


# Tobacco Use Among People Incarcerated in Western Europe: A Systematic Review and Meta-analysis

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## ABSTRACT

**BACKGROUND:** Evidence suggests that the prevalence of tobacco use has declined significantly in the general population but still remains high among people incarcerated in high-income countries. Tobacco use is the second leading risk factor of mortality and morbidity worldwide. The objective of this study is to synthesize evidence on the prevalence of smoking among people incarcerated in Western European countries.

**METHODS:** We searched the PubMed database for articles published between June 2010 and June 2020, website of international organizations and hand-searching references. One author reviewed studies that met pre-defined inclusion criteria, and this was cross-validated by a second reviewer, following the MOOSE guidelines. The Meta prop command of Stata (V16) was used for pooling smoking prevalence estimates. Random effects modelling, heterogeneity with subgroup analysis and publication bias was assessed.

**RESULTS:** Out of the 236 identified articles, 25 with full texts were eligible, and 16 were finally included in this study. The overall pooled estimate of smoking prevalence was 72.3%, 95% CI (54.8–84.7), and high heterogeneity ( $I^2 = 99.73\%$ ). Females had a pooled prevalence 44.1% (95% CI 9.4–82.6) while males 83.3% (95% CI 72.0–92.1). The total number of prisoners combined in this study was 16,435 (ranging from 31–21,451) with age ranging from 24–43 years.

**CONCLUSION:** A relatively high smoking rate was observed among incarcerated people - higher among the male population. The study findings are useful for informing policy-makers of the existing burden of smoking in special vulnerable populations across Western Europe and the need for comprehensive tobacco control policies in different population settings.

**KEYWORDS:** tobacco use, pooled estimate, incarceration, Western Europe

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## Background

The Global Burden of Disease (GBD) Study in 2019 estimated more than 200 million tobacco-attributable deaths worldwide over the past 30 years, and tobacco use is the second leading risk factor for premature mortality and morbidity.<sup>1,2</sup> Recently, smoking rates have decreased in high-income countries partly due to comprehensive changes to policy-making such as a high taxation on tobacco, mass media campaigns, restrictions on tobacco sponsorship, promotion, and advertisement, and smoke-free policies.<sup>3,4</sup> However, this overall decline in smoking rates is not equally distributed, exposing vulnerable populations, such as the incarcerated people, at greater risk of nicotine addiction.<sup>4</sup> Tobacco remains the most frequently used psycho-active drug among the incarcerated people - ranging from 64–90%, with variations across and within countries.<sup>5</sup>

The health of incarcerated people remains a public health challenge because people incarcerated are at a higher risk of substance use, and prone to overall physical and mental health problem as compared to the general population.<sup>6,7</sup> Incarcerated people are also trapped in this vicious cycle of being in prison and out in the community, and again from community to a prison setting,<sup>7</sup> thus influencing the background risk of a specific community.<sup>8</sup> The financial burden of

tobacco use - both on individuals and on the national economy is well-established. A recent WHO report estimated that smoking costs the governments and the households over US\$1.4 trillion globally through healthcare expenditure and lost productivity.<sup>1,9</sup> Importantly, evidence suggests that tobacco use is three to four times higher in the incarcerated population compared to the general population.<sup>5,10–14</sup> However, there has been no meta-analysis conducted to determine the pooled estimate of recent smoking prevalence in the incarcerated population in Western Europe.

Therefore, we set out to systematically synthesize evidence on the prevalence of smoking among the incarcerated population in Western Europe overall, and by gender distribution, to provide a pooled estimate of smoking prevalence, for evidence-informed policy decisions.

## Methods

### Search Strategy

Pre-defined eligibility criteria were formulated based in a PICO format ([Appendix 1](#)). We followed the Meta-analysis of Observational Studies in Epidemiology (MOOSE) reporting



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**Table 1.** Inclusion and Exclusion Criteria.

<p><b>Inclusion Criteria for Quantitative Synthesis</b></p> <ul style="list-style-type: none"> <li>• Cross-sectional, cohort and case-control studies that reports simple prevalence will be included. (in Western Europe).</li> <li>• Studies reporting co-use (tobacco and other substances).</li> <li>• Studies that include prisoners with or without mental illness.</li> <li>• Studies that report exposure of prisoners to second-hand smoke or environmental exposure.</li> <li>• Studies that examine any type of anti-smoking intervention/smoking cessation programs within prison settings.</li> <li>• Only published peer-reviewed literature and grey literature from international organizations such as WHO, United Nations (UN) will be included.</li> <li>• Original studies published in English language from 2010-2020 in the electronic (PUBMED) database</li> </ul>
<p><b>Exclusion Criteria for Both Quantitative and Qualitative Synthesis</b></p> <ul style="list-style-type: none"> <li>• Reviews, randomized control trials, case report, case series, letter, grey literature (exempting reports from international organizations), conference abstracts, editorials, unpublished literature and notes not in Western Europe.</li> <li>• Studies not in English language.</li> <li>• Studies that aren't accessible.</li> <li>• Studies that are non-human.</li> <li>• Studies that focused on prisoners that only use other substances without using tobacco vaping (e-cigarettes).</li> </ul>

guidelines ([Appendix II](#)). One author (DSA) searched PubMed database for relevant articles published between 4th June 2010 and 4th June 2020. The rationale for using only PubMed database is that PubMed is a comprehensive medical database and its most widely cited. We excluded pre-prints and non-peer reviewed journal articles, which lends support to using PubMed.

Details of the full search strategy are available in [Appendix III](#) & [Appendix IV](#). In brief, key search terms coupled with MeSH terms, were employed. Examples include, (tobacco use OR tobacco prevalence OR smoking AND incarcerated\*) using the OR and AND Boolean operator. We also searched through references of systematic review conducted on worldwide prevalence.<sup>4</sup> We searched publicly available international organizational websites, such as the WHO, for additional information on prevalence of tobacco in the general population for comparison. For studies conducted after 2015, the recent WHO report on trends in tobacco use<sup>15</sup> was used, and for studies conducted before 2015, the WHO tobacco report 2015 was used, both for extracting comparison data.<sup>16</sup> Baseline characteristics of the selected studies are shown in [Table 3](#).

### Eligibility Criteria

Our review included cross-sectional, cohort and case-control studies that reported prevalence in any western European country; studies reporting the use of tobacco and or other poly substance use such as, drugs and alcohol; studies reporting incarceration (male or female populations) aged 18 and above; and studies published in English language. For exclusion criteria, we excluded randomized control trials (RCT), case reports, case series, letters to editors, grey literature (exempting reports from international organizations), conference abstracts, editorials, unpublished literature, and preprints; and studies not conducted in Western Europe ([Table 1](#))

Zotero 5.0.95 software was employed for data management. Only studies that met the eligibility criteria were included in this review. A second reviewer (ZK) reviewed the eligible studies.

There were no duplicates because only one comprehensive database was used. The Western European countries included are Greece, Finland, Norway, Italy, France, Switzerland, Germany, Spain, and Netherlands based on the WHO classification. The PRISMA flow diagram<sup>17</sup> is shown in [Figure 1](#)

### Data Abstraction

To extract data, the first reviewer (DSA) independently extracted data into a standardized data collection form. The 2nd reviewer (ZK) cross-checked this to minimize bias. However, any discrepancy was resolved through discussion. Information extracted include author's name & year, study design, region of study, age, sex, purpose, sample size, smoking prevalence of incarcerated population, smoking prevalence of general population, fold increase, list of confounders and intervention type.

**Bias and Quality Assessment.** The NIH (National Institute of Health) quality appraisal tool for observational studies was used to assess the risk of bias in these selected studies.<sup>18</sup> The appraisal tool consisted of 14 questions ([Appendix V](#)) which were assessing the overall quality of the studies. Examples of the criteria asked were if the research objective was clearly stated in the paper, if the study population was clearly defined, if the participation rate of eligible persons were more than 50%, was exposure measured prior to outcome, if there was confounding and if confounding was adjusted. The questions asked had three options to respond to: yes, no and not applicable (NA) with quality rating of good, fair and poor. Depending on the answers to the 14 questions, each paper was graded good, fair or poor. The grades of each paper are shown in [Table 2](#) with reasons as to why they were graded accordingly.

### Statistical Analysis and Meta-Analysis

Meta-analysis was undertaken for the pooled estimate on the prevalence of tobacco use among people in incarceration in

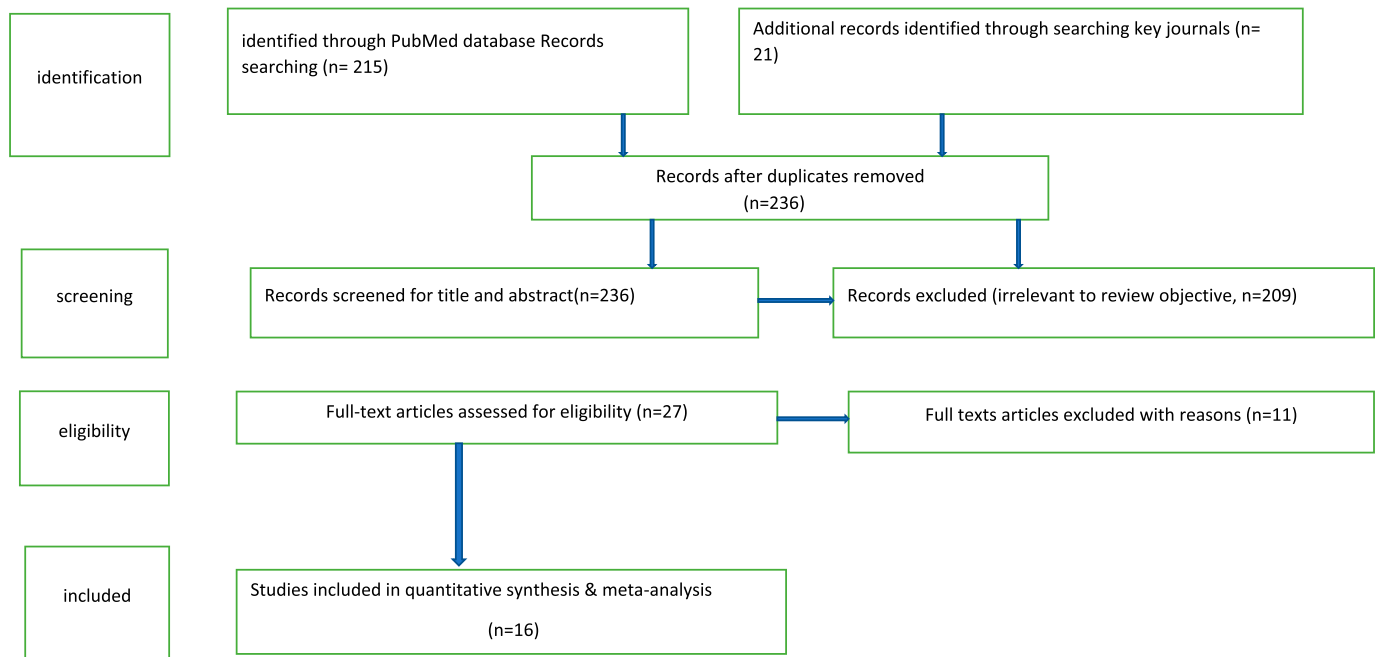


Figure 1. PRISMA flowchart

Western Europe. Stata (version 16) was used for this pooled analysis, and the *meta prop* command was installed to carry out the meta-analysis. Details of the commands and dataset are shown in appendix VI. This study used a random effect model of meta-analysis for combining results because random effect model assigns similar weights to studies regardless of sample size.<sup>34</sup> Forest plot was used to present the pooled estimate, with their corresponding 95% confidence intervals. Heterogeneity was explored through  $I^2$  values. A meta-regression of sample size was conducted.

The following *a-priori* subgroup analysis was proposed in the protocol; study design, study quality, gender, type of tobacco product, duration of incarceration, and number of cigarettes. However, data were inadequately available for all sub-group analysis. Our subgroup analysis was on study quality and gender—shown in Figures 3 and 4, respectively. Fold increase was calculated by dividing the prevalence of smoking among the incarcerated population by the general population in Table 3. Publication bias was assessed by plotting a funnel plot which included more than 10 studies and visually assessing the symmetry of the plot together with Eger's test.<sup>35</sup>

## Results

### Search Results

Our initial search yielded a total of 236 articles in PubMed and additional records (hand searching reference list, journal and WHO data). After screening the titles and abstracts, 211 studies were excluded, and 25 full-text studies were eligible. A total of 16 articles finally met the inclusion criteria.

Reasons for excluding full text eligible studies are shown in appendix VII. The NIH tool was applied to demonstrate that nine studies were rated as 'good', seven were rated as 'fair', and only one was rated being poor as outlined in Table 2. All the studies included for this review were cross sectional except for Hiscock et al.,<sup>36</sup> which was a retrospective cohort study.

## Result of the Meta-Analysis

### Prevalence of Tobacco Use

The overall pooled prevalence of tobacco use among incarcerated people was 72.3% (95%CI 57.8-84.7) with a large heterogeneity ( $I^2$  99.73%,  $P=.00$ ) (Figure 2). One study Vera-Remartínez (2014) (33) was included twice in the meta-analysis because the study reported the prevalence of tobacco use among male and female incarcerated persons, separately. The total number of participants who took part in the 16 studies were 16,435 but the overall population was 21,451 (Table 3). Out of the 9 countries included in our study, there was not any prevalence of tobacco use among people incarcerated lesser than the prevalence in the general population. The fold increase across these countries ranged from 1.36-4.76, suggesting the widening gap of tobacco use among the incarcerated population. Greece and Italy had the highest pooled prevalence of 100%, Norway 97.7%, Finland 90.9%, Spain (only male) 87.4%, France and Netherlands ranging 50.1–65.7 and three countries showed a pooled prevalence <50% which are Germany, Switzerland, Finland, and Spain (only female).

**Table 2.** Quality assessment summary of all studies included in the review (both systematic and narrative).

STUDY/ARTICLE	QUALITY	COMMENT
Bania et al. (2016)(19)	Good	The reason for not calculating sample size was mentioned, exposure and outcome were also measured at the same time because it is a cross-sectional study. In the multiple linear regression, confounders were adjusted for.
Vainoinpaa et al. (2019)(20)	Good	Exposure and outcome were measured simultaneously using a validated instrument and questionnaire.
Geitona and Milioni (2016) <sup>7</sup>	Fair	Lack of standardized questionnaire and self-report of both exposure and outcome. Confounding was not accounted for.
Muller et al. (2018)(21)	Good	Used an already conducted cohort study being representative of the population. Confounders were accounted for.
Lind et al. (2019)(22)	Fair	Researchers did not have any contact with prisoners during data collection. A self-report questionnaire was used, giving rise to recall/response bias. No mention of confounding. Low response rate.
Nobile et al. (2011)(23)	Good	Generalizable to the whole prison population in Italy. Achieved multiple linear regression by adding different independent variables in the model.
Jacomet et al. (2016)(24)	Fair	Reported to be a prospective study, but it seemed to be a cross-sectional study. Less measurement bias because of the use of validated instruments and techniques. In the statistical analysis, multivariate logistic regression was reported to be done but did not mention confounding.
Ceelen et al. (2012)(25)	Good	Conducted a structured health interview; did not account for confounding.
Chariot et al. (2014)(26)	Fair	A large number of participants partook in the study, and a standard questionnaire was used for the collection of data.
Mannocci et al. (2015)(27)	Good	Use of standardized questionnaire but small sample size and only males were in the study - good statistical analysis.
Vera-Remartínez (2014)(28)	Fair	Conducted interview and physical examination. High participation rate. Mentioned confounding but mentioned misclassification bias as a limitation
Ritter and Elger (2013)(29)	Poor	Mixed method (Questionnaires, air quality measurement and interviews) for data collection. The participation rate was less than 50%
Mir et al. (2015)(30)	Fair	Conducted a structured interview. No details on the statistical analysis
Sahajian et al. (2012) <sup>31</sup>	Good	Conducted interview to obtain information from prisoners. Self-report and prone to misclassification bias. Adjusted for confounders statistically.
Sahajian et al. (2017) <sup>32</sup>	Good	Good response rate. Too short time to conduct a study. Though because of the nature of the study design, which is very fast can be a cause. Adjusted for confounders statistically.
Makris et al. (2012) <sup>33</sup>	Good	Face to face interview and self-reported questionnaire; did not account for confounding.

### Subgroup-Analysis

*Study quality:* studies were grouped as “good, fair and poor” based on the NIH quality appraisal tool assessment. “Good” quality studies yielded a pooled smoking estimate of 89.0% (95% CI 75.0–97.8) with significant heterogeneity (I<sup>2</sup> 99.4%,  $P = .00$ ); “fair” quality studies had a pooled smoking estimate of 52.2% (95% CI 25.3–78.5), with significant heterogeneity (I<sup>2</sup> 99.8%,  $P = .00$ ). The pooled smoking estimate of “poor” quality studies (one study) was 25.8% (95% CI 18.8–34.3) with no heterogeneity. The forest plot is shown in [Figure 3](#).

*Gender:* gender was categorized into three: males, females, and both. In the meta-analysis, 7 studies included both genders, 4 studies reporting female rates, and 6 reporting male rates. The

pooled smoking estimate for studies with no gender distinction was 76.9% (95% CI 51.8–94.6), with significant heterogeneity (I<sup>2</sup> 99.7%,  $P = .00$ ); pooled smoking estimate for studies on females only was 44.1% (95% CI 9.4–82.6) with significant heterogeneity (I<sup>2</sup> 99.7%,  $P = .00$ ); the pooled smoking estimate for studies on males only was 83.3% (95% CI 72.0–92.1), with significant heterogeneity (I<sup>2</sup> 99.0%,  $P = .00$ ). The forest plot is shown in [Figure 4](#).

### Publication Bias

We assessed for publication bias, and the  $P$ -value after conducting Egger’s test was not significant suggesting no publication bias (Egger’s test  $P = .76$ ). No study was imputed when the meta trim fill command was used. By visually looking

**Table 3. Characteristics of Studies included on tobacco prevalence amongst prisoners in western Europe(quantitative)**

STUDY AUTHOR(YEAR)	STUDY DESIGN	REGION, STUDY PERIOD	AGE	SEX	PURPOSE	SAMPLE SIZE	SMOKING PREVALENCE IN PRISONERS	GENERAL POPULATION PREVALENCE(24)	FOLD INCREASE	LIST OF CONFOUNDERS	ADJUSTED FOR CONFOUNDERS
Bania et al. (2016)(19)	Cross-sectional	Greece, March 2011-Dec 2011	Median age = 43.0	Male & Female	To estimate the prevalence of smoking and COPD among inmates	N = 552	79%	44%	1.75	Site, age, sex	yes
Vainio et al. (2019)(20)	Cross-sectional	Finland Sept 2014-Feb 2015	Mean age = 35.0 37.8	Male & Female	To evaluate the prevalence and severity of erosive tooth wear, its association with dental caries and use of psychoactive substance among Finnish prisoners	N = 110 n = 100	88%	18.5%	4.76	Alcohol, age	yes
Geitona and Milioni (2016) 7	Cross-sectional	Greece Jan-Dec 2014	Mean age- 37.5	Female	To assess female prisoner's health status & access to healthcare in Greece	N = 135 n = 101	83.8%	30.8%	2.27	Not mentioned	—
Muller et al. (2018)(21)	Cross-sectional	Norway 2013-2014	Meanage-32.8 39.7	Male & Female	To evaluate results from Norwegian inmates according to harmful substance use pre-incarceration, and explored changes in exercise and nicotine use during incarceration.	N = 1499 n = 1464	81.3%(cigarette) 26.0% (smokeless tobacco)	21.6%	3.76	Age, length of incarceration, mental distress	Yes
Lind et al. (2019)(22)	Cross-sectional	Finland Dec 2017- Jan 2018	25-54 Mean age-37.3	Male and female	to explore the prevalence of potential problem gambling among Finnish prisoners; the associations between problem gambling and demographics; substance use and crime-related factors; and problem gamblers' support preferences.	N = 312 n = 96	84.0% (29)	20.2%(29)	4.16	Not mentioned	—
Nobile et al. (2011)(23)	Cross-sectional	Italy, Feb-Dec 2005	Mean age 39.8	Male	to assess self-reported health, quality of life, and access to health services in a sample of male prisoners of Italy.	N = 908 n = 650	67.5%	30.8%	2.19	Age	yes
Jacomet et al. (2016)(24)	Prospective (Cross-sectional)	France June 2012-Dec 2013	Median = 30	Male and female	To assess the prevalence of infectious disease and addictive behaviour	N = 702 n = 357	83.8%	24.7%	3.39	Not mentioned	—
Ceelen et al. (2012)(25)	Cross-sectional	Netherlands, March and June 2009	Mean age = 41	Male and female	Use of healthcare among police detainees	N = 402 n = 264	76%	26.7%	2.85	Age, gender	yes
Chariot et al. (2014)(26)	Prospective study (cross sectional)	France, Jan 1 to Dec 31 2012	Median age = 24	Male	Examining medical characteristics and addictive behaviours among police detainees	N = 13,317 n = 10,276	70%	27.9%	2.51	Not mentioned	-
Makris et al. (2012)(33)	Cross-sectional	Greek, June 2008-dec 2010	Mean-33.6 ± 12.5	Male	To identify the features which led prisoners to quit smoking after a smoking cessation program in Greece prison	204	75.5%	55.7%	1.36	Smoking history, previous use of the addictive substance, the distinctive feature of their life in prison	—

(Continued)

Table 3. Continued.

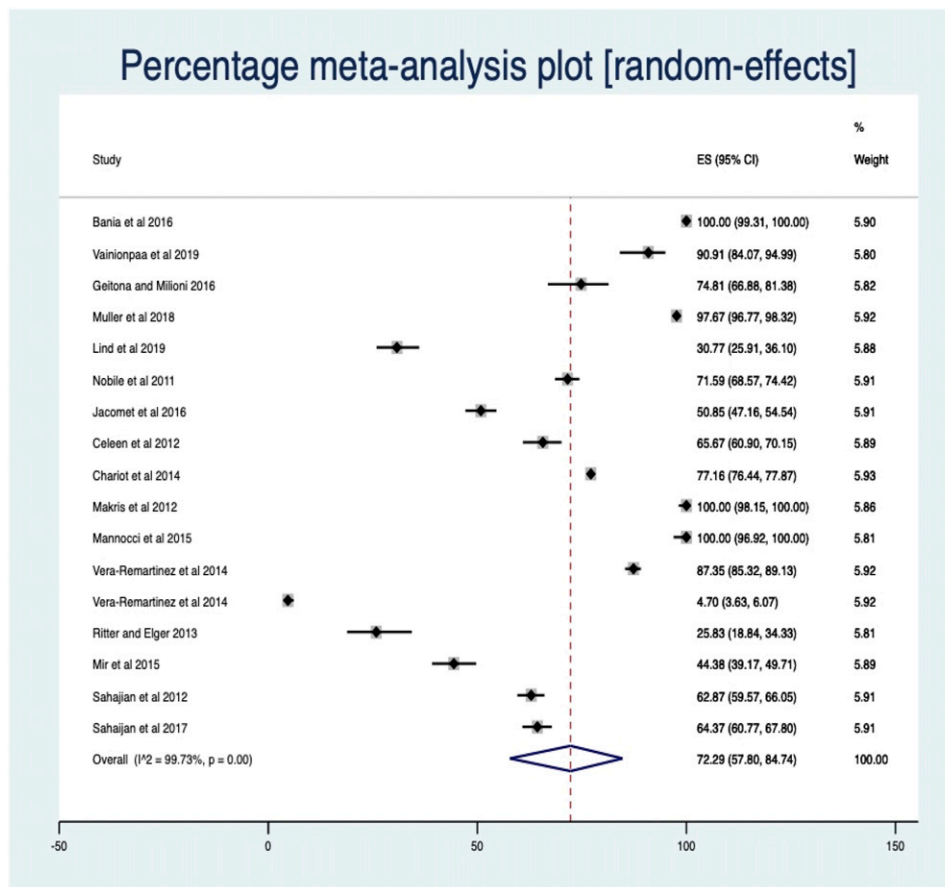
STUDY AUTHOR(YEAR)	STUDY DESIGN	REGION, STUDY PERIOD	AGE	SEX	PURPOSE	SAMPLE SIZE	SMOKING PREVALENCE IN PRISONERS	GENERAL POPULATION PREVALENCE(24)	FOLD INCREASE	LIST OF CONFOUNDERS	ADJUSTED FOR CONFOUNDERS
Mannocci et al. (2015)(27)	Cross-sectional pilot study	Italy, 2010-2011	Mean age = 35	Male	To assess the association between quality of life and physical activity in male inmates in Italy prison	121	69.7%	29.0%	2.40	age, gender, nationality, educational level, the period of civil detention status, smoking habits, BMI	yes
Vera-Remartinez et al. (2014)(28)	Cross-sectional	Spain, May and June 2013	Median age = 37.4	Male Female	To describe the prevalence of main chronic diseases and major risk factors in Spanish penitentiary center	N = 1170 n = 1022(m) 55(f) total (n)-1077	71.0%-m 58.2%-f	29.9% 22.3%	2.37 2.61	—	—
Ritter and Elger (2013)(29)	Mixed study (quantitative and qualitative)	Switzerland, 2009	Mean age = 35	Male	To explore the attitude of staff and detainees towards tobacco smoking	N = 120 n = 31	84%	27.9%	3.01	—	—
Mir et al. (2015)(30)	Cross-sectional	Germany, April 2012 and May 2013	Mean age = 34.3±10.8	Female	To assess comorbidities of substance use disorder and other mental problems with female prisoners on admission. A penal justice system	N = 338 n = 150	81%	23.3%	3.48	—	—
Sahajian et al. (2012)(31)	Cross-sectional	France, June 1, 2004, and Dec 31 2008	Mean age 31.5	Female	To describe the characteristics of female prisoners in Lyon prison and estimate their psychoactive substance use	N = 851 n = 535	57.9%	22.6%	2.56	Not mentioned	yes
Sahajian et al. (2017)(32)	Transversal descriptive study	France, September 23rd and 27th 2013	Mean age = 31.3(m) 31.6(f)	Male and female	To describe psychoactive substance use during incarceration in Lyon prison	N = 710 n = 457	74.4%	24.7%	3.01	Age class, tobacco consumption, cannabis consumption, first incarceration	yes

Abbreviation: COPD- Chronic Obstructive Pulmonary Disorder

Smoking prevalence of prisoners: gotten from each study

General population prevalence: obtained from WHO tobacco report 2015(24) and WHO report in trend in tobacco use 2019(25)

Fold Increase: obtained by dividing prevalence of prisoners by prevalence of general population



**Figure 2.** Forest plot of pooled prevalence of tobacco use among prisoners in Western Europe included in the meta-analysis.

at the funnel plot, the funnel plot was symmetrical, which shows that there is no evidence of small studies effect. This funnel plot is shown in Figure 5. Meta-regression was conducted by plotting a bubble plot to explore heterogeneity and to check if there was an association between the population prevalence (effect estimate) and sample size. The *P*-value was .53 suggesting no evidence of an association between population prevalence and sample size.

## Discussion

The primary aim of this study was to synthesize evidence on the prevalence of tobacco use among incarcerated population in Western Europe. The pooled estimate of smoking prevalence was 72.3%; 95% CI (54.8–84.7). Male incarcerated population had two-fold increased prevalence of tobacco use compared to their female counterparts (44.1%). The fold increase ranged from 1.36–4.76 as there was no country which had a higher prevalence of tobacco use in the general population than in the prison population. To the best of our knowledge, this is the first study to estimate an overall pooled prevalence of tobacco use among people in incarceration, particularly in Western Europe. A recent systematic review reported on the prevalence of smoking in correctional facilities, but it was on a global scale-not

limited to Western Europe and did not estimate a pooled smoking prevalence.<sup>4</sup> By using reports on tobacco trends from WHO data, we could make comparisons between tobacco use among general population and tobacco use among people incarcerated. Nine countries from Western Europe were included in this study with Greece and Italy reported the highest smoking prevalence of 100%. Norway 97.7%, Finland 90.9%, Spain, the Netherlands, and France reported a smoking prevalence ranging from 50.1%–87.4%. Switzerland, Germany, Finland, and Spain reported a prevalence of <50.

One major finding about this study is that the male had a two-fold increased prevalence of tobacco use (83.26%) compared to the females (44.06%). However, a study conducted among female incarcerated in Greece reported that female incarcerated are at higher risk of smoking, using drugs and alcohol, reproductive health, and mental health than male and even the general population.<sup>7,11</sup> The large difference in gender prevalence could be because of the dearth of studies on female incarceration. Moreover, the population of the male incarcerated are 90% or more and generally, women make up approximately 7% of the incarceration rate worldwide.<sup>11</sup>

Our findings are in agreement with published literature<sup>11,19,20</sup> demonstrating that the prevalence of tobacco use is

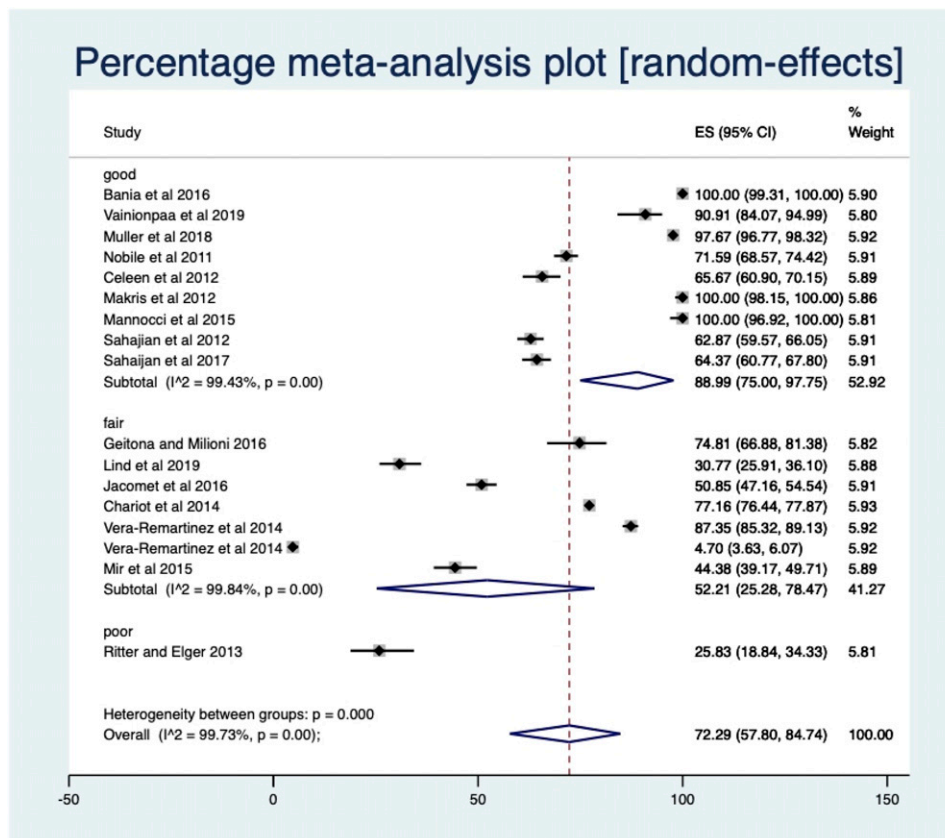


Figure 3. Subgroup analysis by study quality on the prevalence of tobacco use among prisoners in western Europe.

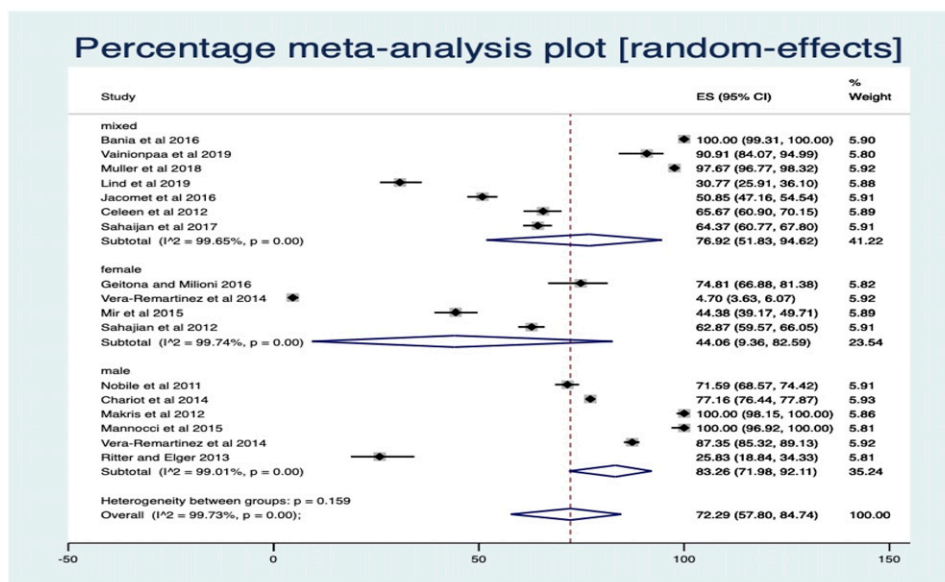
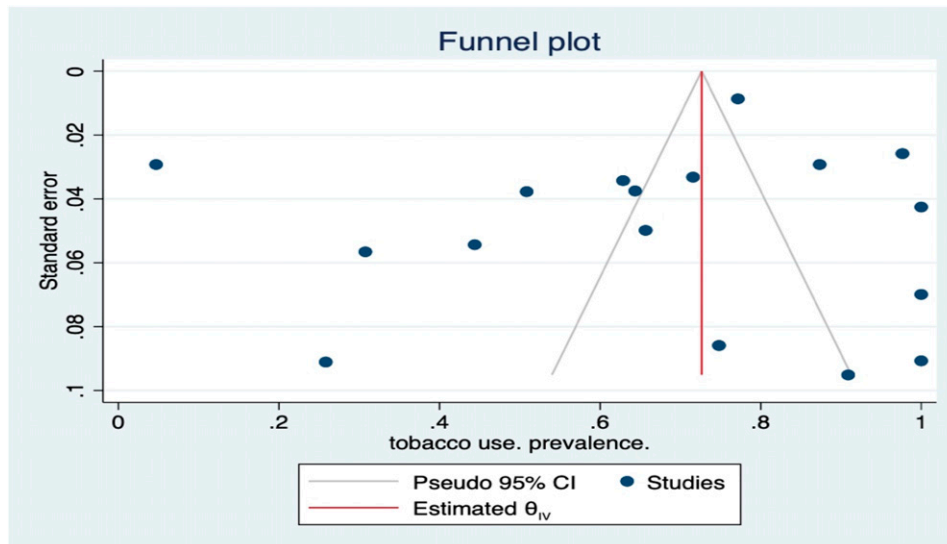


Figure 4. Subgroup analysis by gender on the prevalence of tobacco use among prisoners in western Europe.

heightened among people incarcerated compared to the general population. Another recent systematic review looked at the prevalence of alcohol and substance use disorder among people in incarceration but tobacco use was exempted.<sup>14</sup> This worldwide study carried out a meta-analysis and the pooled prevalence for alcohol was 24% with

male prevalence slightly higher than female, while for drug use male had overall prevalence of 30% and female 51%.<sup>14</sup> The prevalence of alcohol use higher in males than in females lend support to our findings whereby tobacco use is higher in males than in females but the prevalence of drug use was higher in female than in male. To put





**Figure 5.** Funnel plot on the prevalence of tobacco use among prisoners in western Europe.

into perspective, comparing these three substances (alcohol, drug and tobacco), tobacco use in the incarcerated population is the most prevalent.

### Strengths and Limitations

Our study has both strengths and limitations. A strength of our study is an overall pooled estimate on the prevalence of tobacco among Western Europe incarcerated population, which is novel to the best of our knowledge. We demonstrated no evidence of publication bias across the studies included. Another strength is that the meta-regression conducted for these studies showed that there was no association between prevalence and sample size, indicating validity of our study findings.

One of the major limitations is the use of a single database with date restrictions of 2010–2020. However, PubMed database is a comprehensive medical database and is widely cited. Also, some studies had small sample size and data was extracted from them, and even studies in which smoking was not the primary outcome were included in the study. Therefore, there should be cautiousness in interpretation because not all these incarcerated populations be generalizable to the whole incarcerated populations of a particular country. There was not much data on the female incarceration because of relatively fewer female incarcerated. Also, there was insufficient data on the average number of cigarettes smoked and the type of tobacco products. This study only focused on Western Europe, and even though a systematic review on this topic has been done worldwide, no pooled estimate of smoking was undertaken.<sup>4</sup>

Despite these limitations, our study findings can help inform policy targeting people in incarceration, especially in Western Europe.

### Conclusion

Our systematic review showed a very high prevalence of tobacco use among people incarcerated in Western Europe. The findings can inform policy makers and decision practitioners to consider gender-specific, comprehensive tobacco control policies across all Western European countries, targeting this vulnerable population. There is a need to shift focus on the incarcerated population for tobacco control interventions akin to improvements in smoking rates among the general population in Western Europe.

### Appendix I. The *pico*.

Population  
Prisoners

Exposure

Tobacco use—this can be in form of smoked tobacco, smokeless tobacco (dissolvable), waterpipe tobacco, cigars, cigarettes and electronic cigarette.

Comparison

General population—other population different from those in prison.

Outcome

Smoking prevalence(primary), effectiveness of tobacco control policies (secondary).

## Appendix II. MOOSE Guidelines for Meta-Analyses and Systematic Reviews of Observational Studies\*

	TOPIC	PAGE NUMBER
Title	Identify the study as a meta-analysis (or systematic review)	1
Abstract	Use the journal's structured format	1
Introduction	Present:	1
	The clinical problem	1
	The hypothesis	1
	A statement of objectives that includes the study population, the condition of interest, the exposure or intervention, and the outcome(s) considered	15
Sources	Describe:	
	Qualifications of searchers (e.g., librarians and investigators)	1
	Search strategy, including time period included in the synthesis and keywords	1, 2
	Effort to include all available studies, including contact with authors	3
	Databases and registries searched	1
	Search software used, name and version, including special features used (e.g. explosion)	1
	Use of hand searching (e.g., reference lists of obtained articles)	2
	List of citations located and those excluded, including justification	2, 22
	Method of addressing articles published in languages other than English	n/a
	Method of handling abstracts and unpublished studies	n/a
	Description of any contact with authors	3
Study Selection	Describe	
	Types of study designs considered	2
	Relevance or appropriateness of studies gathered for assessing the hypothesis to be tested	
	Rationale for the selection and coding of data (e.g., sound clinical principles or convenience)	n/a
	Documentation of how data were classified and coded (eg, multiple raters, blinding, and inter-rater reliability)	n/a
	Assessment of confounding (e.g. comparability of cases and controls in studies where appropriate)	n/a
	Assessment of study quality, including blinding of quality assessors; stratification or regression on possible predictors of study results	n/a
	Assessment of heterogeneity	3
	Statistical methods (e.g., complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	3
Results	Present	
	A graph summarizing individual study estimates and the overall estimate	9
	A table giving descriptive information for each included study	4-6

(Continued)





Continued.

SEARCH NUMBER	QUERY	RESULTS	TIME
33	(((((tobacco use AND ((ffrt[Filter]) AND (fha[Filter]) AND (humans[Filter]) AND (english[Filter]) AND (2010:2020[pdat]))) OR (tobacco chewing AND ((ffrt[Filter]) AND (fha[Filter]) AND (y_10[Filter]) AND (humans[Filter]) AND (english[Filter]))) OR (tobacco chewing AND ((ffrt[Filter]) AND (fha[Filter]) AND (humans[Filter]) AND (english[Filter]))) OR (tobacco consumption AND ((ffrt[Filter]) AND (fha[Filter]) AND (humans[Filter]) AND (english[Filter]))) OR (tobacco prevalence AND ((ffrt[Filter]) AND (fha[Filter]) AND (y_10[Filter]) AND (humans[Filter]) AND (english[Filter]))) OR (tobacco smoking prevalence AND ((ffrt[Filter]) AND (fha[Filter]) AND (y_10[Filter]) AND (humans[Filter]) AND (english[Filter]))) OR (cigar*smoking AND ((ffrt[Filter]) AND (fha[Filter]) AND (y_10[Filter]) AND (humans[Filter]) AND (english[Filter]))) OR (cigar* smoking AND ((ffrt[Filter]) AND (fha[Filter]) AND (y_10[Filter]) AND (humans[Filter]) AND (english[Filter]))))	1,842,706	17:03:42
32	cessation, smokeless tobacco	5297	17:01:35
31	smokeless tobacco cessation*	240	17:00:56
30	tobacco cessation*	5297	16:59:51
29	cessation*, tobacco use	5371	16:59:30
28	smoking cessation	8294	16:58:37
27	smoking compliance	1046	16:56:16
26	smoking intervention	33,675	16:56:04
25	tobacco program*	3170	16:55:47
24	tobacco use cessation	5297	16:55:31
23	tobacco control	6902	16:55:16
22	tobacco policy	3714	16:55:06
21	vulnerable	23,270	16:54:48
20	marginalized	1145	16:54:35
19	socially disadvantaged	3960	16:54:25
18	internee	7	16:53:56
17	detainees	102	16:53:42
16	incarcerat*	1726	16:53:17
15	correctional facilities	216	16:52:51
14	correctional setting	149	16:52:31
13	smoke-free prison	19	16:51:27
12	prisoner*	1920	16:50:55
11	cigar* smoking	11,154	16:50:30
10	cigar*smoking		
9	tobacco smoking prevalence	7612	16:50:07
7	tobacco prevalence	9887	16:48:42
6	tobacco consumption	18,376	16:48:27
5	tobacco consumption	26,121	16:48:19
3	tobacco chewing	26,121	16:46:26
4	tobacco chewing	18,376	16:46:10
2	tobacco use	18,942	16:44:36
1	tobacco use	26,121	16:44:02

## Appendix IV. Additional Studies Obtained

Because of our eligibility criteria which stated that already conducted review would not be included in this study, the references of an already conducted systematic review on the worldwide prevalence of tobacco use by Anne et al. in 2018<sup>4</sup> was searched, and we obtained an additional 9 articles of which two got excluded as they did not meet the criteria.

In addition to this, WHO report on trends in tobacco use 2019, the European region was also searched to get comparison data on tobacco prevalence among the general population for studies after 2015 (29) and WHO Tobacco Report 2015 was used for comparison data for studies before 2015.(24) Reported smoking prevalence was compared with the general population based on the country being looked at. The 2015 report had four indicators, and the years were divided by interval of five years 2000, 2005, 2010, 2015, 2020, 2025.(24) For any study conducted by the year 2015 and below, this report was used and the study year closest in a forward direction to any of the aforementioned years was used. The point estimate of current smoking trends of both sexes aged 15 and above was the indicator displayed in the table below during the extraction of data for this review. In contrast, for the 2019 report,(29) there were only two indicators used in this report which are current smoking and daily smoking because of the availability of data. However, for the purpose of this review, the author used data on current smoking by looking at the graph in the report showing the overall age-standardized estimate and giving a sense of precise estimate. It is also of importance to know that for mixed studies; meaning studies that had both sexes, the point estimate of both sexes calculated in the report already was used while for gender-specific studies, the point estimate of that particular sex was used.

## Appendix V. NIH Quality Appraisal For Included Studies

Criteria:

1. Was the research question or objective in this paper clearly stated?
2. Was the study population clearly specified and defined?
3. Was the participation rate of eligible persons at least 50%?
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?
5. Was a sample size justification, power description, or variance and effect estimates provided?
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?
10. Was the exposure(s) assessed more than once over time?
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?
12. Were the outcome assessors blinded to the exposure status of participants?
13. Was loss to follow-up after baseline 20% or less?
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?

STUDY AUTHORS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
a. Bania et al. 2016	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Other	Other	Yes
b. Vainnionpaa et al. 2019	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Other	Other	Yes
c. Geiotona and Miloni 2016	Yes	Yes	Yes	Yes	No	No	No	Yes	No	No	No	Other	Other	No
d. Muller et al. 2018	Yes	Yes	Yes	Yes	No	No	No	Yes	Other	No	No	Other	Other	Yes
e. Lind et al. 2015	Yes	Yes	No	Yes	No	No	No	Yes	Yes	No	Yes	Yes	Other	No
f. Nobile et al. 2011	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Other	Other	Yes

(Continued)

Continued.

STUDY AUTHORS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
g. Hiscock et al. 2013	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes
h. Makris et al. 2012	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Other	Other	Yes
i. Etter et al. 2012	Yes	Yes	No	No	No	No	No	Yes	Yes	No	Yes	Other	Other	Yes
j. Jayes et al. 2019	Yes	Yes	Other	Other	Other	Other	Yes	Yes	Yes	Yes	Yes	No	Other	No
k. Semple et al. 2020	Yes	Yes	Other	Other	Other	Other	Yes	Yes	Yes	Yes	Yes	Other	Other	No
l. Jacomet et al. 2016	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Other	Other	No
m. Celeen et al. 2012	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Other	Other	Yes
n. Chariot et al. 2014	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Other	Other	No
o. Mannocci et al. 2015	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Other	Other	Yes
p. Vera-Remartinez (2014)	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Other	Other	No
q. Ritter and Elger 2013	Yes	Yes	No	No	No	No	No	Yes	Yes	No	Yes	Other	Other	No
r. Mir et al. 2015	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Other	Other	No
s. Sahajian et al. 2012	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Other	Other	Yes
t. Sahajian et al. 2017	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Other	Other	Yes

## Appendix VI. Metaprop command for pooled estimate of smoking prevalence

STUDY	STUDYQUALITY	COUNTRY	GENDER	AGE	N	N	PRISONERS	GENPOP
Bania et al. 2016	good	Greece	mixed	43	552	552	79	44
Vainionpaa et al. 2019	good	Finland	mixed	35	110	100	88	18.5
Geitona and Milioni 2016	fair	Greece	female	37.5	135	101	83.8	30.8
Muller et al. 2018	good	Norway	mixed	32.8	1499	1464	81.3	21.6
Lind et al. 2019	fair	Finland	mixed	37.3	312	96	84	20.2
Nobile et al. 2011	good	Italy	male	39.8	908	650	67.5	30.8
Jacomet et al. 2016	fair	France	mixed	30	702	357	83.8	24.7
Ceelen et al. 2012	good	Netherlands	mixed	41	402	264	76	26.7
Chariot et al. 2014	fair	France	male	24	13317	10276	70	27.9
Makris et al. 2012	good	Greece	male	33.6	204	204	75.5	55.7
Mannocci et al. 2015	good	Italy	male	35	121	121	69.7	29
Vera-Remartinez et al. 2014	fair	Spain	male	37.4	1170	1022	71	29.9
Vera-Remartinez et al. 2014	fair	Spain	female	37.4	1170	55	58.2	22.3
Ritter and Elger 2013	poor	Switzerland	male	35	120	31	84	27.9
Mir et al. 2015	fair	Germany	female	34.3	338	150	81	23.3
Sahajian et al. 2012	good	France	female	31.5	851	535	57.9	22.6
Sahajian et al. 2017	good	France	mixed	31.6	710	457	74.4	24.7

## Appendix VII. Reasons for excluding eligible studies

STUDY AUTHOR	REASONS FOR EXCLUSION
1. Semple et al. 2017 (50)	This study focused only on nicotine concentration affecting prison staffs.
2. Jaka et al. 2014(51)	Though the study was on the prevalence of tobacco used but it was in Albania which is not in western Europe(the review's target population).
3. Brown et al. 2019(42)	Opinions about prisoners and prison staff view on smoking ban.
4. Jayes et al. 2016(52)	Nothing on prevalence as it only portrayed particulate matter concentration in four English prisons.
5. McCaffrey et al. 2012(45)	Study was on exposure of prison staff to environmental tobacco smoke and opinions on whether there should be a complete smoking ban. Although in the study discussion, prevalence of smoking in a 2000was mentioned to reference a point.
6. Robinson et al. 2018(53)	Thematic analysis.
7. Moffat et al. 2019(54)	Focused on prevalence of chronic oedema (CO) and wound in two vulnerable population.
8. Sweeting et al. 2019(55)	This study was on different structure of opinions with respect to prison smoking bans.
9. Caravaca-Sanchez et al. 2015(56)	Full text not in English; it was in Spanish.
10. Carnie and Broderick 2015(57)	Didn't fit to eligibility criteria because it was a survey report.
11. Pinto et al. 2015(58)	Full text wasn't open access as it was asking for authorization. Author tried accessing with the institution interlibrary loan access but access was denied.

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