Addictive Behaviors 148 (2024) 107854

Contents lists available at ScienceDirect

Addictive Behaviors

journal homepage: www.elsevier.com/locate/addictbeh

Effectiveness of smoking cessation interventions among pregnant women: An updated systematic review and meta-analysis

A. Vila-Farinas [a], M. Pérez-Rios [a,b,c,*], A. Montes-Martinez [a,b,c], A. Ruano-Ravina [a,b,c], Ariadna Forray [d], J. Rey-Brandariz [a], C. Candal-Pedreira [a,b], E. Fernández [e,f,g,h], B. Casal-Acción [i], L. Varela-Lema [a,b,c]

[a] Department of Preventive Medicine and Public Health, Universidade de Santiago de Compostela, Santiago de Compostela, Spain
[b] Health Research Institute of Santiago de Compostela, Santiago de Compostela, A Coruña, Spain
[c] Consortium for Biomedical Research in Respiratory Diseases (CIBER de Enfermedades Respiratorias/CibeRes), Madrid, Spain
[d] Department of Psychiatry, Yale School of Medicine, New Haven, CT, USA
[e] Tobacco Control Unit, WHO Collaborating Center for Tobacco Control, Institut Català d'Oncologia (ICO), Barcelona, Spain
[f] Tobacco Control Research Group, Institut d'Investigació Biomèdica de Bellvitge (IDIBELL), Barcelona, Spain
[g] School of Medicine and Health Sciences, Universitat de Barcelona, Barcelona, Spain
[h] CIBER of Respiratory Diseases (CIBERES), Madrid, Spain
[i] Galician Agency for Health Knowledge Management (avalia-t; ACIS), Santiago de Compsotela, Spain

ARTICLE INFO

Keywords:
Pregnancy
Interventions
Smoking
Cessation
Meta-analysis
Systematic review

ABSTRACT

Objective: To carry out a systematic review of systematic reviews with an update of the existing evidence relating to a broad range of smoking cessation interventions, including psycho-social, digital and pharmacologic interventions, for pregnant women.
Data-sources: Search was conducted in March 2022 in PubMed, EMBASE, and Cochrane in two stages: 1) a search of systematic reviews and meta-analyses, published from January 2012 through January 2022; 2) an update of those that fulfilled eligibility criteria reproducing the primary search strategy.
Study eligibility criteria: We selected randomized clinical trials (RCTs) that evaluated the effectiveness of pharmacological, digital, and psychosocial interventions in aged 18 years and over who were daily smokers, and compared these with routine care, less intense interventions or placebo.
Study appraisal and synthesis methods: Data from eligible studies were manually extracted by two authors and reviewed by a third. The quality of the reviews was evaluated using the AMSTAR scale, and risk of bias was measured with the Rob-2 tool and GRADE level of evidence.
Results: The meta-analysis included 63 RCTs (n = 19849 women). The interventions found to be effective were: financial incentives (RR:1.77; 95%CI:1.21–2.58), counseling (RR:1.27; 95%CI:1.13–1.43) and long-term nicotine replacement therapy (NRT) (RR:1.53; 95%CI:1.16–2.01). Short-term NRT, bupropion, digital interventions, feedback, social support, and exercise showed no effectiveness. The GRADE level of evidence was moderate-to-high for all interventions, with the exception of long-term NRT.
Conclusions: Non-pharmacological interventions for smoking cessation are the most effective for pregnant women. The moderator analysis suggests that pregnant women of low socioeconomic status might benefit less from smoking cessation interventions than women of a high socioeconomic status. These women are usually heavier smokers that live in pro-smoking environments and could require more intensive and targeted interventions.

1. Introduction

Tobacco and nicotine exposure during pregnancy is a preventable cause of obstetric and fetal complications (Homa et al., 2015). It is associated with ectopic pregnancy, miscarriage, placental abruption, fetal death, fetal growth restriction, premature birth, and low

* Corresponding author at: Área de Medicina Preventiva y Salud Pública, Universidad de Santiago de Compostela, Santiago de Compostela, Spain.
E-mail address: monica.perez.rios@usc.es (M. Pérez-Rios).

https://doi.org/10.1016/j.addbeh.2023.107854
Received 5 May 2023; Received in revised form 8 August 2023; Accepted 1 September 2023
Available online 3 September 2023

birthweight (Pineles et al., 2016; Fernandez-Rodriguez, 2022). In exposed infants it increases the risk of asthma and respiratory infections, sudden infant death syndrome, and can give rise to adverse neurodevelopmental and cardiovascular effects (World Drug Report, 2021; Míguez & Pereira, 2020). Long-term health effects related to prenatal and postnatal exposure to tobacco and nicotine include increased insulin resistance, dyslipidemia, arterial hypertension, arrhythmias, obesity and impaired lung development (Holbrook, 2016), which can persist until childhood or adult life (Banderali et al., 2015). Offspring from smoking mothers have been seen to have increased risk of diminished lung function, asthma, wheezing, apnea and viral infections in childhood (De Queiroz et al., 2020). Maternal smoking has also been associated with an increased risk of lung diseases in adulthood, such as Chronic Obstructive Lung Disease (Duan et al., 2021). Recently, several studies have suggested that tobacco and nicotine can induce genomic and epigenetic changes, such as alterations in DNA methylation. These permanent derangements could adversely affect life-long health but also impact in future generations, as these epigenetic changes may be transmitted transgenerationally (Nakamura et al., 2021; Torchin et al., 2020; Leslie, 2013)."

Despite the fact that the population is increasingly better informed, and that great efforts have been made to educate women and raise their awareness about the harmful effects of tobacco use on the fetus, 53.0% of women in the world, who smoke daily, do not quit smoking during pregnancy (Lange et al., 2018). It is estimated that 1.7% of women worldwide smoke during pregnancy; with a prevalence of 5.9% in America and 8.1% in Europe (Lange et al., 2018).

Since the 1990s, different types of interventions targeted at smoking cessation in pregnant women have been reported (Lange et al., 2018; Haug et al., 1994). Many of these interventions have been individually evaluated in different systematic reviews and are presumed to be effective and safe for smoking cessation in pregnant women (Claire et al., 2020; Chamberlain et al., 2017; Griffiths et al., 2018). However, existing systematic reviews present important gaps and shortcomings. The most recent systematic review and meta-analysis on pharmacological interventions (Claire et al., 2020), despite of being methodologically sound, does not cover the potential implications of implementing these interventions in practice. With regards to the latest systematic review and *meta*-analysis on psychosocial interventions (Chamberlain et al., 2017), authors themselves note that this review requires updating given that trials with a large sample size were published during the preparation of the review. In the only high-quality systematic review and meta-analysis on digital interventions (Griffiths et al., 2016), several of the studies included computer-based interventions where computer programs were accessed on laptops in midwifery clinics or in private rooms of a prenatal care clinic. Given the evolution in the use of digital interventions, findings cannot always be extrapolated over time as digital interventions nowadays mainly include apps that can be accessed via women's personal smartphone/computer at a time which is convenient to them. In addition, the inclusion criteria of these reviews differ, and this constitutes a limitation when it comes to comparing the most effective intervention (Aromataris et al., 2015). We feel that a thorough analysis could be critical for research and clinical decision making because the wide range of existing systematic reviews with different methodological standards can lead to confusion regarding the extrapolation of results (Ioannidis & Trikalinos, 2007).

2. Objective

The objective of the current paper is to carry out a systematic review of systematic reviews with an update of the existing evidence relating to a broad range of smoking cessation interventions, including pharmacologic, psycho-social and digital mobile interventions, exploring moderating factors and feasibility issues. The study aims to provide an answer to the following clinical question: what is the effectiveness of psycho-social, digital and pharmacologic interventions for smoking cessation biochemically confirmed in comparison to routine care administered in prenatal care, which may include a less intense intervention than the intervention in question for psycho-social or digital interventions or a placebo group for the pharmacologic interventions.

3. Methods

We conducted an updated Systematic Review and Meta-Analysis following the **P**referred **R**eporting **I**tems for **S**ystematic Reviews and **M**eta-**A**nalyses (PRISMA 2020) guidelines (Page et al., 2022). The study protocol was registered in the PROSPERO database (reference CRD42022309530).

3.1. Bibliographic search

This was conducted by an information specialist in two stages:

A search was conducted in the MEDLINE (PubMed), EMBASE, and Cochrane databases on January 2022 to identify systematic reviews and meta-analyses published, which evaluated the effectiveness of interventions targeted at smoking cessation during pregnancy. For search purposes, we used MeSH terms and free terms, which were combined using boolean operators. The following keywords were used: "smok*", "tobacco", "program*", "intervention", "strategies", "national health program", "cessation", "quit*", and "pregnan* (Supplementary Files 1). High-quality systematic reviews and meta-analyses were included and evaluated using **A** **M**ea**S**urement **T**ool to **A**ssess systematic **R**eviews (AMSTAR version 2 (Shea et al., 2017). We excluded narrative reviews and other types of non-systematic reviews, clinical practice guidelines, clinical protocols, technical reports, and other evidence-based documents. No language restrictions were applied to the search.

We carried out an update of the most recent high quality systematic reviews and meta-analyses identified for each type of intervention (pharmacological, digital, and psychosocial) to identify new randomized controlled trials (RCTs). The search for new RCTs was performed on March 2022 reproducing and adapting the original search strategy (Claire et al., 2020; Chamberlain et al., 2017; Griffiths et al., 2018). The search strategy was rerun again in March 2023 to update records. In addition, we conducted an additional search in the International Clinical Trials Registry Platform (World Health Organization).

3.2. Selection of studies included in the review

To identify studies that met the eligibility criteria, two researchers (AVF and LVL) separately screened the titles and abstracts of primary studies included in selected systematic reviews and meta-analyses, as well as those identified in the update. The full text of potentially relevant studies were read to decide on final compliment. Where there were differences of opinion, these were settled by consensus.

The updated systematic review included all randomized clinical trials (RCTs) that fulfilled the following PECOS (**p**atient, **e**xposure, **c**omparator, **o**utcomes and **s**tudy design) criteria: a) they included pregnant women aged 18 years and over who smoked conventional cigarettes; b) they evaluated interventions targeted at smoking cessation; c) the comparison group was routine care administered in prenatal care, a less intense intervention than the intervention in question, or the placebo group in the pharmacologic interventions; d) they evaluated effectiveness by reporting smoking abstinence during the second or third trimester of pregnancy, confirmed biochemically by reference to carbon monoxide (CO), thiocyanate, and/or cotinine (the cut-off points are provided in Supplementary Files 2); and e) they furnished relative risks (RRs) or the necessary data to calculate these, along with their respective confidence intervals (95%CIs). Studies published in languages different to English, Spanish, French, Portuguese and Italian were excluded.

3.3. Data-extraction and synthesis

Data from RCTs that fulfilled the eligibility criteria were manually extracted using a pre-designed and adapted data-extraction sheet (Supplementary Files 2). Two independent researchers (AVF & LVL) performed the extraction and it was reviewed by a third researcher (MPR).

For the purpose of ascertaining effectiveness, interventions were classified into 1) pharmacological, differentiating between nicotine replacement therapy (NRT) and bupropion; 2) digital (when the intervention was carried out exclusively by means of an electronic device, without the participation of health professionals); and 3) psychosocial. In the case of psychosocial interventions, a distinction was drawn between: a) counselling: providing motivation to quit smoking, and enhancing problem-management and -solving skills; b) feedback: measuring and reporting CO and/or cotinine results, and informing mothers about the consequences of their CO and/or cotinine concentrations on fetal health status; c) incentives: rewarding smoking cessation financially (in cash or by voucher); d) social support: providing the support of a "peer", health professional, or partner; and e) exercise: giving structured support to the performance of exercise, with the aim of promoting smoking cessation. All interventions that involved personal support to quit were coded as psychosocial, with independence of whether they were accompanied or not by other interventions (pharmacologic, counselling, incentives, feedback, etc.), were provided face-to-face, by phone or digital means.

No health education interventions were included since these already form part of routine pregnancy care in most countries.

3.4. Meta-analysis

We extracted or calculated the RRs and 95% CIs of each of the RCTs. Heterogeneity in the studies was assessed using Cochran's Q test and estimation of the I^2 statistic (Bowden et al., 2011; Higgins et al., 2003), and classified as low (0%–30%), moderate (>30%–60%), substantial (>60%–90%), or considerable (>90%–100%) (Higgins and Green, 2011). We applied a random effects model, to account for heterogeneity not explained by known factors and performed a sensitivity analysis to explore the impact of removing each of the studies from the meta-analysis. Where the number of studies allowed for it, an meta-analysis by subgroup was performed. When subgroups included ≤3 studies, a narrative synthesis was conducted.

In the case of pharmacologic interventions, a distinction was drawn between bupropion, short-term NRT (chewing gum and nicotine inhalers), and long-term NRT (nicotine patches); and in the case of psychosocial interventions, a distinction was drawn between counseling, feedback, incentives, social support, and exercise. Moderator analyses were also carried out, whenever information was available, to explore the influence of the country of the study, year of publication, and socioeconomic status/financial income of participants. The rationale for performing a moderator analysis for studies on digital interventions published before and after 2000 was that the delivery of digital smoking-cessation interventions changed substantially after the 21st century given the exponential growth and evolution of mobile devices. The emergence of a wide range of tools and applications allowed for complex interventions to be delivered via women's personal phone/computer at a time which is convenient to them.

Funnel plots were used to evaluate publication bias, which was then validated by means of Egger's regression asymmetry test (Egger et al., 1997) (p-value < 0,1, confirms the existence of bias). All statistical analyses were performed using the RevMan (Version 5.4.1; Cochrane Collaboration, Oxford, United Kingdom) and Stata v17 computer software programs.

3.5. Evaluation of study quality and level of evidence

Risk of biases in the RCTs was assessed by applying the Cochrane Handbook guidelines and using the Rob-2 tool (Sterne et al., 2019). For study purposes, the following six types of bias were considered: selection, blinding, attrition/exclusion, reporting, biochemical confirmation and incomplete implementation. Studies were separately assessed by two independent researchers (AVF and LVL), and in any case where there were differences of opinion, these were settled by consensus with a third researcher (MPR).

The level of evidence was evaluated with the GRADE tool (Guyatt et al., 2008). The quality of the evidence was classified as high, moderate, low or very low, by reference to risk of bias, consistency, uncertainty as to whether the evidence was direct, accuracy, and publication bias.

4. Results

4.1. Search results

The bibliographic search identified 156 systematic reviews or meta-analyses published in the last ten years. Following the screening of titles and abstracts, 12 were preselected for a reading of the full text (Claire et al., 2020; Chamberlain et al., 2017; Griffiths et al., 2018; Rathbone & Prescott, 2017; DeNicola et al., 2020; Peer et al., 2020; Myung et al., 2012; Overdijkink et al., 2018; Hemsing et al., 2012; Hussain et al., 2020; Heslehurst et al., 2020; Wilson et al., 2018). Of these, three (Claire et al., 2020; Chamberlain et al., 2017; Griffiths et al., 2018) systematic reviews and meta-analyses were rated as being high-quality by the AMSTAR-2 tool (Shea et al., 2017) and subsequently selected for updating. These reviews included 63 RCTs that met the inclusion/exclusion criteria. As result of the update, 8 additional RCTs were identified.

Fig. 1 shows the flow chart of the studies included in accordance with the PRISMA 2020 guidelines (Page et al., 2021). The flow chart includes the reasons for exclusion of systematic reviews or meta-analysis as well as RCTs derived from the updated search that were read at full text. The main characteristics of the studies are summarized in the Supplementary Files 2.

4.2. Pharmacological interventions

4.2.1. Characteristics of studies included

Twelve RCTs (Wisborg et al., 2000; Kapur et al., 2001; Hotham et al., 2006; Pollak et al., 2007; Oncken et al., 2008; Coleman et al., 2012; El-Mohandes et al., 2013; Berlin et al., 2014; Oncken et al., 2019; Stotts et al., 2015; Nanovskaya et al., 2017; Kranzler et al., 2021) contributed data on pharmacologic interventions (n = 2505 pregnant women) to the *meta*-analysis. The RCTs came from the USA (n = 7), Netherlands (n = 1), Canada (n = 1), France (n = 1), United Kingdom (n = 1), and Australia (n = 1). Nine (Wisborg et al., 2000; Kapur et al., 2001; Hotham et al., 2006; Pollak et al., 2007; Oncken et al., 2008; Coleman et al., 2012; El-Mohandes et al., 2013; Berlin et al., 2014; Oncken et al., 2019) evaluated the effectiveness of NRT (n = 2336 pregnant women), two (Oncken et al., 2008; Oncken et al., 2019) evaluated short-term NRT, and seven (Wisborg et al., 2000; Kapur et al., 2001; Hotham et al., 2006; Pollak et al., 2007; Coleman et al., 2012; El-Mohandes et al., 2013; Berlin et al., 2014) evaluated long-term NRT. The remaining three (Stotts et al., 2015; Nanovskaya et al., 2017; Kranzler et al., 2021) evaluated the effectiveness of bupropion (n = 169 pregnant women). In all the RCTs that assessed pharmacologic interventions, the control group was treated with placebo in the same presentation.

4.2.2. Effectiveness of pharmacologic interventions

The results of the meta-analysis showed that NRT slightly increases smoking cessation versus placebo (RR: 1.37; 95%CI:1.08–1.74, I^2 =

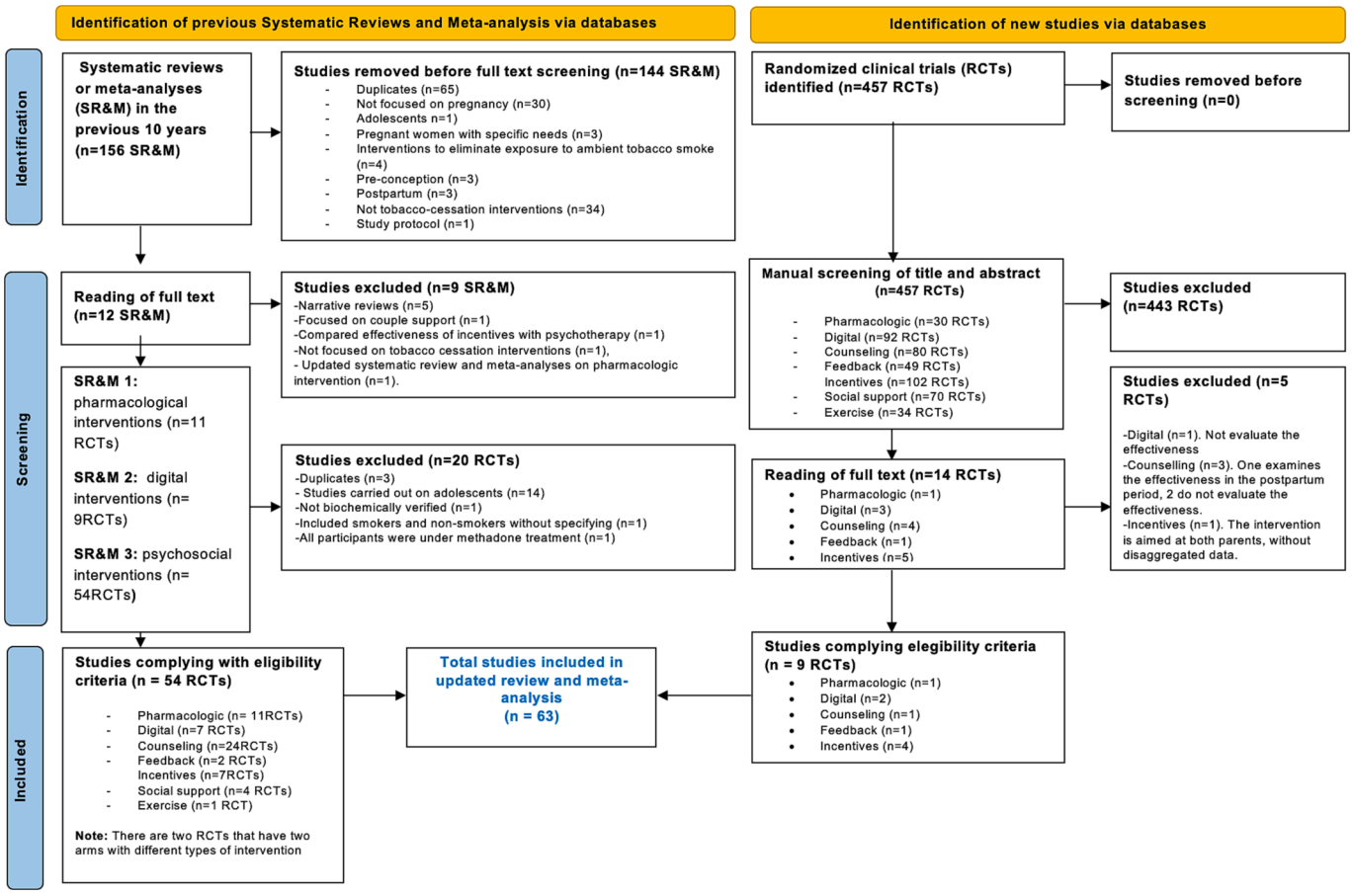

Fig. 1. . Flow chart of studies included in accordance with the PRISMA 2020 guidelines.

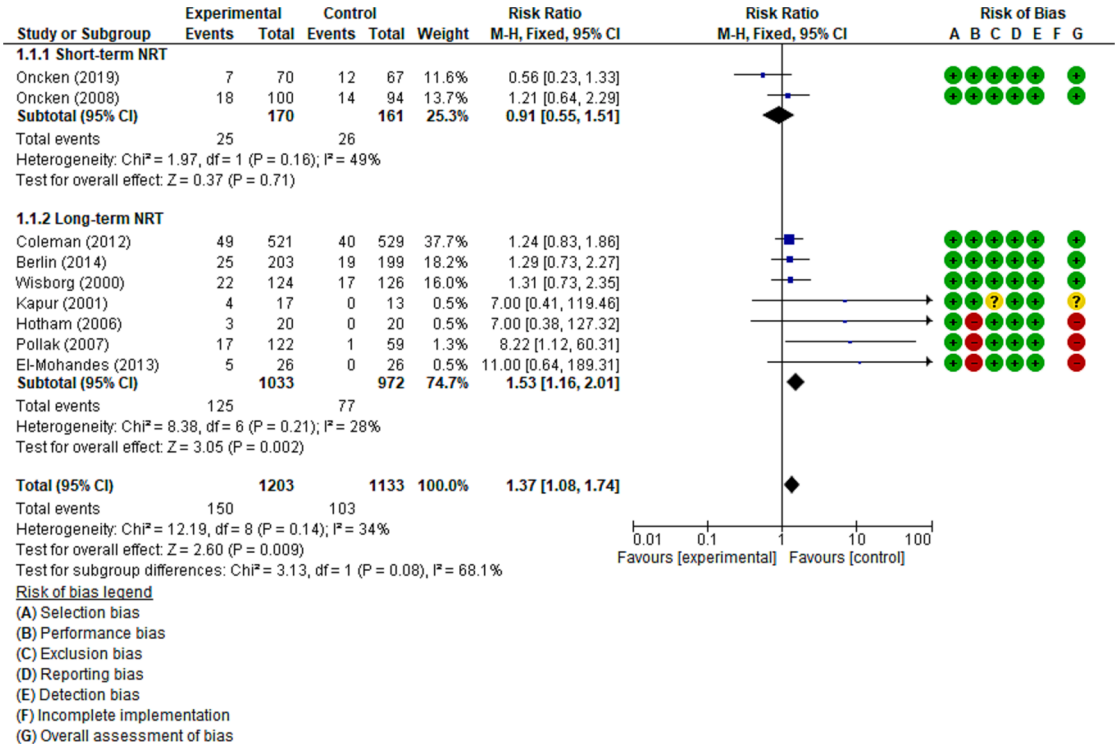

Fig. 2. . Forest plot of the meta-analysis of random effects of the association between NRT and biochemically-confirmed smoking cessation.

34%) (Fig. 2). By subgroups, short-term NRT did not show higher effectiveness (RR: 0.91, 95%CI: 0.55–1.51, $I^2 = 49\%$) whilst long-term NRT was significantly effective for smoking cessation among pregnant women (RR: 1.53, 95%CI: 1.16–2.01, $I^2 = 28\%$). No differences were observed in the moderator analysis by country of origin (n = 2336 pregnant women) (Supplementary Files 5). The funnel plot (Supplementary Files 3) and Egger's test ($p = 0.0481$) pointed to a potential borderline publication bias.

No differences were found between bupropion and placebo for smoking cessation during pregnancy (RR: 0.65, 95%CI: 0.31–1.35, $I^2 = 0\%$) (Fig. 3). When the sensitivity analysis was performed, none of the studies substantially modified the effect. The funnel plot (Supplementary Files 3) and Egger's test ($p = 0.95$) were consistent as to the non-existence of publication bias.

The GRADE level of evidence was low for long-term NRT and moderate for short-term NRT and bupropion (Supplementary Files 4).

4.3. Digital interventions

4.3.1. Characteristics of studies included

For *meta*-analysis purposes, nine RCTs (n = 1575 pregnant women) conducted in the USA (n = 6), United Kingdom (n = 2) and Turkey (n = 1), were included. In one of the RCTs, the intervention consisted of mailing participants a v.ideo containing six 25–30 min cartoons that addressed different smoking cessation-related topics (Cinciripini et al., 2000). Five used text messages with different strategies ranging from information on beliefs, motivation, and a 5A-based intervention to scheduled gradual reduction (Naughton et al., 2012; Pollak et al., 2013; Abroms et al., 2017; Naughton et al., 2017; Forinash et al., 2018). One study used WhatsApp messages based on the transtheoretical model (Balmumcu & Ünsal, 2021), one a v.ideotape based on social learning theory (Secker-Walker et al., 1997) and one an interactive computer program, which provided customized messages from a voice model (Ershoff et al., 1999).

The comparator was routine care (guidelines, pamphlets, brief advice, etc.), except in two studies, which respectively used informative text messages about smoking (Pollak et al., 2013) and informative telephone messages about general health (Abroms et al., 2017).

4.3.2. Effectiveness of digital interventions

Overall, the results of the meta-analysis showed no significant association for digital interventions (RR:1.30 95%CI: 0.95–1.77; $I^2 = 24\%$) (Fig. 4). In the subgroup analysis by year (n = 1575 pregnant women), digital interventions showed no effectiveness for smoking cessation before the year 2000 (RR: 2.40, 95%CI: 0.12–47.50, $I^2 = 78\%$) but a significant association was found in studies published after the year 2000 (RR: 1.44, 95%CI: 1.08–1.92, $I^2 = 0\%$). No differences were observed in the moderator analysis by socioeconomic status or country (n = 1575 pregnant women) (Supplementary Files 5). When the sensitivity analysis was performed, none of the studies substantially modified the effect. The funnel plot (Supplementary Files 3) and Egger's test (p = 0.28) indicated the absence of publication bias.

The GRADE level of evidence was moderate (Supplementary Files 4).

4.4. Psychosocial interventions

Characteristics of studies included

A total of 44 RCTs (n = 15733 pregnant women) from the USA (n = 30), United Kingdom (n = 6), Greece (n = 1) Netherlands (n = 1), New Zealand (n = 2), Australia (n = 2) and France (n = 1) were included: the breakdown showed 25 RCTs on counseling (n = 11425 pregnant women), 3 on feedback (n = 664 pregnant women), 11 on incentives (n = 2289 pregnant women), 4 on social support (n = 570 pregnant women), and one on exercise (n = 785 pregnant women). In all but four studies (Parker et al., 2007; Cope et al., 2003; Higgins et al., 2014; Harris & Reynolds, 2015) the control group received routine care. In Parker's et al. study (Parker et al., 2007) the intervention arm received motivational telephone calls and incentives (raffle) and the control arm a self-guide and a v.ideo. Cope et al. (2003) compared the use of a point-of-care test that provided visual and numerical feedback of cotinine levels with routine care and monitoring of cotinine without delivery of results; Higgins et al. (Higgins et al., 2014) evaluated two different schemes of financial incentives; the provision abstinence-contingent vouchers versus non-contingent vouchers provided to controls with independence of smoking status and Harris et al. (Harris & Reynolds, 2015) assessed the delivery of intensive telephone counselling calls in comparison to the delivery of incentives (vouchers) if women sent v. ideos demonstrating abstinence using CO monitors (Supplementary Files 2).

- *Counselling*

In two RCTs (Dornelas et al., 2006; El-Mohandes et al., 2011) the intervention consisted of face-to-face psychotherapy sessions. The rest of RCTs (Secker-Walker et al., 1997; Ershoff et al., 1999; Parker et al., 2007; Tappin et al., 2000; Hajek et al., 2001; Stotts et al., 2002; Hegaard et al., 2003; McLeod et al., 2004; Pbert et al., 2004; Tappin et al., 2005; Rigotti et al., 2006; Patten et al., 2010; Windsor et al., 2011; Lee et al., 2015; Loukopoulou, 2018; Ershoff et al., 1989; Gielen et al., 1997; Hartmann et al., 1996; Kendrick et al., 1995; Panjari et al., 1999; Walsh et al., 1997; Windsor et al., 1985; Heil et al., 2008; Solomon et al., 2000) used motivation-based interventions; 10 were face-to-face (Secker-

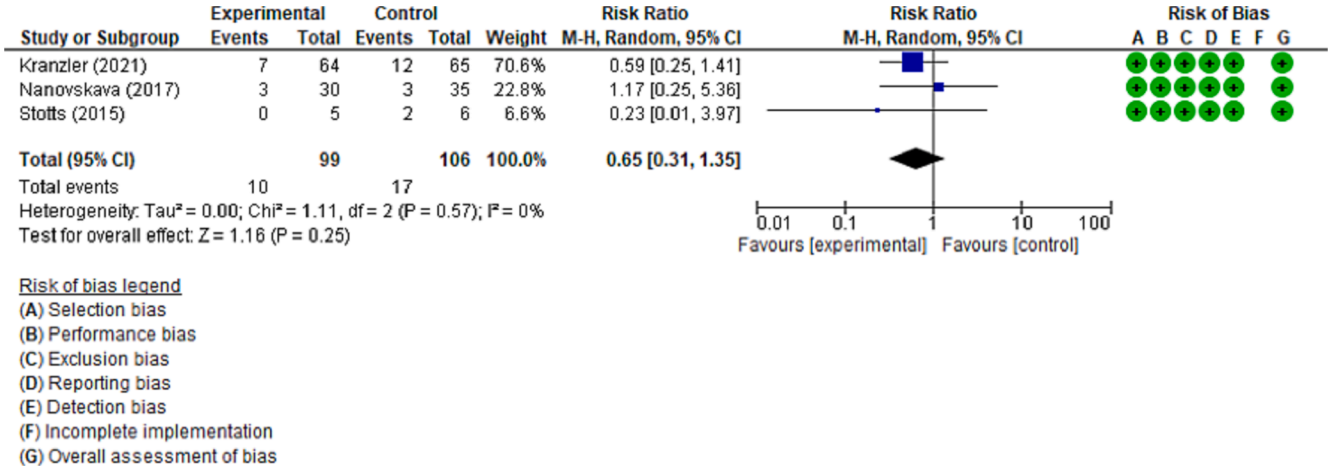

Fig. 3. . Forest plot of the meta-analysis of random effects of the association between bupropion and biochemically-confirmed smoking cessation.

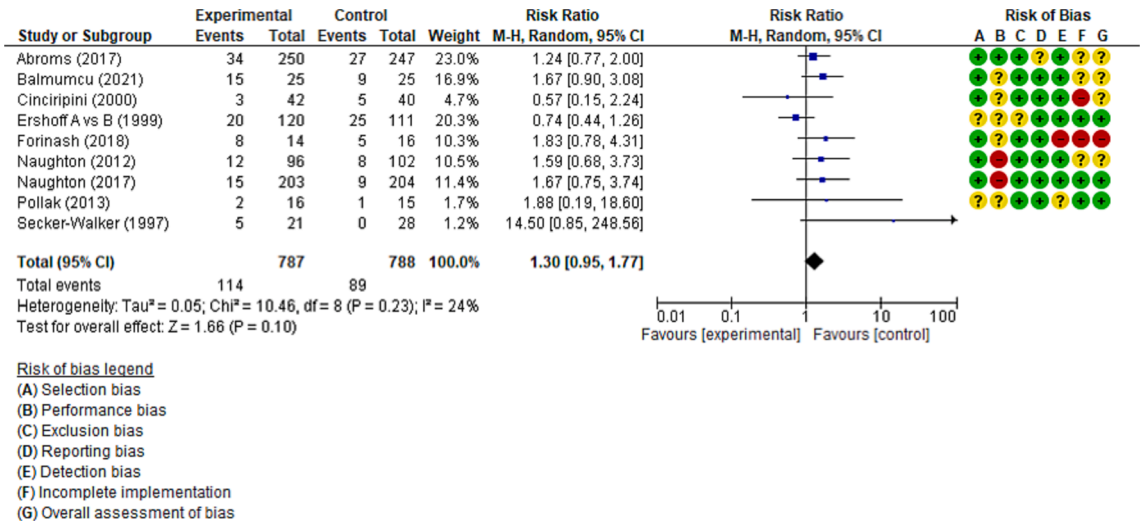

Fig. 4. . Forest plot of the meta-analysis of random effects of the association between digital interventions and biochemically-confirmed smoking cessation.

Walker et al., 1997; Ershoff et al., 1999; Tappin et al., 2000; Hajek et al., 2001; Stotts et al., 2002; McLeod et al., 2004; Pbert et al., 2004; Tappin et al., 2005; Rigotti et al., 2006; Patten et al., 2010; Windsor et al., 2011; Loukopoulou, 2018; Ershoff et al., 1989; Gielen et al., 1997; Hartmann et al., 1996; Kendrick et al., 1995; Panjari et al., 1999; Walsh et al., 1997; Windsor et al., 1985) and 3 (Parker et al., 2007; Rigotti et al., 2006; Patten et al., 2010) were by telephone. Lee et al. (2015) combined a face-to-face approach during pregnancy with the use of a phone call after delivery. In addition to phone counselling, Parker et al.'s study (Parker et al., 2007) included a second arm offering raffles ($100) in which subjects could only participate after 30 days of abstinence (the results of this arm are provided under incentives). Hegaard et al. (2003) combined in-person motivation with the offer of NRT in the form of patches or chewing gum. Of the women participating in the trial, 86.0% used NRT.

- *Biochemical feedback*

The intervention consisted in all cases of informing the mother of the cotinine results, in saliva (Stotts et al., 2009) or in urine (Cope et al., 2003; Patten et al., 2019), and the risks to the fetus of smoking. In all studies (Cope et al., 2003; Stotts et al., 2009; Patten et al., 2019), the information was relayed to participants by letter and telephone, with the single exception of an intervention arm in Stotts et al.'s study (Stotts et al., 2009) where the mothers were informed during the obstetric ultrasonography.

- *Incentives*

Four RCTs (Heil et al., 2008; Ondersma et al., 2012; Kurti et al., 2020; Berlin, 2021) evaluated the use of direct financial incentives if smoking abstinence was biochemically confirmed. The amounts handed out ranged from $25 in vouchers (Glover et al., 2015) to €520 in cash (Berlin, 2021). In four RCTs (Higgins et al., 2014; Harris & Reynolds, 2015; Glover et al., 2015; Olson et al., 2019), participants were given exchangeable vouchers to purchase a range of articles of their choice, excluding baby formula, alcohol, or tobacco. The vouchers were handed over after smoking abstinence had been biochemically confirmed. In one intervention arm in Parker et al.'s study (Parker et al., 2007), a raffle was held ($100) in which subjects could only take part after providing proof of 30 days' abstinence.

- *Social support*

In four RCTs (Solomon et al., 2000; Malchodi et al., 2003; Bullock et al., 2009; Hennrikus et al., 2010), a health professional provided support to pregnant women; and in one of these (Bullock et al., 2009), pregnant women also had 24-hour telephone access to a nurse.

- *Exercise*

In the RCT included (Ussher et al., 2015), in addition to behavioral support, participants were offered a physical activity intervention combining supervised exercise and physical activity consultations.

4.4.1. *Effectiveness of psychosocial interventions*

The results of the meta-analysis showed that psychosocial interventions were effective for the purpose of quitting smoking during pregnancy (RR:1.41; 95%CI:1.25–1.59; I^2 = 39%). The funnel plot (Supplementary Files 3) and Egger's test (p = 0.02) indicated lack of publication bias.

When the analysis was performed by subgroup, counselling and incentives were significantly associated with smoking cessation: RRs of 1.27 (95%CI:1.13–1.43; I^2 = 18%) and 1.77 (95%CI:1.21–2.58; I^2 = 64%), respectively. In the sensitivity analysis, Parker's study (Parker et al., 2007) substantially modified the effect, and after excluding it, the RR was 2.05; (95%CI: 1.50–2.81; I^2 =36%). Social support (RR: 1.18; 95%CI: 0.82–1.72; I^2 = 0%) and feedback 1.67 (95%CI: 1.00–2.80; I^2 = 21%), was not associated with smoking cessation. The results of the only study on physical exercise showed no impact on smoking cessation during pregnancy (RR: 1.20; 95%CI: 0.72–2.00) (Fig. 5).

Moderator analyses have been performed by year, socioeconomic level and country (Supplementary Files 5) for counselling, biochemical feedback and incentives. For counselling, differences were only observed by country (n = 664 pregnant women): significant association was observed in the USA (RR:1.20; 95%CI:1.06–1.36; I^2 = 4%), Australia/New Zealand (RR:1.55;95%CI: 1.08–2.24; I^2 = 14%) and Europe (RR:2.49; 95%CI: 1.48–4.19; I^2 = 0%), while no significant association was observed in the UK (RR: 1.09; 95%CI: 0.85–1.41; I^2 = 0%). For biochemical feedback, the only study conducted in UK (n = 244 pregnant women) (Cope et al., 2003) show a significant association (RR: 3.88; 95%CI: 1.38–10.93; I^2 = 0%); whereas the two studies (n = 420) (Stotts et al., 2009; Patten et al., 2019) conducted in the USA showed a non-significant association (RR: 1.35; 95%CI: 0.81–2.25; I^2 = 0%). For incentives (n = 2289 pregnant women), no significant association was observed in pregnant women with a low socioeconomic status (RR: 1.29; 95%CI:0.86–1.94; I^2 = 38%); whereas the association was significant for women who were not of a low socioeconomic status (RR: 2.71; 95%

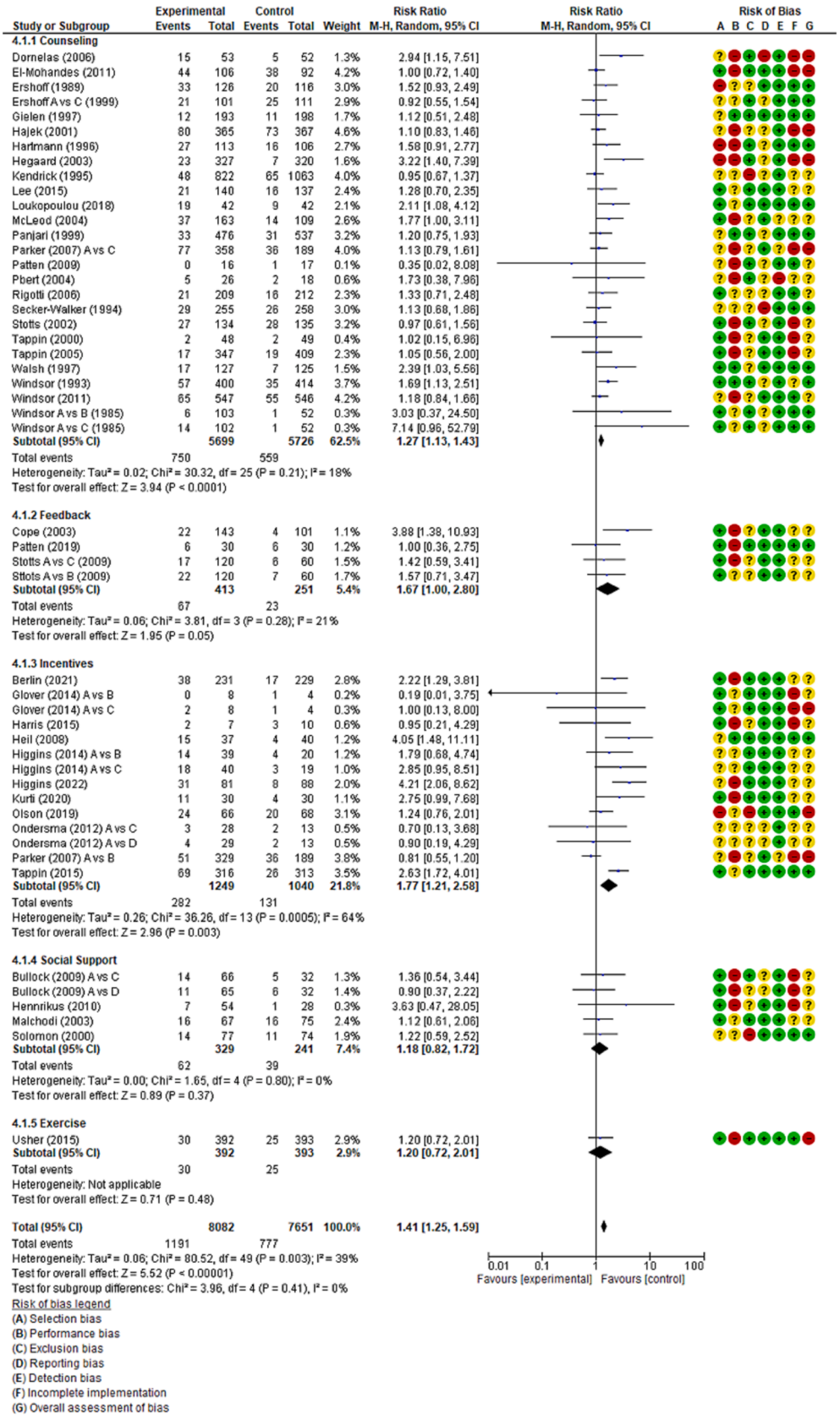

Fig. 5. . Forest plot of the meta-analysis of random effects of biochemically-confirmed psychosocial interventions.

CI:2.03–3.63; $I^2 = 0\%$).

The GRADE level of evidence was high for counseling, feedback, and incentive interventions, and moderate for social support and exercise (Supplementary Files 4).

Whilst acknowledging that the lack of blinding could be a concern, studies were not rated down for this reason because it is not feasible to blind participants to the intervention.

5. Comment

5.1. Principal finding

Existing evidence is not consistent regarding the effectiveness of pharmacological interventions for smoking cessation during pregnancy. Among the non-pharmacologic interventions, those that have shown the highest rates of abstinence are financial incentives, followed by digital and counseling interventions. The moderator analysis shows that pregnant women of low socioeconomic status do not show significant benefits from economic incentives or counseling interventions. These women are usually heavier smokers that live in pro-smoking environments and could require more intensive and targeted interventions. The effect of other interventions, such as social support and feedback, could not have been fully assessed due to the lack of studies.

5.2. Comparison with existing literature

The harmful health effects of tobacco have been well documented for decades, and a wide range of interventions targeted at smoking cessation during pregnancy have been assessed during this time. However, the net impact of interventions for smoking cessation among pregnant women is not satisfactory, since almost 50% of women continue smoking during pregnancy (Lange et al., 2018). Tobacco therefore ranks as the most important modifiable risk factor on which professionals who attend pregnant women should focus their efforts. Clinical practice guidelines, published by different health systems (Verbiest et al., 2017), offer a series of general recommendations as regards the various interventions that can be effective for quitting smoking, including pharmacological interventions, counseling, professional support, digital interventions, and feedback, but do not indicate which could be most effective. Currently, a great deal of controversy exists regarding these interventions, especially surrounding pharmacologic interventions, due to the potential risk posed to the pregnant woman and fetus, which brings in a precautionary principle. Whereas the guidelines of Norway (Røykeavvenning-nasjonale-retningslinjer, 2022), Scotland (Health Education Board for Scotland, 2004), USA (Panel TU and DG, 2008), Japan (JCS, 2010) and Kyrgyzstan (2022) recommend that NRT and/or bupropion should not be administered to pregnant women, both the Australian (Australian Government Department of Health, 2018) and Canadian guidelines (CAN-ADAPTT, 2011) recommend NRT after other alternatives have been explored. In the United Kingdom, the National Health Service guideline (NICE, 2022) proposes NRT use in the event of the expectant mother being unable to quit smoking, arguing that it is a less harmful option than smoking itself. The US Preventive Services Task Force guidelines (2021) leave prescription of bupropion to the discretion of the medical doctor who attends the pregnant woman, and urge physicians to consider the severity of tobacco dependence individually.

In several countries that consider pharmacological treatment, the intermittent dosing forms of short-term NRT (e.g., chewing gum, nasal and oral aerosols) are recommended as preferred pharmacotherapy to patches (Australia (Australian Government Department of Health, 2018) and Canada (CAN-ADAPTT, 2011). However, the only two RCTs on short-term NRT included in our review failed to show a significant effect for smoking cessation (moderate GRADE level of evidence). Insofar as long-term NRT is concerned, its effectiveness also seems to be unclear. The RRs observed in individual studies are very inconsistent, and three of the studies (Kapur et al., 2001; Hotham et al., 2006; El-Mohandes et al., 2013) display very wide confidence intervals, highlighting the marked imprecision of the results. Risk of blinding bias in these three studies (Hotham et al., 2006; Pollak et al., 2007; El-Mohandes et al., 2013) is high as they did not compare with a placebo but with psychosocial interventions. On the other hand, the four RCTs (Overdijkink et al., 2018; Hemsing et al., 2012; Page et al., 2021; Kapur et al., 2001) that compared NRT patches with placebo patches found no differences between groups.

It should be noted that the use of NRT during pregnancy has been controversial due the fact that the pharmacokinetics of nicotine differs in intrauterine fetal exposure and adults, with the mean time of elimination in the former being greater (Dempsey et al., 2000). Certain studies indicate that prenatal exposure to nicotine leads to significant irremediable adverse effects on fetal development, including alterations in the normal development of the endocrine, reproductive, respiratory, cardiovascular and neurologic systems (Holbrook, 2016). A meta-analysis of recent RCTs which assessed the safety of NRT during pregnancy, found no significant differences between NRT and placebo for any of the events investigated (Taylor et al., 2021).

High quality evidence is lacking for bupropion: the three studies retrieved agree on its lack of effectiveness for smoking cessation during pregnancy (moderate GRADE level of evidence). A systematic review and meta-analysis which assessed the safety of bupropion during pregnancy, evaluating birthweight, congenital malformations and birth, found no differences between the intervention and control groups (Turner et al., 2019).

Among the non-pharmacological interventions, digital interventions showed a no significant global effect when compared with routine care. The results should be interpreted with caution. The moderator analysis shows that post-2000 interventions are indeed effective, which could be explained by the great evolution of development and access to technology that has taken place in the 21st century. Moreover, none of the individual studies showed a significant association and that, in turn, the quality of these studies is itself uncertain (moderate GRADE level of evidence). Furthermore, comparison but also generalization of findings is difficult because studies included a wide range of digital interventions encompassing multiple media (v.ideo, sms, app, WhatsApp, etc.). In the case of sms, though the mean was the same, some studies (Tappin et al., 2000; Hegaard et al., 2003) used different motivation strategies, some used scheduled gradual reduction of cigarettes (Parker et al., 2007), and others used transmission of personalized information (Naughton et al., 2012). Despite diversity of interventions, they were included in the digital category because all interventions have in common that they do not require a health professional to perform the intervention. Digital interventions like telemedicine have classically been considered a useful tool for reducing the cost of healthcare or accessing remote places (Almuslim & AlDossary, 2022). As a result of the COVID-19 pandemic, its use increased considerably worldwide. However, when it comes to planning a digital intervention, it is important to bear in mind the characteristics of the target population. Access to technology is a key barrier to implementing these interventions since digital gaps can exist even in developed countries, specially among vulnerable populations (Almuslim & AlDossary, 2022). Lower levels of education are commonly associated with limited Internet access. Accordingly, pregnant women in more disadvantaged socioeconomic circumstances could face inequalities affecting smoking cessation effectiveness (Griffiths et al., 2018). We did not observe differences by socioeconomic level in the present study, but the results should be interpreted with caution because only two studies (Abroms et al., 2017; Secker-Walker et al., 1997) were conducted in women of low socioeconomic level. Moreover, some misclassification could have occurred as socioeconomic status was defined based on the target population from whom the sample was selected. Most of the studies were conducted in the USA and United Kingdom, so that their external validity is not guaranteed.

Existing moderate-to-high GRADE quality evidence (depending on the subgroup) supports that psychosocial interventions are also effective

for quitting smoking when compared to routine care. However, a certain degree of heterogeneity exists. In the moderator analysis by country, professional counseling showed no statistical significance in UK while it did in the rest of the countries analyzed (Supplementary Files). One possible explanation could be that, although counseling forms part of general practice in most countries, the implementation of these practices can vary substantially across countries (Verbiest et al., 2017). Furthermore, in counseling, as in digital approaches, multiple interventions are involved. Nowadays, comparing to a zero-intervention scenario would not be possible for ethical reasons. The study of Hegaard's et al. (Hegaard et al., 2003) is noteworthy because it includes nicotine replacement therapy in addition to counselling in some women. However, this study did not change overall results in the sensitivity analysis. [Overall RR of psychosocial intervention excluding Hegaards et al study (Hegaard et al., 2003): 1.38 (1.23–1.56; I2 = 37%); RR of counselling interventions excluding Hegaards et al study (Hegaard et al., 2003): 1.23 (1.11–1.37, I2 = 5%)]. The study of Parkers (Parker et al., 2007) et al and Harriss (Harris & Reynolds, 2015) et al are also liable to bias towards the negative direction given that the comparator arm includes other smoking-cessation interventions in addition to routine care. It should be stressed that most studies were also biased due to incomplete implementation, with the ensuing possibility that the effect might have been underestimated. Nonetheless, we cannot rule out this might also occur in "real" clinical practice. A qualitative study conducted in Australia found that lack of training; limited time for medical visits; and lack of a proper record showing whether or not the intervention had been conducted were the main barriers perceived by health professionals when implementing counselling interventions for smoking cessation among pregnant women (Longman et al., 2018).

According to the results of the current meta-analysis, incentives appear to be the most effective intervention for smoking cessation (high GRADE quality). On the contrary to what could be expected (Casetta et al., 2017), women of lower socioeconomic levels do not show significant benefits from incentives. This trend is also observed in relation to other interventions. Consideration should be given to the fact that this subgroup of pregnant women are commonly heavier smokers that have less capacity for self-initiation and self-control and would probably require more intensive and targeted interventions. Moreover, low-socioeconomic smokers are more likely to belong to a pro-smoking social context compared to high-socioeconomic smokers, which is a main barrier to quit successfully. (Saito et al., 2018).

Nonetheless, the use of incentives for smoking cessation during pregnancy is a highly controversial issue, since there are many aspects to be solved prior to proposing their implementation in clinical practice, such as time, frequency, financial value, duration, and type of incentive (Breunis, 2021). Moreover, the encouraging results of incentives have led to some ethical questions being raised, such as their possible coercive nature, the risk of cheating, and the fact that such incentives might be regarded as unfair by persons who do not smoke (Breunis et al., 2020). One study which compares French and UK population acceptability concludes that it should be examined in each country before implementation of these policies because, even though France and UK have a similar socioeconomic level, public acceptability differs in the two countries (Berlin et al., 2018).

Social support did not appear to have an influence on smoking cessation in any of the studies included. However, these findings should be interpreted with caution because in all the studies included in this review, support was provided by a health professional and not by a "peer". Several studies indicate that women who continue smoking during pregnancy are more likely to have a partner who smokes, and to have less support for and assistance in quitting than do those who stop smoking spontaneously (Solomon & Quinn, 2004). It is commonly accepted that the mere perception of another person's behavior automatically increases the probability of participating in such behavior oneself (Chartrand & Bargh, 1999).

Only three (Cope et al., 2003; Stotts et al., 2009; Patten et al., 2019) of the included studies reported on feedback, and of these, only one (Cope et al., 2003) found a significant effect. In this study, the comparison group solely received routine advice from the physician or nurse, whereas in the rest of the studies, routine care was based on the 5A model. The only study (Ussher et al., 2015) on exercise likewise showed no effectiveness, very likely because of the low achievement of the sessions offered (participants attended a median of 4 out of the 14 sessions of the full intervention).

5.3. Strengths and limitations

The fact that the intervention may be used as part of a wider intervention or in combination with other strategies constitutes an important limitation to drawing up definitive conclusions, since it is unclear how each component contributes to the observed smoking cessation effect. The biochemical confirmation also raises some concerns, since at times cotinine is used as a biomarker (smoking-specific biomarker) and at others, CO (less sensitive) is used. Furthermore, the duration of the effect of the intervention has not been evaluated. Underestimation of the effect in the case of psychosocial interventions cannot be ruled out because in many healthcare systems, routine care for pregnant woman already incorporates counseling and/or advice. Overall, there is scant information with respect to the selection or the characteristics of the participants. For example, we observed that the socioeconomic status was not systematically recorded in most of the RCTs, nor did studies provide sufficient information to classify patients accordingly. The reason for this is uncertain, although it constitutes a source of bias and an obstacle for the generalization of results given that not all studies could be included in the moderator analysis.

Patching together pre-existing reviews is limited by different eligibility criteria, evaluation methods and thoroughness of updating information across the merged reviews. Moreover, pre-existing reviews may not cover all the possible management options.

The main strength of the current review is that it includes an updated analysis of studies complying with the same eligibility criteria and evaluation methods, allowing for the results to be critically compared. All the studies included in the current review confirmed smoking cessation biochemically and this is an important added value versus other existing meta-analyses, because without biochemical confirmation, non-disclosure of smoking due to social desirability bias might be present. A USA study among 4197 pregnant women aged 20 to 44 years compared questionnaire-based maternal self-reported smoking and serum cotinine concentrations, and found that 23.0% of pregnant smokers did not report tobacco use (Dietz et al., 2011). Another strength of this review is that we conducted moderator analyses to explore the influence of the country of the study, year of publication and socioeconomic status of participants Searching for unpublished studies reduces publication bias due to selective publication. We have restricted the search to RCTs published after 2012 because when high quality systematic reviews/meta-analysis exist the probability of missing trials is minimum and updating is considered more efficient than starting all over again when new evidence emerges (The BMJ, 2022).

However, it should not be forgotten that the effectiveness of an intervention targeted at smoking cessation during pregnancy does not only depend on the intervention as much and the way it is organized. It also depends on the capacities of the expectant mother, her needs, culture, and personal situation. Hence, interventions may be context-dependent, as shown in the moderator analyses by country, to which must be added the fact that 43 of the 63 RCTs included were undertaken in the USA.

6. Conclusions and implications

In brief, though the results might differ slightly at the level of the different countries, the results of this meta-analysis support the adoption of psychosocial interventions to promote smoking cessation during

pregnancy (moderate-high quality evidence). The evidence supporting the use of long-term NRT was found to be of low quality.

Existing evidence suggests that, if routine care already includes some type of counseling, it would be beneficial to consider boosting this with incentives or feedback interventions. The moderator analysis suggests that pregnant women of low socioeconomic status might benefit less from smoking cessation interventions like economic incentives than women of a high socioeconomic status. These women are usually heavier smokers that live in pro-smoking environments and could require more intensive and targeted interventions.

Bearing in mind the doubts surrounding the implementation of psychosocial interventions, it would be advisable to explore their viability and acceptability in different healthcare-service delivery settings and contexts.

Funding/Support

All phases of this study were supported by the Government Delegation for the National Plan on Drugs (Spain) grant, 2021I009.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Leonor Varela Lema reports financial support was provided by Government Delegation for the National Plan on Drugs (Spain). Leonor Varela Lema reports a relationship with University of Santiago de Compostela that includes: funding grants.

Data availability

No data was used for the research described in the article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.addbeh.2023.107854.

References

Abroms, L. C., Johnson, P. R., Leavitt, L. E., Cleary, S. D., Bushar, J., Brandon, T. H., et al. (2017). A randomized trial of text messaging for smoking cessation in pregnant women. *American Journal of Preventive Medicine, 53*(6), 781–790.

Almuslim, H., & AlDossary, S. (2022). Models of incorporating telehealth into obstetric care during the COVID-19 pandemic, its benefits and barriers: A scoping review. *Telemedicine Journal and e-Health is a Journal Official Journal of American Telemedicine Association, 28*(1), 24–38.

Aromataris, E., Fernandez, R., Godfrey, C. M., Holly, C., Khalil, H., & Tungpunkom, P. (2015). Summarizing systematic reviews: Methodological development, conduct and reporting of an umbrella review approach. *International Journal of Evidence-Based Healthcare, 13*(3), 132–140.

Health AGD of. Australian Government Department of Health (2018). *Australian Government Department of Health [cited April 2022]*. https://www.health.gov.au/resources/pregnancy-care-guidelines.

Balmumcu, A., & Ünsal, A.Ş. (2021). Smoking cessation programs for pregnant women: utilizing whatsapp text messaging. *Journal of Addictions Nursing, 32*(3), 188–196.

Banderali, G., Martelli, A., Landi, M., Moretti, F., Betti, F., Radaelli, G., et al. (2015). Short and long term health effects of parental tobacco smoking during pregnancy and lactation: A descriptive review. *Journal of Translational Medicine, 13*, 327.

Berlin, I., Berlin, N., Malecot, M., Breton, M., Jusot, F., & Goldzahl, L. (2021). Financial incentives for smoking cessation in pregnancy: multicentre randomised controlled trial. *BMJ, 375*.

Berlin, N., Goldzahl, L., Bauld, L., Hoddinott, P., & Berlin, I. (2018). Public acceptability of financial incentives to reward pregnant smokers who quit smoking: A United Kingdom-France comparison. *The European Journal of Health Economics, 19*(5), 697–708.

Berlin, I., Grangé, G., Jacob, N., & Tanguy, M. L. (2014). Nicotine patches in pregnant smokers: Randomised, placebo controlled, multicentre trial of efficacy. *British Medical Journal (Clinical Research Education) (London), 348*, Article g1622.

Health Education Board for Scotland, *ASH Scotland (Organization). Smoking cessation guidelines for Scotland: 2004 update [Internet]*. Edinburgh: Health Education Board for Scotland; 2004 [cited April 2022]. http://www.hebs.com/services/pubs/pdf/SmokingCes2004.pdf.

Bowden, J., Tierney, J. F., Copas, A. J., & Burdett, S. (2011). Quantifying, displaying and accounting for heterogeneity in the meta-analysis of RCTs using standard and generalised Q statistics. *BMC Medical Research Methodology, 11*, 41.

Breunis, L. J., Bauld, L., & Been, J. V. (2021). Incentives for smoking cessation in pregnancy. *BMJ., 375*, n2889.

Breunis, L. J., Been, J. V., de Jong-Potjer, L., Steegers, E. A., de Beaufort, I. D., de Kroon, M. L., et al. (2020). Incentives for smoking cessation during pregnancy: An ethical framework. *Nicotine & Tobacco Research: Official Journal of the Society for Research on Nicotine and Tobacco, 22*(9), 1553–1559.

Bullock, L., Everett, K. D., Mullen, P. D., Geden, E., Longo, D. R., & Madsen, R. (2009). Baby BEEP: A randomized controlled trial of nurses' individualized social support for poor rural pregnant smokers. *Maternal and Child Health Journal, 13*(3), 395–406.

CAN-ADAPTT Practice-Informed Guidelines | *Nicotine Dependence Services* [Internet] [cited April 2022]. https://www.nicotinedependenceclinic.com/en/canadaptt/Pages/CAN-ADAPTT-Guidelines.aspx.

Casetta, B., Videla, A. J., Bardach, A., Morello, P., Soto, N., Lee, K., et al. (2017). Association between cigarette smoking prevalence and income level: A systematic review and meta-analysis. *Nicotine & Tobacco Research: Official Journal of the Society for Research on Nicotine and Tobacco, 19*(12), 1401–1407.

Chamberlain, C., O'Mara-Eves, A., Porter, J., Coleman, T., Perlen, S. M., Thomas, J., et al. (2017). Psychosocial interventions for supporting women to stop smoking in pregnancy. *Cochrane Database of Systematic Reviews, 2*, CD001055.

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: The perception-behavior link and social interaction. *Journal of Personality and Social Psychology, 76*(6), 893–910.

Cinciripini, P. M., McClure, J. B., Wetter, D. W., Perry, J., Blalock, J. A., Cinciripini, L. G., et al. (2000). An evaluation of videotaped vignettes for smoking cessation and relapse prevention during pregnancy: The very important pregnant smokers (VIPS) program. *Tobacco Control, 9*(Suppl 3), III61–III63.

Claire, R., Chamberlain, C., Davey, M. A., Cooper, S. E., Berlin, I., Leonardi-Bee, J., et al. (2020). Pharmacological interventions for promoting smoking cessation during pregnancy. *Cochrane Database of Systematic Reviews, 3*, CD010078.

Coleman, T., Cooper, S., Thornton, J. G., Grainge, M. J., Watts, K., Britton, J., et al. (2012). A randomized trial of nicotine-replacement therapy patches in pregnancy. *The New England Journal of Medicine, 366*(9), 808–818.

Cope, G. F., Nayyar, P., & Holder, R. (2003). Feedback from a point-of-care test for nicotine intake to reduce smoking during pregnancy. *Annals of Clinical Biochemistry, 40*(Pt 6), 674–679.

De Queiroz, A. E., Da Silva Sena, C. R., Collison, A., Murphy, V. E., Gould, G. S., Bonevski, B., et al. (2020). Association between active tobacco use during pregnancy and infant respiratory health: A systematic review and meta-analysis. *BMJ Open, 10*(9), e037819.

Dempsey, D., Jacob, P., & Benowitz, N. L. (2000). Nicotine metabolism and elimination kinetics in newborns. *Clinical Pharmacology and Therapeutics, 67*(5), 458–465.

DeNicola, N., Grossman, D., Marko, K., Sonalkar, S., Butler Tobah, Y. S., Ganju, N., et al. (2020). Telehealth interventions to improve obstetric and gynecologic health outcomes: A systematic review. *Obstetrics & Gynecology, 135*(2), 371–382.

Dietz, P. M., Homa, D., England, L. J., Burley, K., Tong, V. T., Dube, S. R., et al. (2011). Estimates of nondisclosure of cigarette smoking among pregnant and nonpregnant women of reproductive age in the United States. *American Journal of Epidemiology, 173*(3), 355–359.

Dornelas, E. A., Magnavita, J., Beazoglou, T., Fischer, E. H., Oncken, C., Lando, H., et al. (2006). Efficacy and cost-effectiveness of a clinic-based counseling intervention tested in an ethnically diverse sample of pregnant smokers. *Patient Education and Counseling, 64*(1–3), 342–349.

Duan, P., Wang, Y., Lin, R., Zeng, Y., Chen, C., Yang, L., et al. (2021). Impact of early life exposures on COPD in adulthood: A systematic review and meta-analysis. *Respirology (Carlton Vic.), 26*(12), 1131–1151.

Egger, M., Davey Smith, G., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *British Medical Journal (Clinical Research Education) (London), 315*(7109), 629–634.

El-Mohandes, A. A. E., El-Khorazaty, M. N., Kiely, M., & Gantz, M. G. (2011). Smoking cessation and relapse among pregnant African-American smokers in Washington, DC. *Maternal and Child Health Journal, 15*(Suppl 1), S96–S.

El-Mohandes, A. A. E., Windsor, R., Tan, S., Perry, D. C., Gantz, M. G., & Kiely, M. (2013). A randomized clinical trial of trans-dermal nicotine replacement in pregnant African-American smokers. *Maternal and Child Health Journal, 17*(5), 897–906.

Ershoff, D. H., Mullen, P. D., & Quinn, V. P. (1989). A randomized trial of a serialized self-help smoking cessation program for pregnant women in an HMO. *American Journal of Public Health, 79*(2), 182–187.

Ershoff, D. H., Quinn, V. P., Boyd, N. R., Stern, J., Gregory, M., & Wirtschafter, D. (1999). The Kaiser Permanente prenatal smoking-cessation trial: When more isn't better, what is enough? *American Journal of Preventive Medicine, 17*(3), 161–168.

Fernandez-Rodriguez, B., Gomez, A. R., Jimenez Moreno, B. S., de Alba, C., Galindo, A., Villalain, C., et al. (2022). Smoking influence on early and late fetal growth. *Journal of Perinatal Medicine, 50*(2), 200–206.

Forinash, A. B., Yancey, A., Chamness, D., Koerner, J., Inteso, C., Miller, C., et al. (2018). Smoking Cessation Following Text Message Intervention in Pregnant Women. *The Annals of Pharmacotherapy, 52*(11), 1109–1116.

Gielen, A. C., Windsor, R., Faden, R. R., O'Campo, P., Repke, J., & Davis, M. (1997). Evaluation of a smoking cessation intervention for pregnant women in an urban prenatal clinic. *Health Education Research, 12*(2), 247–254.

Glover, M., Kira, A., Walker, N., & Bauld, L. (2015). Using incentives to encourage smoking abstinence among pregnant indigenous women? A feasibility study. *Maternal and Child Health Journal, 19*(6), 1393–1399.

Griffiths, S. E., Brown, K. E., Fulton, E. A., Tombor, I., & Naughton, F. (2016). Are digital interventions for smoking cessation in pregnancy effective? A systematic review protocol. *Systematic Reviews, 5*(1), 207.

Griffiths, S. E., Parsons, J., Naughton, F., Fulton, E. A., Tombor, I., & Brown, K. E. (2018). Are digital interventions for smoking cessation in pregnancy effective? A systematic review and meta-analysis. *Health Psychology Review, 12*(4), 333–356.

Guyatt, G. H., Oxman, A. D., Vist, G. E., Kunz, R., Falck-Ytter, Y., Alonso-Coello, P., et al. (2008). GRADE: An emerging consensus on rating quality of evidence and strength of recommendations. *British Medical Journal (Clinical Research Education) (London), 135*(2), 371–382.

Hajek, P., West, R., Lee, A., Foulds, J., Owen, L., Eiser, J. R., et al. (2001). Randomized controlled trial of a midwife-delivered brief smoking cessation intervention in pregnancy. *Addiction (Abingdon, England), 96*(3), 485–494.

Harris, M., & Reynolds, B. (2015). A pilot study of home-based smoking cessation programs for rural, appalachian, pregnant smokers. *Journal of Obstetric, Gynecologic & Neonatal Nursing JOGNN., 44*(2), 236–245.

Hartmann, K. E., Thorp, J. M., Pahel-Short, L., & Koch, M. A. (1996). A randomized controlled trial of smoking cessation intervention in pregnancy in an academic clinic. *Obstetrics and Gynecology, 87*(4), 621–626.

Haug, K., Aarø, L. E., & Fugelli, P. (1994). Pregnancy–a golden opportunity for promoting the cessation of smoking? *Scandinavian Journal of Primary Health Care, 12*(3), 184–189.

Hegaard, H. K., Kjaergaard, H., Møller, L. F., Wachmann, H., & Ottesen, B. (2003). Multimodal intervention raises smoking cessation rate during pregnancy. *Acta Obstetricia et Gynecologica Scandinavica, 82*(9), 813–819.

Heil, S. H., Higgins, S. T., Bernstein, I. M., Solomon, L. J., Rogers, R. E., Thomas, C. S., et al. (2008). Effects of voucher-based incentives on abstinence from cigarette smoking and fetal growth among pregnant women. *Addiction (Abingdon, England), 103*(6), 1009–1018.

Hemsing, N., Greaves, L., O'Leary, R., Chan, K., & Okoli, C. (2012). Partner support for smoking cessation during pregnancy: A systematic review. *Nicotine & Tobacco Research: Official Journal of the Society for Research on Nicotine and Tobacco, 14*(7), 767–776.

Hennrikus, D., Pirie, P., Hellerstedt, W., Lando, H. A., Steele, J., & Dunn, C. (2010). Increasing support for smoking cessation during pregnancy and postpartum: Results of a randomized controlled pilot study. *Preventive Medicine, 50*(3), 134–137.

Heslehurst, N., Hayes, L., Jones, D., Newham, J., Olajide, J., McLeman, L., et al. (2020). The effectiveness of smoking cessation, alcohol reduction, diet and physical activity interventions in changing behaviours during pregnancy: A systematic review of systematic reviews. *PLoS One1, 15*(5), e0232774.

Higgins, J. P. T, Green, S. (Eds.) (2011). *Cochrane Handbook for Systematic Reviews of InterventionsVersion 5.1.0* [updated March 2011]. The Cochrane Collaboration. www.cochrane-handbook.org.

Higgins, J. P. T., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *British Medical Journal (Clinical Research Education) (London), 327*(7414), 557–560.

Higgins, S. T., Washio, Y., Lopez, A. A., Heil, S. H., Solomon, L. J., Lynch, M. E., et al. (2014). Examining two different schedules of financial incentives for smoking cessation among pregnant women. *Preventive Medicine, 68*, 51–57.

Holbrook, B. D. (2016). The effects of nicotine on human fetal development. *Birth Defects Research Part C: Embryo Today: Reviews, 108*(2), 181–192.

Homa, D. M., Neff, L. J., King, B. A., Caraballo, R. S., Bunnell, R. E., Babb, S. D., et al. (2015). Vital signs: Disparities in nonsmokers' exposure to secondhand smoke–United States, 1999–2012. *MMWR. Morbidity and Mortality Weekly Report, 64*(4), 103–108.

Hotham, E. D., Gilbert, A. L., & Atkinson, E. R. (2006). A randomised-controlled pilot study using nicotine patches with pregnant women. *Addictive Behaviors abril de, 31*(4), 641–648.

Hussain, T., Smith, P., & Yee, L. M. (2020). Mobile phone-based behavioral interventions in pregnancy to promote maternal and fetal health in high-income countries: systematic review. *JMIR mHealth and uHealth, 8*(5), e15111.

Ioannidis, J. P. A., & Trikalinos, T. A. (2007). An exploratory test for an excess of significant findings. *Clin Trials Lond Engl., 4*(3), 245–253.

JCS Joint Working Group, Japanese Society for Oral Health, Japanese Society of Oral and Maxillofacial Surgeons, Japanese Society of Public Health, Japanese Respiratory Society, Japan Society of Obstetrics and Gynecology, et al. (2012). *Guidelines for Smoking Cessation (JCS 2010)–digest version. Circulation Journal: Official Journal of the Japanese Circulation Society* 76(4), 1024–1043.

Kapur, B., Hackman, R., Selby, P., Klein, J., & Koren, G. (2001). Randomized, double-blind, placebo-controlled trial of nicotine replacement therapy in pregnancy. *Current Therapeutic Research, 62*(4), 274–278.

Kendrick, J. S., Zahniser, S. C., Miller, N., Salas, N., Stine, J., Gargiullo, P. M., et al. (1995). Integrating smoking cessation into routine public prenatal care: The Smoking Cessation in Pregnancy project. *American Journal of Public Health, 85*(2), 217–222.

Kranzler, H. R., Washio, Y., Zindel, L. R., Wileyto, E. P., Srinivas, S., Hand, D. J., et al. (2021). Placebo-controlled trial of bupropion for smoking cessation in pregnant women. *The American Journal of Obstetrics and Gynecology MFM, 3*(6), Article 100315.

Kurti, A. N., Tang, K., Bolivar, H. A., Evemy, C., Medina, N., Skelly, J., et al. (2020). Smartphone-based financial incentives to promote smoking cessation during pregnancy: A pilot study. *Preventive Medicine, 140*, Article 106201.

Kyrgyzstan treatment guidelines in English [Internet] [cited April 2022]. http://www.tabaccologia.it/PDF/Kyrgyzstan%20treatment%20guidelines%20in%20English%202004.pdf.

Lange, S., Probst, C., Rehm, J., & Popova, S. (2018). National, regional, and global prevalence of smoking during pregnancy in the general population: A systematic review and meta-analysis. *The Lancet Global Health, 6*(7), e769–e776.

Lee, M., Miller, S. M., Wen, K. Y., Hui, S., & kuen A, Roussi P, Hernandez E.. (2015). Cognitive-behavioral intervention to promote smoking cessation for pregnant and postpartum inner city women. *Journal of Behavioral Medicine, 38*(6), 932–943.

Leslie, F. M. (2013). Multigenerational epigenetic effects of nicotine on lung function. *BMC Medicine, 11*, 27.

Longman, J. M., Adams, C. M., Johnston, J. J., & Passey, M. E. (2018). Improving implementation of the smoking cessation guidelines with pregnant women: How to support clinicians? *Midwifery, 58*, 137–144.

Loukopoulou, A. N., Vardavas, C. I., Farmakides, G., Rosolymos, C., Chrelias, C., Tzatzarakis, M., et al. (2018). Counselling for smoking cessation during pregnancy reduces tobacco-specific nitrosamine (NNAL) concentrations: A randomized controlled trial. *The European Journal of Midwifery, 2*, 14.

Malchodi, C. S., Oncken, C., Dornelas, E. A., Caramanica, L., Gregonis, E., & Curry, S. L. (2003). The effects of peer counseling on smoking cessation and reduction. *Obstetrics and Gynecology, 101*(3), 504–510.

McLeod, D., Pullon, S., Benn, C., Cookson, T., Dowell, A., Viccars, A., et al. (2004). Can support and education for smoking cessation and reduction be provided effectively by midwives within primary maternity care? *Midwifery, 20*(1), 37–50.

Míguez, M. C., & Pereira, B. (2020). Effects of active and/or passive smoking during pregnancy and the postpartum period. *Anales de Pediatría, S1695–4033*(20), 30288–30295.

Myung, S. K., Ju, W., Jung, H. S., Park, C. H., Oh, S. W., Seo, H., et al. (2012). Efficacy and safety of pharmacotherapy for smoking cessation among pregnant smokers: A meta-analysis. *BJOG: An International Journal of Obstetrics & Gynaecology, 119*(9), 1029–1039.

Nakamura, A., François, O., & Lepeule, J. (2021). Epigenetic alterations of maternal tobacco smoking during pregnancy: A narrative review. *International Journal of Environmental Research and Public Health, 1;18*(10), 5083.

Nanovskaya, T. N., Oncken, C., Fokina, V. M., Feinn, R. S., Clark, S. M., West, H., et al. (2017). Bupropion sustained release for pregnant smokers: A randomized, placebo-controlled trial. *American Journal of Obstetrics and Gynecology, 216*(4), 420.e1–420.e9.

Naughton, F., Cooper, S., Foster, K., Emery, J., Leonardi-Bee, J., Sutton, S., et al. (2017). Large multi-centre pilot randomized controlled trial testing a low-cost, tailored, self-help smoking cessation text message intervention for pregnant smokers (MiQuit). *Addict Abingdon Engl., 112*(7), 1238–1249.

Naughton, F., Prevost, A. T., Gilbert, H., & Sutton, S. (2012). Randomized controlled trial evaluation of a tailored leaflet and SMS text message self-help intervention for pregnant smokers (MiQuit). *Nicotine & Tobacco Research: Official Journal of the Society for Research on Nicotine and Tobacco, 14*(5), 569–577.

Overview | Tobacco: preventing uptake, promoting quitting and treating dependence | Guidance | NICE [Internet]. NICE; [cited April 2022]. https://www.nice.org.uk/guidance/ng209.

Olson, A. L., Boardman, M. B., & Johnson, D. J. (2019). Smoke-free moms: Financial rewards for smoking cessation by low-income rural pregnant women. *American Journal of Preventive Medicine, 56*(6), 852–859.

Oncken, C., Dornelas, E., Greene, J., Sankey, H., Glasmann, A., Feinn, R., et al. (2008). Nicotine gum for pregnant smokers: A randomized controlled trial. *Obstetrics and Gynecology, 112*(4), 859–867.

Oncken, C., Dornelas, E. A., Kuo, C. L., Sankey, H. Z., Kranzler, H. R., Mead, E. L., et al. (2019). Randomized trial of nicotine inhaler for pregnant smokers. *The American Journal of Obstetrics and Gynecology MFM., 1*(1), 10–18.

Ondersma, S. J., Svikis, D. S., Lam, P. K., Connors-Burge, V. S., Ledgerwood, D. M., & Hopper, J. A. (2012). A randomized trial of computer-delivered brief intervention and low-intensity contingency management for smoking during pregnancy. *Nicotine & Tobacco Research: Official Journal of the Society for Research on Nicotine and Tobacco, 14*(3), 351–360.

Overdijkink, S. B., Velu, A. V., Rosman, A. N., van Beukering, M. D., Kok, M., & Steegers-Theunissen, R. P. (2018). The usability and effectiveness of mobile health technology-based lifestyle and medical intervention apps supporting health care during pregnancy: Systematic review. *JMIR mHealth and uHealth, 6*(4), e109.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *British Medical Journal (Clinical Research Education) (London), 372*, Article n71.

Page, M. J., Moher, D., & McKenzie, J. E. (2022). Introduction to preferred reporting items for systematic reviews and meta-analyses 2020 and implications for research synthesis methodologists. *Research Synthesis Methods, 13*(2), 156–163.

Panel TU and DG (2008). *Treating Tobacco Use and Dependence: 2008 Update*. US Department of Health and Human Services.

Panjari, M., Bell, R., Bishop, S., Astbury, J., Rice, G., & Doery, J. (1999). A randomized controlled trial of a smoking cessation intervention during pregnancy. *The Australian & New Zealand Journal of Obstetrics & Gynaecology, 39*(3), 312–317.

Parker, D. R., Windsor, R. A., Roberts, M. B., Hecht, J., Hardy, N. V., Strolla, L. O., et al. (2007). Feasibility, cost, and cost-effectiveness of a telephone-based motivational intervention for underserved pregnant smokers. *Nicotine & Tobacco Research: Official Journal of the Society for Research on Nicotine and Tobacco, 9*(10), 1043–1051.

Patten, C. A., Koller, K. R., Flanagan, C. A., Hiratsuka, V. Y., Hughes, C. A., Wolfe, A. W., et al. (2019). Biomarker feedback intervention for smoking cessation among Alaska Native pregnant women: Randomized pilot study. *Patient Education and Counseling, 102*(3), 528–535.

Patten, C. A., Windsor, R. A., Renner, C. C., Enoch, C., Hochreiter, A., Nevak, C., et al. (2010). Feasibility of a tobacco cessation intervention for pregnant Alaska Native women. *Nicotine & Tobacco Research: Official Journal of the Society for Research on Nicotine and Tobacco, 12*(2), 79–87.

Pbert, L., Ockene, J. K., Zapka, J., Ma, Y., Goins, K. V., Oncken, C., et al. (2004). A community health center smoking-cessation intervention for pregnant and postpartum women. *American Journal of Preventive Medicine, 26*(5), 377–385.

Peer, N., Naicker, A., Khan, M., Kengne, A. P. (2020). A narrative systematic review of tobacco cessation interventions in Sub-Saharan Africa. *SAGE Open Medicine* 8, 2050312120936907.

Pineles, B. L., Hsu, S., Park, E., & Samet, J. M. (2016). Systematic review and meta-analyses of perinatal death and maternal exposure to tobacco smoke during pregnancy. *American Journal of Epidemiology, 184*(2), 87–97.

Pollak, K. I., Lyna, P., Bilheimer, A., Farrell, D., Gao, X., Swamy, G. K., et al. (2013). A pilot study testing SMS text delivered scheduled gradual reduction to pregnant smokers. *Nicotine & Tobacco Research: Official Journal of the Society for Research on Nicotine and Tobacco, 15*(10), 1773–1776.

Pollak, K. I., Oncken, C. A., Lipkus, I. M., Lyna, P., Swamy, G. K., Pletsch, P. K., et al. (2007). Nicotine replacement and behavioral therapy for smoking cessation in pregnancy. *American Journal of Preventive Medicine, 33*(4), 297–305.

Rathbone, A. L., & Prescott, J. (2017). The use of mobile apps and SMS messaging as physical and mental health interventions: Systematic review. *Journal of Medical Internet Research, 19*(8), e295.

Rigotti, N. A., Park, E. R., Regan, S., Chang, Y., Perry, K., Loudin, B., et al. (2006). Efficacy of telephone counseling for pregnant smokers: A randomized controlled trial. *Obstetrics and Gynecology, 108*(1), 83–92.

Røykeavvenning-nasjonale-retningslinjer [Internet]. [cited April 2022]. http://www.bedrepsykosebehandling.no/wp-content/uploads/2016/10/R%C3%B8ykeavvenning-nasjonale-retningslinjer-2016.pdf.

Saito, J., Shibanuma, A., Yasuoka, J., Kondo, N., Takagi, D., & Jimba, M. (2018). Education and indoor smoking among parents who smoke: The mediating role of perceived social norms of smoking. *BMC Public Health, 18*(1), 211.

Secker-Walker, R. H., Solomon, L. J., Geller, B. M., Flynn, B. S., Worden, J. K., Skelly, J. M., et al. (1997). Modeling smoking cessation: Exploring the use of a videotape to help pregnant women quit smoking. *Women & Health, 25*(1), 23–35.

Shea, B. J., Reeves, B. C., Wells, G., Thuku, M., Hamel, C., Moran, J., et al. (2017). AMSTAR 2: A critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *British Medical Journal (Clinical Research Education) (London), 358*, Article j4008.

Solomon, L. J., & Quinn, V. P. (2004). Spontaneous quitting: Self-initiated smoking cessation in early pregnancy. *Nicotine Tob Res., 6*(Suppl_2), S203–S216.

Solomon, L. J., Secker-Walker, R. H., Flynn, B. S., Skelly, J. M., & Capeless, E. L. (2000). Proactive telephone peer support to help pregnant women stop smoking. *Tobacco Control, 9*(Suppl 3), III72–III74.

Sterne, J. A. C., Savović, J., Page, M. J., Elbers, R. G., Blencowe, N. S., Boutron, I., et al. (2019). RoB 2: A revised tool for assessing risk of bias in randomised trials. *British Medical Journal (Clinical Research Education) (London), 366*, Article l4898.

Stotts, A. L., Diclemente, C. C., & Dolan-Mullen, P. (2002). One-to-one: A motivational intervention for resistant pregnant smokers. *Addictive Behaviors, 27*(2), 275–292.

Stotts, A. L., Groff, J. Y., Velasquez, M. M., Benjamin-Garner, R., Green, C., Carbonari, J. P., et al. (2009). Ultrasound feedback and motivational interviewing targeting smoking cessation in the second and third trimesters of pregnancy. *Nicotine & Tobacco Research: Official Journal of the Society for Research on Nicotine and Tobacco, 11*(8), 961–968.

Stotts, A. L., Northrup, T. F., Cinciripini, P. M., Minnix, J. A., Blalock, J. A., Mullen, P. D., et al. (2015). Randomized, controlled pilot trial of bupropion for pregnant smokers: Challenges and future directions. *American Journal of Perinatology, 32*(4), 351–356.

Tappin, D. M., Lumsden, M. A., Gilmour, W. H., Crawford, F., McIntyre, D., Stone, D. H., et al. (2005). Randomised controlled trial of home based motivational interviewing by midwives to help pregnant smokers quit or cut down. *British Medical Journal (Clinical Research Education) (London), 331*(7513), 373–377.

Tappin, D. M., Lumsden, M. A., McIntyre, D., Mckay, C., Gilmour, W. H., Webber, R., et al. (2000). A pilot study to establish a randomized trial methodology to test the efficacy of a behavioural intervention. *Health Education Research, 15*(4), 491–502.

Taylor, L., Claire, R., Campbell, K., Coleman-Haynes, T., Leonardi-Bee, J., Chamberlain, C., et al. (2021). Fetal safety of nicotine replacement therapy in pregnancy: Systematic review and meta-analysis. *Addiction (Abingdon, England), 116*(2), 239–277.

When and how to update systematic reviews: consensus and checklist | *The BMJ* [Internet]. [cited April 2022]. https://www.bmj.com/content/354/bmj.i3507.

Torchin, H., Le Lous, M., & Houdouin, V. (2020). In utero EXPOSURE to maternal smoking: impact on the child from birth to Adulthood - CNGOF-SFT expert report and guidelines for smoking management during pregnancy. *Gynecologie Obstetrique Fertilite et Senologie, 48*(7–8), 567–577.

Turner, E., Jones, M., Vaz, L. R., & Coleman, T. (2019). Systematic review and meta-analysis to assess the safety of bupropion and varenicline in pregnancy. *Nicotine & Tobacco Research: Official Journal of the Society for Research on Nicotine and Tobacco, 21*(8), 1001–1010.

US Preventive Services Task Force, Krist, A. H., Davidson, K. W., Mangione, C. M., Barry, M. J., Cabana, M., et al. (2021). Interventions for tobacco smoking cessation in adults, including pregnant persons: US preventive services task force recommendation statement. *Journal of the American Medical Association, 325*(3), 265–279.

Ussher, M., Lewis, S., Aveyard, P., Manyonda, I., West, R., Lewis, B., et al. (2015). Physical activity for smoking cessation in pregnancy: Randomised controlled trial. *British Medical Journal (Clinical Research Education) (London), 350*, Article h2145.

Verbiest, M., Brakema, E., van der Kleij, R., Sheals, K., Allistone, G., Williams, S., et al. (2017). National guidelines for smoking cessation in primary care: A literature review and evidence analysis. *npj Primary Care Respiratory Medicine, 27*(1), 2.

Walsh, R. A., Redman, S., Brinsmead, M. W., Byrne, J. M., & Melmeth, A. (1997). A smoking cessation program at a public antenatal clinic. *American Journal of Public Health, 87*(7), 1201–1204.

Wilson, S. M., Newins, A. R., Medenblik, A. M., Kimbrel, N. A., Dedert, E. A., Hicks, T. A., et al. (2018). Contingency management versus psychotherapy for prenatal smoking cessation: A meta-analysis of randomized controlled trials. *Womens Health Issues: Official Publications of the Jacobs Institute of Womens Health, 28*(6), 514–523.

Windsor, R. A., Cutter, G., Morris, J., Reese, Y., Manzella, B., Bartlett, E. E., et al. (1985). The effectiveness of smoking cessation methods for smokers in public health maternity clinics: A randomized trial. *American Journal of Public Health, 75*(12), 1389–1392.

Windsor, R., Woodby, L., Miller, T., & Hardin, M. (2011). Effectiveness of Smoking Cessation and Reduction in Pregnancy Treatment (SCRIPT) methods in Medicaid-supported prenatal care: Trial III. *Health Educ Behav Off Publ Soc Public Health Educ., 38*(4), 412–422.

Wisborg, K., Henriksen, T. B., Jespersen, L. B., & Secher, N. J. (2000). Nicotine patches for pregnant smokers: A randomized controlled study. *Obstetrics and Gynecology, 96*(6), 967–971.

World Drug Report 2021[Internet]. *United Nations: Office on Drugs and Crime* [cited March 2022] www.unodc.org/unodc/en/data-and-analysis/wdr2021.html.