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.1,2 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.3,4 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.5 Tobacco remains the most frequently used psychoactive drug among the incarcerated people– ranging from 64-90%, with variations across and within countries.6

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 problems compared to the general population.6,7 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,7 thus influencing the background risk of a specific community.8 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.1,9 Importantly, evidence suggests that tobacco use is three to four times higher in the incarcerated population compared to the general population.10-14 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 and provide a pooled estimate of recent 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
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 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 3).

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 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. 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

| Table 1. Inclusion and Exclusion Criteria. |
|------------------------------------------|
| Inclusion Criteria for Quantitative Synthesis |
| • Cross-sectional, cohort and case-control studies that reports simple prevalence will be included. (in Western Europe). |
| • Studies reporting co-use (tobacco and other substances). |
| • Studies that include prisoners with or without mental illness. |
| • Studies that report exposure of prisoners to second-hand smoke or environmental exposure. |
| • Studies that examine any type of anti-smoking intervention/smoking cessation programs within prison settings. |
| • Only published peer-reviewed literature and grey literature from international organizations such as WHO, United Nations (UN) will be included. |
| • Original studies published in English language from 2010-2020 in the electronic (PUBMED) database |
| Exclusion Criteria for Both Quantitative and Qualitative Synthesis |
| • 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. |
| • Studies not in English language. |
| • Studies that aren’t accessible. |
| • Studies that are non-human. |
| • Studies that focused on prisoners that only use other substances without using tobacco vaping (e-cigarettes). |
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. Forest plot was used to present the pooled estimate, with their corresponding 95% confidence intervals. Heterogeneity was explored through I² 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.

**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., 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 (I² 99.73%, \( P < .00 \)) (Figure 2). One study Vera-Remartinez (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).
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 (I² 99.4%, \(P = .00\)); “fair” quality studies had a pooled smoking estimate of 52.2% (95% CI 25.3–78.5), with significant heterogeneity (I² 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 (I² 99.7%, \(P = .00\)); pooled smoking estimate for studies on females only was 44.1% (95% CI 9.4–82.6) with significant heterogeneity (I² 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 (I² 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 at Table 2.

| 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)  | 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)      | Good    | Conducted interview to obtain information from prisoners. Self-report and prone to misclassification bias. Adjusted for confounders statistically.                                                      |
| Sahajian et al. (2017)      | 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)        | Good    | Face to face interview and self-reported questionnaire; did not account for confounding.                                                                                                              |
| 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                      |
| Vainionpaa 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                          | 86%                              | 18.5%         | Alcohol, age          | yes                      |
| Geitona and Milioni (2016) | 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%         | Not mentioned         | —                        |
| Muller et al. (2018)(21)  | Cross-sectional | Norway 2013-2014                        | Mean age = 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 routine use during incarceration. | N = 1499    | n = 1464                         | 81.3% (cigarette) 26.0% (smokeless tobacco) | 21.6%        | 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)    | Not mentioned         | —                        |
| Noble 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%         | 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 diseases and addictive behaviour                           | N = 702     | n = 267                          | 83.8%                             | 24.7%         | 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%         | Age, gender           | yes                      |
| Chariot et al. (2014)(26) | Prospective study (cross-sectional) | France, Jan 1 to Dec 31 2012         | Median = 24       | Male                  | Examining medical characteristics and addictive behaviours among police detainees                | N = 13,317  | n = 10,276                        | 70%                              | 27.9%         | Not mentioned         | —                        |
| Meletis et al. (2012)(33) | Cross-sectional | Greece, 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 Greek prisons | 204         | 75.5%                            | 55.7%                             | 1.36          | Smoking history, previous use of the addictive substance, the distinctive feature of their life in prison | —                        |

(Continued)
| STUDY | AUTHOR(YEAR) | STUDY DESIGN | REGION, STUDY PERIOD | AGE | SEX | PURPOSE | SAMPLE SIZE | SMOKING PREVALENCE IN PRISONERS | GENERAL POPULATION PREVALENCE(%) | 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, 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 | — | — |
| Mr et al. (2015)(30) | Cross-sectional | Germany, April 2012 and May 2013 | Mean age = 34.3±10 Mean age = 34.3±108 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 - obtained from each study
General population prevalence - obtained from WHO tobacco report 2015(24) and WHO report on trend in tobacco use 2019(25)
Fold increase: obtained by dividing prevalence of prisoners by prevalence of general population
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. 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. 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.

Our findings are in agreement with published literature demonstrating that the prevalence of tobacco use is
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.\textsuperscript{14} 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%.\textsuperscript{14} 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
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. 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                                                               | 1           |
| Identify the study as a meta-analysis (or systematic review)        |             |
| Abstract                                                             | 1           |
| Use the journal’s structured format                                 |             |
| Introduction                                                         | 1           |
| The clinical problem                                                 |             |
| 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 (e.g, 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)
Appendix III. Search Strategy-4th of June 2020 (sort by most recent, filter by abstract, free full text, in the last 10 years, humans, English)
| SEARCH NUMBER | QUERY | RESULTS | TIME     |
|---------------|-------|---------|----------|
| 33 | (((((tobacco use AND (ffrft[Filter]) AND (tha[Filter]) AND (humans[Filter]) AND (english[Filter]) AND (2010:2020[pdat]))) OR (tobacco chewing AND (ffrft[Filter]) AND (tha[Filter]) AND (humans[Filter]) AND (english[Filter]))) OR (tobacco chewing AND (ffrft[Filter]) AND (tha[Filter]) AND (humans[Filter]) AND (english[Filter]))) OR (tobacco chewing AND (ffrft[Filter]) AND (y_10[Filter]) AND (humans[Filter]) AND (english[Filter]))) OR (tobacco consumption AND (ffrft[Filter]) AND (tha[Filter]) AND (humans[Filter]) AND (english[Filter]))) OR (tobacco consumption AND (ffrft[Filter]) AND (tha[Filter]) AND (humans[Filter]) AND (english[Filter]))) OR (tobacco smoking prevalence AND (ffrft[Filter]) AND (tha[Filter]) AND (y_10[Filter]) AND (humans[Filter]) AND (english[Filter]))) OR (cigar* smoking AND (ffrft[Filter]) AND (tha[Filter]) AND (humans[Filter]) AND (english[Filter]))) OR (cigar* smoking AND (ffrft[Filter]) AND (tha[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 | internees | 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 | 149 | 16:50:27 |
| 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 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 and WHO Tobacco Report 2015 was used for comparison data for studies before 2015. 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. 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, 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 | No | Other | No  |
| d. Muller et al. 2018       | Yes | Yes | Yes | Yes | No | No | No | Yes | No | No | Yes | Other | No  | Yes |
| e. Lind et al. 2015         | Yes | Yes | No  | Yes | No | No | No | Yes | No | Yes | Yes | Other | No  | Yes |
| f. Nobile et al. 2011       | Yes | Yes | Yes | Yes | No | No | No | Yes | No | Yes | Yes | Other | Yes | (Continued) |
Appendix VI. Metaprop command for pooled estimate of smoking prevalence

| 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 | Yes | Yes | No | Yes | 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 | Other | Other | Yes |
| 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 | No | No | No | Yes | Yes | No | Yes | Other | Other | Yes |
| 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 |

| 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 | 41.4 | 402 | 264 | 76 | 26.7 |
| Chariot et al. 2014 | fair | France | male | 24.3 | 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 |
Tobacco Use Insights

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 2000 was 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. Carrie 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. |

REFERENCES

1. Murray CJL, Aravkin AY, Zheng P, et al. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. The Lancet. 2020;396(10258):1223–1249. Available from: https://www.who.int/news-room/detail/30-05-2017-world-no-tobacco-day-2017–beating-tobacco-for-health-prosperity-the-environment-and-national-development. 2017;389(10083):1885–1906. 3. Leal-López E, Sánchez-Queija I, Moreno C. Trends in tobacco use among adolescents in Spain; 2002–2018. Adicciones. 2019;31(4):289–297. Available from: http://www.adicciones.es/index.php/adicciones/article/view/1111 4. Spaulding AC, Eldridge GD, Chico CE, et al. Smoking in correctional settings worldwide: prevalence, bans, and interventions. Epidemiol Rev. 2018;40(1):82–95. Available from: https://academic.oup.com/epirev/article/40/1/82/4994065 https://academic.oup.com/epirev/article/40/1/82/4994065 5. Baybutt MR, Ritter C, Stöver H. Tobacco.use in prison settings: a need for policy implementation. 16. Denmark: WHO Regional Office for Europe; 2014. 6. Dumont DM, Brockmann B, Dickman S, Alexander N, Rich JD Public health and the epidemic of incarceration. Annual Review of Public Health. 2012;33:325–339. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3329888/ 7. Geitona M, Milioni SO. Health status and access to health services of female prisoners in Greece: a cross-sectional survey. BMJ health services research. 2016;16:243. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4940824/ 8. Stefan E, Lars M, Gauden G, Caroline U. Prisoners’ attitudes towards cigarette smoking and smoking cessation: a questionnaire study in Poland. BMC Public Health. 2006;6:181. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC204549/ 9. WHO. Europe. European tobacco use. Trends report 2019. Denmark: WHO Regional Office for Europe; 2019. Available from: https://www.euro.who.int/en/health-topics/disease-prevention/tobacco/publication/2019/european-tobacco-use-trends-report-2019–2019 10. WHO. WHO global report on trends in prevalence of tobacco smoking 2015. Denmark: World Health Organization; 2015. Available from: https://apps.who.int/iris/handle/10665/156262 11. Antometti G, D’Angelo D, Scampati P, et al. The health needs of women prisoners: an Italian field survey. Ann Ist Super Sanita. 2018;54(2):96-103. 12. Gambaryan M, Reeves A, Dee A, et al. Effects of tobacco control policy on cardiovascular morbidity and mortality in Russia. European journal of public health. 2018;28(suppl 2):14-16. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6204549/ 13. John U, Hanke M. Trends of tobacco and alcohol consumption over 65 years in Germany. Gms Gesundheitsw. 2018;80(2):160-171. 14. Sieminska A, Jassem E, Konopa K. Prisoners’ attitudes towards cigarette smoking and smoking cessation: a questionnaire study in Poland. BMC Public Health. 2006;6:181. Available from: https://doi.org/10.1186/1471-2458-6-181 15. WHO/Europe. European tobacco use. Trends report 2019. Denmark: WHO Regional Office for Europe; 2019. Available from: https://www.euro.who.int/en/health-topics/disease-prevention/tobacco/publication/2019/european-tobacco-use-trends-report-2019–2019 16. WHO. WHO global report on trends in prevalence of tobacco smoking 2015. Denmark: World Health Organization; 2015. Available from: https://apps.who.int/iris/handle/10665/156262 17. Libanari A, Almgren TD, Teraiff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ. 2009:339:b2700. Available from: https://www.bmj.com/content/339/bmj.b2700. 18. National Heart, Lung, and Blood Institute (NHLBI) [Internet]. Study Quality Assessment Tools. Bethesda, MA: NHLBI; 2020. Available from: https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools. 19. Bania EG, Danil J, Hatogolou C, Alexopoulos EC, Gonzaladinas K, Mitsi E. COPD characteristics and socioeconomic burden in Hellenic correctional institutions. Int J Chron Obstruct Pulmon Dis. 2016;11:341-349. 20. Vainionpää R, Tiuslaariemi K, Posenen P, Laatila ML, Anttonen V. Erosive tooth wear and use of psychoactive substances among Finnish prisoners. BMC Oral Health. 2019;19(1):97. 21. Muller AE, Harves IA, Rogeli EB, Bukten A. Inmate with Harmful Substance Use Increase Both Exercise and Nicotine Use Under Incarceration. Int J Environ Res Public Health 2018 27; 15(12). 22. Lind K, Skonen AH, Javrin-Tasoulosos J, Albo H, Castren S. Problem gambling and support preferences among Finnish prisoners: a pilot study in an adult correctional population. Int J Prison Health. 2019 05;15(4):316–331. 23. Noble CGA, Flotta D, Nicozera G, Pileggi C, Angelillo IF. Self-reported health status and access to health services in a sample of prisoners in Italy. BMC Public Health 2011 Jul;411:529.
24. Jacomet C, Guyot-Lénat A, Bonny C,Henquell C, Rude M, Dydymski S, et al. Addressing the challenges of chronic viral infections and addiction in prisons: the PRODEPIST study. Eur J Public Health [Internet]. 2016 Feb 1 [cited 2020 Jul 10];26(1):122–128. Available from: https://academic-oup-com.ucc.idm.oclc.org/eurpub/article/26/1/122/2467472

25. Creden M, Dorn T, Buster M, Stirbu I, Donker G, Das K. Health-care issues and health-care use among detainees in police custody. Journal of Forensic and Legal Medicine [Internet]. 2012 Aug 1 [cited 2020 Jul 11];19(6):324–331. Available at: http://www.sciencedirect.com/science/article/pii/S1752928X12000376

26. Chariot P, Beaufrie A, Denis C, Dang C, Vincent R, Boraud C. Detainees in police custody in the Paris, France area: medical data and high-risk situations (a prospective study over 1 year). Int J Legal Med [Internet]. 2014 Sep 1 [cited 2020 Jul 12];128(5):853–860. Available from: https://doi.org/10.1007/s00414-014-0990-4

27. Mannocci A, Musala D, Mipatirini D, Rizzo J, Meggiolaro S, Thieme DID, et al. The relationship between physical activity and quality of life in prisoners: a pilot study. J Prev Med Hyg. 2015;56(4):E172–175.

28. Vera-Remartín EJ, Borraz-Fernández JR, Domínguez-Zamorano JA, Morá-Purra LM, Casado-Hoces SV, González-Gómez JA, et al. Prevalence of chronic diseases and risk factors among the Spanish prison population. Revista Española de Sanidad Penitenciaria [Internet]. 2014 [cited 2020 Jul 12];128(5):853–860. Available from: http://scielo.isciii.es/scielo.php?script=sci_abstract&pid=S1575-0620201400038&lng=en&nrm=iso&tlng=en

29. Ritter C, Elger BS. Second-hand tobacco smoke in prison: Tackling a public health matter through research. Public Health [Internet]. 2013 Feb 1 [cited 2020 Jul 12];127(2):119–124. Available from: http://www.sciencedirect.com/science/article/pii/S0033350612004052

30. Mir J, Kastner S, Pribe S, Konrad N, Ströhle A, Mundt AP. Treating substance abuse is not enough: Comorbidities in consecutively admitted female prisoners. Addictive Behaviors [Internet]. 2015 Jul 1 [cited 2020 Jul 12];46:25–30. Available from: http://www.sciencedirect.com/science/article/pii/S030646031500088X

31. Sahajian F, Lamothe P, Fahy J, Vanhems P. Consumption of psychoactive substances among 535 women entering a Lyon prison (France) between June 2004 and December 2008. Rev Epidemid Sante Publique 2012 Oct;60(5):371–381.

32. Sahajian F, Berger-Vergiat A, Pot E. Use of psychoactive substances in prison: Results of a study in the Lyon-Corbas prison, France. Rev Epidemid Sante Publique 2017 Sep;65(5):361–367.

33. Makri E, Gourgoulianis KI, Hatzoglou C. Prisoners and cigarettes or "imprisoned in cigarettes"? What helps prisoners quit smoking? BMC Public Health 2012 Jul;12:508.

34. Fazel S, Yoon IA, Hayes AJ. Substance use disorders in prisoners: an updated systematic review and meta-regression analysis in recently incarcerated men and women. Addiction. 2017;112(10):1725–1739.

35. Sterne JAC, Sutton AJ, Ioannidis JPA, et al. Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised controlled trials. BMJ. 2011;343:d4002.

36. Hiscocock R, Murray S, Brose LS, et al. Behavioural therapy for smoking cessation: the effectiveness of different intervention types for disadvantaged and affluent smokers. Addict Behav. 2013;38(11):2787–2796.