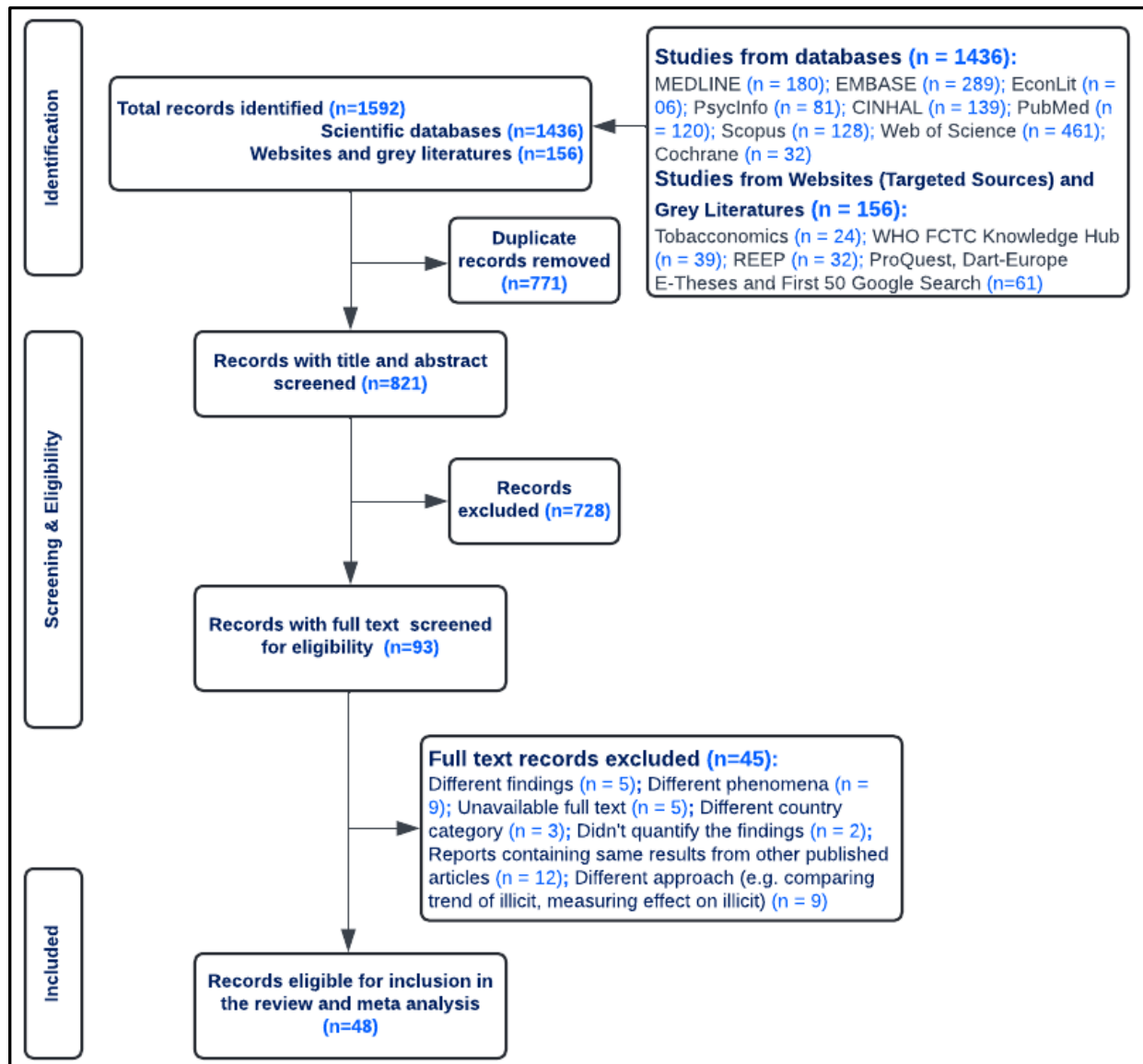


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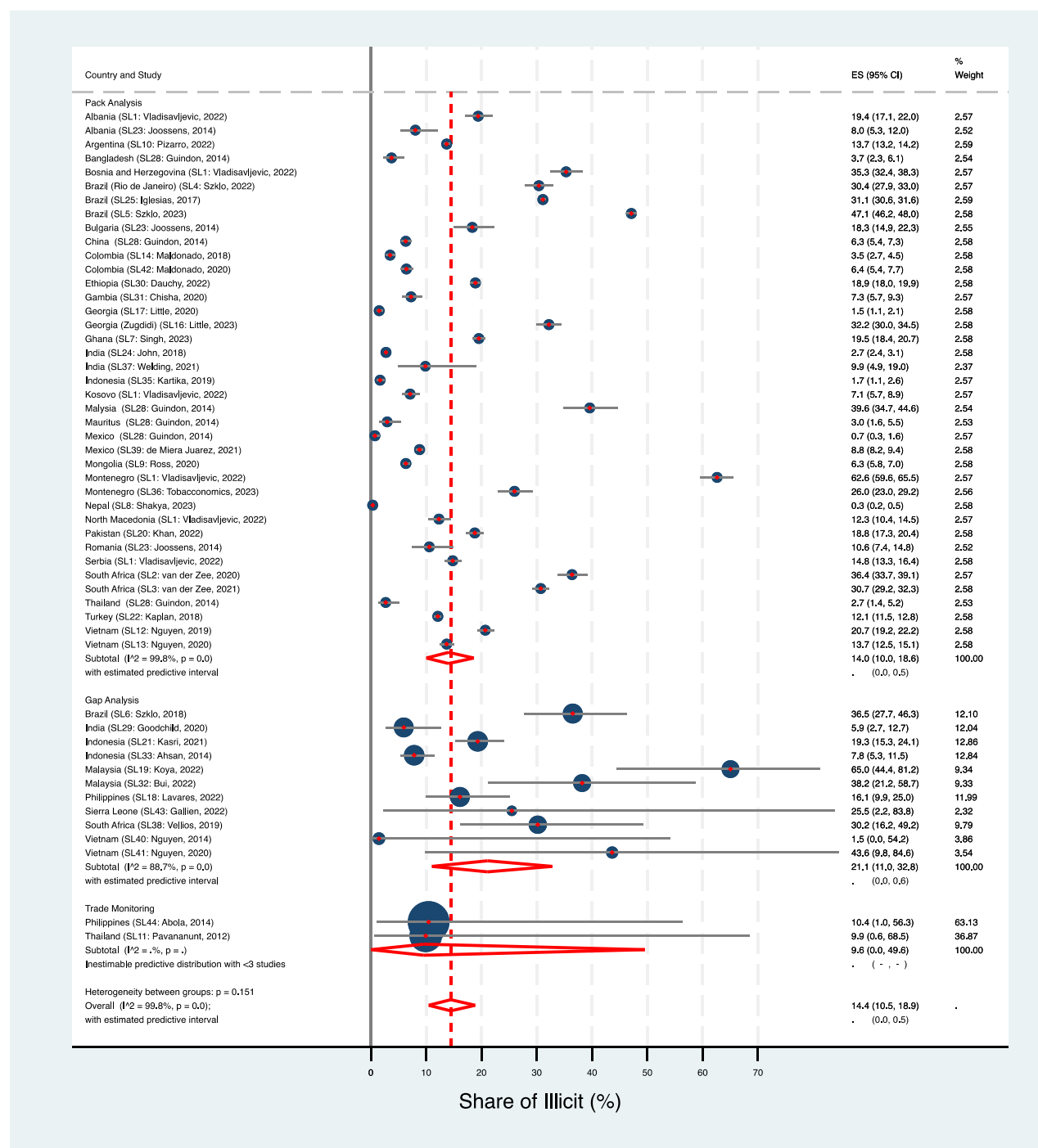


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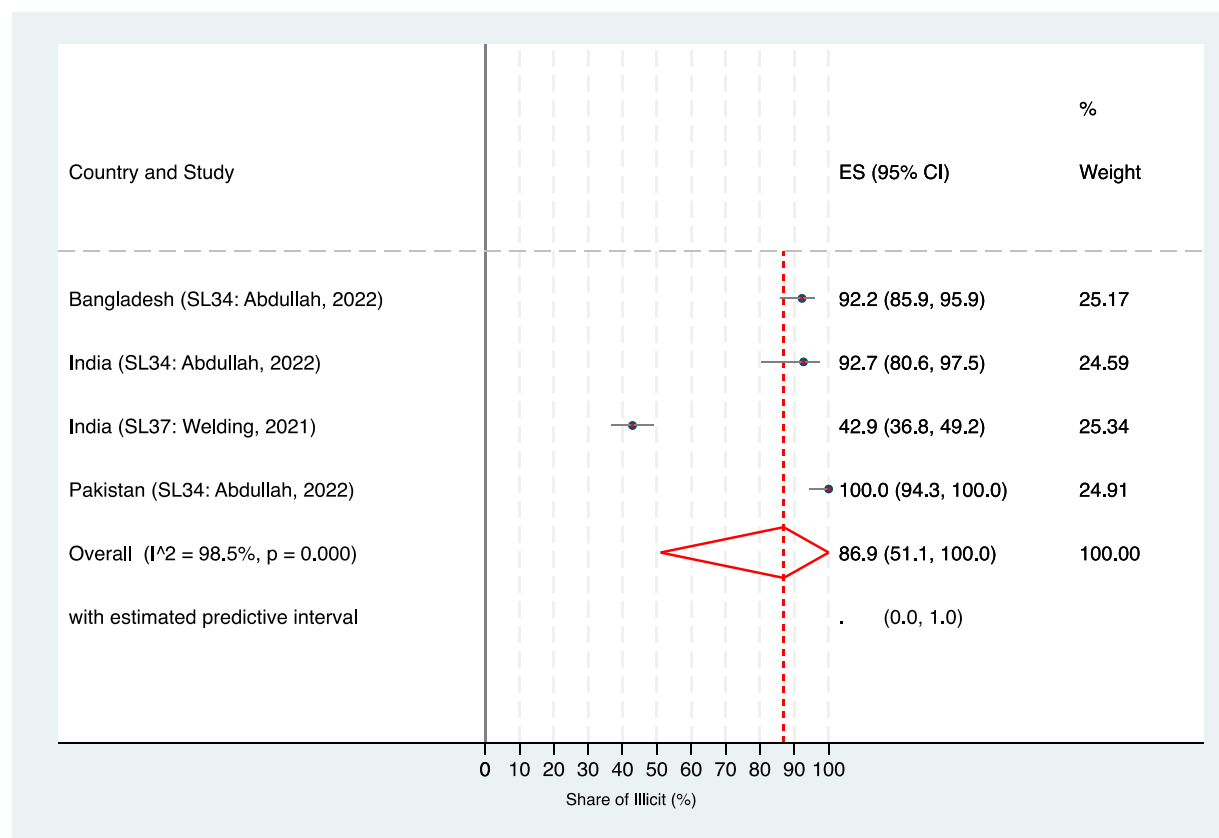


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	Risk of bias domains							Overall
	D1	D2	D3	D4	D5	D6	D7	
SL1: Vladislavjevic, 2022	+	+	-	+	+	+	+	+
SL2: van der Zee, 2020a	+	+	-	-	-	+	+	+
SL3: van der Zee, 2020b	+	+	-	+	+	+	+	+
SL4: Szklo, 2022	+	+	-	-	+	+	+	-
SL5: Szklo, 2023	+	+	+	+	-	-	+	+
SL6: Szklo, 2018	+	+	+	+	+	+	+	-
SL7: Singh, 2023	+	+	+	-	+	+	+	-
SL8: Shaky, 2023	+	+	+	-	+	+	+	-
SL9: Ross, 2023	+	+	-	-	+	+	+	-
SL10: Pizzaro, 2022	+	+	+	+	+	-	+	+
SL11: Pavananunt, 2012	+	+	+	+	+	-	+	+
SL12: Nguyen, 2019	+	+	-	+	+	+	+	+
SL13: Nguyen, 2020a	+	+	+	+	+	+	+	+
SL14: Maldonado, 2018	+	+	+	-	-	+	+	-
SL15: Machado, 2021	+	+	+	+	+	+	+	+
SL16: Little, 2023	+	+	+	-	+	+	+	-
SL17: Little, 2020	+	+	+	+	+	+	+	-
SL18: Lavares, 2022	+	+	+	-	+	+	+	-
SL19: Koya, 2022	+	+	+	+	+	+	+	-
SL20: Khan, 2022	+	+	-	-	+	+	+	-
SL21: Kasri, 2021	+	+	-	+	+	-	+	-
SL22: Kaplan, 2018	+	+	+	-	+	+	+	-
SL23: Joossens, 2014	+	+	-	-	+	+	+	-
SL24: John, 2018	+	+	+	+	+	+	+	+
SL25: Iglesias, 2017	+	+	-	+	+	+	+	+
SL26: Heydari, 2016	+	+	+	+	+	+	+	+
SL27: Heydari, 2022	+	+	-	+	+	-	+	-
SL28: Guindon, 2014	+	+	-	+	-	-	+	+
SL29: Goodchild, 2020	+	+	-	+	+	-	+	-
SL30: Dauchy, 2022	+	+	-	+	-	-	+	-
SL31: Chisha, 2020	+	+	+	+	+	-	+	+
SL32: Bui, 2022	+	+	+	-	+	-	+	-
SL33: Ahsan, 2014	+	+	-	+	-	+	+	-
SL34: Abdullah, 2022	+	+	-	-	+	-	+	-
SL35: Kartika, 2019	+	+	+	+	+	+	+	-
SL36: Tobacconomics, 2023	+	+	+	-	+	+	+	+
SL37: Welding, 2021	+	+	-	+	+	+	+	-
SL38: Vellios, 2019	+	+	-	+	+	+	+	-
SL39: de Miera Juarez, 2021	+	+	-	+	+	+	+	+
SL40: Nguyen, 2014	+	+	+	-	-	+	+	-
SL41: Nguyen, 2020b	+	+	-	-	-	+	+	-
SL42: Maldonado, 2020	+	+	+	-	+	-	+	-
SL43: Gallien, 2022	+	+	+	+	-	-	+	-
SL44: Abola, 2014	+	+	+	+	+	-	+	-
SL45: Morais, 2018	+	+	+	+	+	+	+	+
SL46: FTI Consulting, 2019	+	+	+	+	+	+	+	+
SL47: Oxford Economics, 2020	+	+	+	+	+	+	+	+
SL48: International Tax and Investment Center and Oxford Economics, 2016	+	+	+	+	+	+	+	+

Domains: D1: Peer Reviewed; D2: Funding; D3: Replicability & Theory Relevance; D4: Generalizability & Criteria Selection; D5: Definition & identification of Illicit; D6: Results & Cross Validation of Illicit; D7: Limitation Acknowledgement.

Judgement:
 ✖ Serious
 - Moderate
 + Low