Interventions by Health Care Professionals Who Provide Routine Child Health Care to Reduce Tobacco Smoke Exposure in Children: A Review and Meta-analysis

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IMPORTANCE Reducing child exposure to tobacco smoke is a public health priority. Guidelines recommend that health care professionals in child health settings should address tobacco smoke exposure (TSE) in children.

OBJECTIVE To determine the effectiveness of interventions delivered by health care professionals who provide routine child health care in reducing TSE in children.

DATA SOURCES A secondary analysis of 57 trials included in a 2014 Cochrane review and a subsequent extended search was performed. Controlled trials (published through June 2015) of interventions that focused on reducing child TSE, with no restrictions placed on who delivered the interventions, were identified. Secondary data extraction was performed in August 2015.

STUDY SELECTION Controlled trials of routine child health care delivered by health care professionals (physicians, nurses, medical assistants, health educators, and dieticians) that addressed the outcomes of interest (TSE reduction in children and parental smoking behaviors) were eligible for inclusion in this review and meta-analysis.

DATA EXTRACTION AND SYNTHESIS Study details and quality characteristics were independently extracted by 2 authors. If outcome measures were sufficiently similar, meta-analysis was performed using the random-effects model by DerSimonian and Laird. Otherwise, the results were described narratively.

MAIN OUTCOMES AND MEASURES The primary outcome measure was reduction in child TSE. Secondary outcomes of interest were parental smoking cessation, parental smoking reduction, and maternal postpartum smoking relapse prevention.

RESULTS Sixteen studies met the selection criteria. Narrative analysis of the 6 trials that measured child TSE indicated no intervention effects relative to comparison groups. Similarly, meta-analysis of 9 trials that measured parental smoking cessation demonstrated no overall intervention effect (n = 6399) (risk ratio 1.05; 95% CI, 0.74-1.50; P = .78). Meta-analysis of the 3 trials that measured maternal postpartum smoking relapse prevention demonstrated a significant overall intervention effect (n = 1293) (risk ratio 1.53; 95% CI, 1.10-2.14; P = .01). High levels of study heterogeneity likely resulted from variability in outcome measures, length of follow up, intervention strategies, and unknown intervention fidelity.

CONCLUSIONS AND RELEVANCE Interventions delivered by health care professionals who provide routine child health care may be effective in preventing maternal smoking relapse. Further research is required to improve the effectiveness of such interventions in reducing child TSE and increasing parental smoking cessation. The findings of this meta-analysis have policy and practice implications relating to interventions by routine pediatric health care professionals that aim to reduce child exposure to tobacco smoke.

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It is estimated that approximately 40% of the world's children are exposed to secondhand smoke.1 Children exposed to secondhand smoke are at increased risk of respiratory infections, ear infections, meningococcal disease, asthma, and sudden infant death syndrome.2-3 As such, reducing children's exposure to secondhand smoke has been identified by the World Health Organization4 as a global public health priority. Emerging evidence indicates that children may be at further risk from the accumulation of toxic residue from secondhand smoke on indoor surfaces, known as thirdhand smoke.5,6 To encompass the entirety of tobacco's harms, secondhand smoke exposure and thirdhand smoke exposure are collectively referred to as tobacco smoke exposure (TSE).7

The primary source of child TSE is parental smoking.8 Consequently, interventions to reduce child TSE have focused on increasing TSE avoidance strategies (eg, not smoking in the home or car), supporting parental smoking cessation, and preventing postpartum maternal smoking relapse.9 A common setting for the delivery of parent-targeted interventions to reduce child TSE is child health care services.9 This setting provides an opportunity to access parents at a time when they may be particularly receptive to health advice.10 Guidelines recommend that health care professionals in child health settings should provide parent-targeted interventions that address child TSE risk as part of routine clinical care.11-13

Despite these recommendations, it is unclear whether interventions delivered by child health care professionals are effective in reducing child TSE. While previous reviews have examined the effectiveness of interventions aimed at child TSE reduction,2-9,14-16 parental smoking cessation,17 and maternal smoking relapse prevention,18-21 such reviews included studies implemented outside of the context of child health care as well as efficacy trials in which the intervention was delivered by personnel employed in research settings. To our knowledge, none have specifically investigated the effectiveness of interventions to reduce child TSE when delivered by child health care professionals in the context of routine care.

Given this gap, the aim of the present study was to determine the effectiveness of interventions delivered by health care professionals who provide routine child health care in reducing TSE in children (primary outcome). We also examined the effect of such interventions on parental smoking behavior, including smoking cessation, reduction in smoking, and maternal smoking relapse in the postpartum period (secondary outcomes).

Methods

Data Sources
The Cochrane Collaboration is recognized for publishing systematic reviews, and it first published “Family and Carer Smoking Control Programmes for Reducing Children's Exposure to Environmental Tobacco Smoke” in 2003 by Roseby et al22 (updated in 2008 by Priest et al14 and in 2014 by Baxi et al).9 Given the comprehensiveness of the 2014 review search strategy as well as the congruence of the inclusion criteria with our study objectives, we conducted a secondary analysis of trials included in that review. In addition, a literature search was performed using the Cochrane search strategy to identify additional relevant studies that may have been published since the 2014 Cochrane literature search.

At a Glance

- This review and meta-analysis aimed to determine the effectiveness of interventions delivered by health care professionals who provide routine child health care in reducing tobacco smoke exposure (TSE) in children, increasing parental smoking cessation, and preventing maternal postpartum smoking relapse.
- Of trials that measured reductions in child TSE, no intervention effects were reported. No overall intervention effect was demonstrated for parental smoking cessation (risk ratio, 1.05; 95% CI, 0.74-1.50; P = .78). A significant overall intervention effect was demonstrated for maternal postpartum smoking relapse prevention (risk ratio, 1.53; 95% CI, 1.10-2.14; P = .01).
- Interventions delivered by health care professionals who provide routine child health care may be effective in preventing maternal smoking relapse. Further research is required to improve the effectiveness of such interventions in reducing child TSE and increasing parental smoking cessation.

Study Eligibility

Primary Inclusion Criteria
The most recent Cochrane review update by Baxi et al9 (in 2014) identified randomized clinical trials (RCTs) and controlled trials (CTs) conducted in a range of settings and delivered by various interventionists. The review included any health promotion, educational, social behavioral, clinical, or technological interventions that met the following 3 criteria. (1) Study participants included persons involved with the education and care of infants, toddlers, and young children (age range, 0-12 years). (2) Study interventions focused on reducing child TSE and parental smoking, with no restrictions placed on who delivered the intervention. (3) Study outcome measures were related to children (exposure to or absorption of tobacco smoke, frequency of illness events, and health service use) or to parents or caregivers (behavioral change relating to smoking and child TSE). Biochemical validation of tobacco exposure was not a requirement for study inclusion.

Secondary Inclusion Criteria
For the present study, studies that met the review criteria by Baxi et al9 were further assessed. The following secondary criteria were addressed.

Types of Interventions | Only interventions delivered by health care professionals who provide routine child health care (physicians, nurses, medical assistants, health educators, and dietitians) were eligible for inclusion. Health care professionals who provide routine child health care were defined as clinicians employed by any health service (government or nongovernment) to deliver child health care (eg, physicians or nurses providing care in the setting of well-child visits, immunization clinics, or hospitalization). Efficacy trials in which clinicians or research staff were employed to implement the intervention were excluded.
Types of Outcome Measures | Studies were eligible for inclusion that included any measure of child TSE reduction (ambient air monitoring for nicotine, parental report of tobacco smoke avoidance strategies, and cotinine or nicotine in child urine, blood, saliva, or hair). Also eligible for inclusion were studies of secondary outcomes of interest, including maternal smoking cessation, parental smoking reduction, and maternal postpartum smoking relapse prevention.

Study Selection
Primary Search Strategy
Studies identified through the Cochrane review process reported by Baxi et al were used as the starting point for this review. As described by them, the Cochrane Tobacco Addiction Group review methods and specialized register were used to undertake a systematic review of the literature (performed in September 2013). The eMethods in the Supplement summarizes the databases and search strategies,9,14,15 Applying the same search strategies and inclusion criteria used for the Cochrane review, we extended the search to identify additional studies published between September 2013 and June 2015.

Secondary Study Selection
Two of us (J.B.D and L.J.M.) independently reviewed article titles, abstracts, and full-text articles relating to the studies identified by Baxi et al and the additional search. We used a standardized, piloted screening tool to assess study eligibility and exclude articles not meeting the eligibility criteria. When agreement regarding eligibility could not be resolved, full-text articles were assessed by a third reviewer (M.F.). For articles with insufficient information to determine trial eligibility, study authors were contacted for clarification. When sufficient information was not available, the trial was excluded.

Data Extraction
Two of us (J.B.D and L.J.M.) independently extracted the following from eligible studies: study authors and publication date, study setting (country, recruitment sites, and intervention sites), population demographics (including parent or caregiver and child age and sex), intervention and control conditions (interventionist characteristics, any theoretical basis or rationale, and intervention content, duration, and intensity), and trial outcomes and results (sample size, length of follow-up, consent rates and attrition, and number of participants per experimental condition and per cluster if relevant, as well as information for assessment of study bias and results of the primary outcomes). Disagreements regarding data extraction were resolved through discussion with a third reviewer (M.F.). Additional simplifications made in the data extraction process included categorization of intervention components (brief advice, behavioral counseling, biochemical feedback, nicotine therapy [NT], quitline referral, and self-help materials) and summarization of intervention intensity and duration (based on the number of contacts between interventionists and study participants). Secondary data extraction was performed in August 2015.

Assessment of Methodological Quality
Risk of Bias
Risk-of-bias assessments reported by Baxi et al9 were used for the Cochrane review studies. Two of us (J.B.D. and L.J.M.) independently assessed risk of bias for studies identified from the additional search using the methods outlined in the Cochrane Handbook for Systematic Reviews of Interventions.22 Methodological quality variables include a description of the study design (RCT or CT), sample size, and consent rate. The Cochrane risk-of-bias criteria (eg, low risk, high risk, and unclear risk) are applied to selection (randomization and concealment of group allocation), detection (masking of observers and biochemical validation of tobacco exposure and smoking behavior), and attrition bias (loss to follow-up).22

Intervention Fidelity
Intervention fidelity was assessed in relation to adherence to the treatment protocol, indicated by the proportion of participants who received the full intervention. If data were available for extraction, adherence was classified as high (>80%), moderate (50%-79%), or low (<50%).23

Data Synthesis
For the outcomes of reduction in child TSE and parental smoking reduction, study outcomes are described narratively because considerable variation in measures across studies precluded meta-analysis. For the remaining outcomes (parental smoking cessation and maternal smoking relapse prevention), meta-analysis was performed that included RCTs and CTs using the random-effects model by DerSimonian and Laird.24 To test the robustness of the primary model, post hoc meta-analysis was also performed, removing CT trials with high risk of bias. Risk ratios (RRs) with 95% CIs were calculated for individual studies and for the overall intervention study populations and are presented in forest plots25 using statistical software (Review Manager; Copenhagen, Denmark).26 Statistical heterogeneity was examined using the I² statistic, which quantifies inconsistency across studies. An I² statistic exceeding 50% indicates substantial heterogeneity.22 Publication bias was assessed by visual examination of funnel plots.22

If both biochemically validated and self-reported child TSE and parental smoking behavior outcome data were available, the biochemically validated data were used.27 If the outcomes were presented for multiple follow-up periods, the longest was used (with point prevalence selected over sustained measures). An intent-to-treat analysis was used. If trials reported on multiple outcomes of interest, they were eligible for inclusion in each relevant analysis. The term comparison group is used to describe the control condition because some trials compared the intervention condition with a lesser intervention rather than with a usual care control group.

Results
Description of Studies
Of the 57 studies identified by Baxi et al,9 a total of 41 were excluded because the intervention was not delivered by health
Interventions to Reduce Tobacco Smoke Exposure in Children

Comparison Group. Reduction in child TSE was apparent in the comparison groups of 2 of these studies. One trial consisted of physician-delivered brief advice during a well-child clinic visit and provision of biochemical feedback of infant urinary cotinine. One trial involved brief advice delivered over 3 contacts by a pediatric primary care team consisting of a pediatrician and a nurse. The remaining 2 studies involved nurse-delivered brief advice and self-help materials during one well-child clinic visit or over 2 contacts during child hospitalization.

Parental Smoking Behavior

Parental Smoking Cessation | Meta-analysis of 8 RCTs and one CT (n = 6399 participants) demonstrated no overall intervention effect on urinary cotinine, child serum cotinine, nicotine in child's hair, or implementation of TSE avoidance strategies. No significant intervention effects were reported relative to the comparison group. Reduction in child TSE was apparent in the comparison groups of 2 of these studies.

Assessment of Methodological Quality

Risk of Bias

Eleven studies had high or unclear risk of allocation (selection) bias primarily because of missing or poor methods of randomization. Similarly, 9 studies were of high or unclear risk of allocation concealment, with many providing no description of allocation concealment. Six studies were of high or unclear risk of detection bias, typically owing to nonvalidation of self-reported outcomes and nonmasking of study data collectors to the experimental group allocation. Seven studies were at high or unclear risk of attrition bias primarily because of high or differential attrition rates between the experimental and comparison groups. The intervention fidelity of individual studies included the potential for contamination between intervention and comparison groups, and variability between groups and small sample sizes. Funnel plots seemed to be symmetrical, providing little evidence of publication bias. (Figure 2 and eFigure 3 in the Supplement).

Intervention Fidelity

Four of the 16 studies reported adherence to the treatment protocol. All described moderate intervention fidelity, with 50% to 79% of participants receiving the full intervention.

Effectiveness of Interventions

Child Tobacco Smoke Exposure

Of the 6 trials that measured TSE reduction in children by child urinary cotinine, child serum cotinine, nicotine in child's hair, or implementation of TSE avoidance strategies, no significant intervention effects were reported relative to the

References up to September 2013 identified by the Cochrane Collaboration Tobacco Addiction Group through database and hand searching (number not specified)

Updated search records (September 2013 to June 2015) identified by us

A 32 Studies excluded

23 Did not meet selection criteria for study design, participants, and outcomes

9 Ongoing study (outcome data not available)

B 287 Records excluded

286 Did not meet selection criteria for study design, participants, and outcomes

1 Ongoing study (outcome data not available)

A 89 Studies screened by the Cochrane Collaboration Tobacco Addiction Group (137 references)

A 57 Studies assessed against secondary selection criteria (full text available for 89 of 98 references)

B 14 Studies assessed against secondary selection criteria (full text available for all references)

B 16 Studies included in qualitative synthesis

Studies included in quantitative synthesis (meta-analysis)

2 RCTs and 1 CT for parental smoking cessation

2 RCTs and 1 CT for maternal postpartum smoking relapse prevention

CT indicates controlled trial; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; and RCT, randomized clinical trial.
<table>
<thead>
<tr>
<th>Source</th>
<th>Primary Aim of Intervention</th>
<th>Study Design</th>
<th>Child Age at Study Enrollment</th>
<th>Study Setting</th>
<th>Health Care Professional Components</th>
<th>Intensity and Duration of Intervention</th>
<th>Intervention Fidelity</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilmonczyk et al.31 1992 (United States)</td>
<td>Reduction in child TSE</td>
<td>RCT</td>
<td>Mean age, 1.8 mo</td>
<td>Well-child clinic visit</td>
<td>Physician A, C, D</td>
<td>1 Contact</td>
<td>Not reported</td>
<td>2 mo</td>
</tr>
<tr>
<td>Vineis et al.39 1993 (Italy)</td>
<td>Parental smoking cessation</td>
<td>CT</td>
<td>3 mo</td>
<td>Well-child clinic visit</td>
<td>Nurse A, D</td>
<td>1 Contact</td>
<td>Not reported</td>
<td>24 mo</td>
</tr>
<tr>
<td>Eriksen et al.41 1996 (Norway)</td>
<td>Reduction in child TSE, parental smoking cessation</td>
<td>RCT</td>
<td>Less than 4 y; enrolled at 6 wk, 2 y, or 4 y</td>
<td>Well-child clinic visit</td>
<td>Nurse A, D</td>
<td>1 Contact</td>
<td>Not reported</td>
<td>1 mo</td>
</tr>
<tr>
<td>Severson et al.33 1997 (United States)</td>
<td>Parental smoking cessation, maternal postpartum smoking relapse prevention</td>
<td>Cluster RCT</td>
<td>Less than 10 wk; median age, 14 d</td>
<td>Well-child clinic visit</td>
<td>Physician, nurse practitioner, or physician assistant A, D</td>
<td>4 Contacts over 6 mo</td>
<td>Moderate</td>
<td>12 mo</td>
</tr>
<tr>
<td>Fossum et al.40 2004 (Sweden)</td>
<td>Parental smoking reduction</td>
<td>CT</td>
<td>0-4 wk</td>
<td>Well-child clinic visit</td>
<td>Nurse B, D</td>
<td>2-3 Contacts over 3 mo</td>
<td>Not reported</td>
<td>3 mo</td>
</tr>
<tr>
<td>Zakanian et al.46 2004 (United States)</td>
<td>Reduction in child TSE, parental smoking cessation</td>
<td>RCT</td>
<td>Less than 5 y; mean age, 17 mo</td>
<td>Well-child clinic visit</td>
<td>Health educator, nurse, or medical assistant B, D</td>
<td>7 Contacts over 6 mo</td>
<td>Moderate</td>
<td>12 mo</td>
</tr>
<tr>
<td>Chan and Lam.42 2006 (Hong Kong)</td>
<td>Reduction in child TSE</td>
<td>RCT</td>
<td>0 to &gt; 15 y; mean age, 4.77 y</td>
<td>Hospital</td>
<td>Nurse A, D</td>
<td>2 Contacts over 2 wk</td>
<td>Not reported</td>
<td>12 mo</td>
</tr>
<tr>
<td>Kallio et al.43 2006 (Finland)</td>
<td>Reduction in child TSE, parental smoking cessation</td>
<td>RCT</td>
<td>5 mo</td>
<td>Well-child clinic visit</td>
<td>Physician, dietician B, D</td>
<td>Up to 16 contacts over 8 y</td>
<td>Not reported</td>
<td>8 y</td>
</tr>
<tr>
<td>Nueslein et al.44 2006 (Germany)</td>
<td>Parental smoking reduction</td>
<td>RCT</td>
<td>Unknown</td>
<td>Pediatric clinic</td>
<td>Physician A, C, D</td>
<td>1 Contact</td>
<td>Not reported</td>
<td>6 wk</td>
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<tr>
<td>Yilmaz et al.45 2006 (Turkey)</td>
<td>Parental smoking cessation</td>
<td>RCT</td>
<td>Unknown</td>
<td>Pediatric clinic</td>
<td>Nurse A, D</td>
<td>1 Contact</td>
<td>Not reported</td>
<td>6 mo</td>
</tr>
<tr>
<td>French et al.32 2007 (United States)</td>
<td>Maternal postpartum smoking relapse prevention</td>
<td>CT</td>
<td>Less than 1 wk</td>
<td>Well-child home visit</td>
<td>Nurse B, D</td>
<td>4 Contacts over 2 mo</td>
<td>Moderate</td>
<td>6 mo</td>
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<tr>
<td>Ralston and Roohi43 2008 (United States)</td>
<td>Parental smoking cessation</td>
<td>RCT</td>
<td>Newborn &lt;1 mo to 17 y</td>
<td>Hospital</td>
<td>Physician B, E</td>
<td>1 Contact</td>
<td>Not reported</td>
<td>6 mo</td>
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<tr>
<td>Phillips et al.37 2012 (United States)</td>
<td>Maternal postpartum smoking relapse prevention</td>
<td>RCT</td>
<td>Less than 1 wk</td>
<td>Hospital</td>
<td>Physician B, D</td>
<td>1 Contact</td>
<td>Not reported</td>
<td>2 mo</td>
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<tr>
<td>Ralston et al.33 2013 (United States)</td>
<td>Parental smoking cessation</td>
<td>RCT</td>
<td>Maximum age, 51 mo; mean age, 29 mo</td>
<td>Hospital</td>
<td>Physician A, D, F</td>
<td>1 Contact</td>
<td>Not reported</td>
<td>2 mo</td>
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<tr>
<td>Winickoff et al.38 2014 (United States)</td>
<td>Parental smoking cessation</td>
<td>Cluster RCT</td>
<td>Mean age, 14.5 mo</td>
<td>Pediatric clinic</td>
<td>Physician, nurse, or medical assistants A, E, F</td>
<td>Minimum of 1 contact over 12 mo</td>
<td>Moderate</td>
<td>12 mo</td>
</tr>
<tr>
<td>Ortega Cuevea et al.46 2015 (Spain)</td>
<td>Reduction in child TSE</td>
<td>Cluster RCT</td>
<td>Less than 18 mo</td>
<td>Pediatric clinic</td>
<td>Physician, nurse A, D</td>
<td>3 Contacts</td>
<td>Not reported</td>
<td>6 mo</td>
</tr>
</tbody>
</table>

Abbreviations: CT, controlled trial; RCT, randomized clinical trial; TSE, tobacco smoke exposure.

*A* is brief advice; *B* is behavioral counseling (face to face or telephone); *C* is biochemical feedback; *D* is self-help materials, *E* is nicotine therapy, and *F* is quitline referral.

*b* High is at least 80%; moderate is 50% to 79%; and low is less than 50%.23
effect on parental smoking cessation (RR, 1.05; 95% CI, 0.74-1.50; P = .78), with evidence of substantial heterogeneity across studies (I² = 60%, P = .01). Limiting the meta-analysis to the 8 RCTs (n = 5824) had a limited influence on the overall effect (RR, 1.04; 95% CI, 0.67-1.62; P = .86) or on heterogeneity across studies (I² = 65%, P = .005).

Of the 9 RCTs and CTs reporting parental smoking cessation outcomes, one reported a statistically significant reduction in parental smoking in the intervention group (vs a comparison group) at 12 months. However, this study was found to be at high risk of selection and detection bias (Figure 2 and eFigure 1 in the Supplement). The study consisted of brief advice and self-help materials delivered by a nurse during a single pediatric clinic. Removal of this study from the meta-analysis reduced the heterogeneity (I² = 40%, P = .14).

Of the remaining 8 unsuccessful trials targeting parental smoking cessation, 5 were performed among well-child clinic visits. Of these studies, 2 consisted of nurse-delivered brief advice during 1 contact, another involved brief advice delivered over 4 contacts by multiple health care professionals, and 2 provided behavioral counseling over multiple contacts with multiple health care professionals. One trial was implemented in pediatric clinics and included physician-delivered or nurse-delivered routine tobacco screening, motivational messaging, provision of NT, and quitline enrollment. The final 2 trials were conducted during child hospitalization and consisted of physician-delivered brief advice or behavioral counseling plus NT during a single hospital visit. Increased cessation was evident in the comparison groups of 5 of these studies (eTable in the Supplement).

Parental Smoking Reduction | Two trials focused on parental smoking reduction.40,44 The first assessed the effectiveness of nurse-delivered behavioral counseling over 3 contacts during well-child clinic visits and reported significant reductions in maternal salivary cotinine in the intervention group compared with a comparison group at 3 months.40 This study was found to be at high risk of selection, attrition, and detection bias (eFigure 1 in the Supplement). The second trial, involving physician-delivered brief advice and maternal cotinine feedback, found no effect of the intervention on maternal urinary cotinine.44 Reduction in parental smoking was apparent in the control group of this study (eTable in the Supplement).

Maternal Postpartum Smoking Relapse Prevention | All 3 studies32,35,37 addressing maternal postpartum relapse prevention reported significant intervention effects on maternal smoking rates. Meta-analysis of the 2 RCTs and one CT (n = 1293) demonstrated a significant intervention effect for maternal smoking abstinence (RR, 1.53; 95% CI, 1.10-2.14; P = .01) (Figure 3). The results were not significantly heterogeneous (I² = 49%, P = .14). Restricting the meta-analysis to RCTs also produced a significant intervention effect (RR, 1.39; 95% CI, 1.03-1.88; P = .03) (I² = 44%, P = .18). The first study35 involved brief advice delivered over 4 occasions by a range of health care professionals during well-child clinic visits. The second study37 consisted of brief advice provided at a single contact during infant admission to a neonatal intensive care unit. The third study32 incorporated nurse-delivered behavioral counseling provided during 4 well-child home visits. A sustained relapse prevention effect was apparent in the comparison group in one study35 (eTable in the Supplement).

Discussion

To our knowledge, this review is the first to specifically examine the effectiveness of child TSE reduction interventions when delivered by health care professionals who provide rou-
tine child health care. The findings fail to establish the effectiveness of interventions delivered by health care professionals in the context of routine child health care in decreasing child TSE, increasing parental smoking cessation, or reducing the number of cigarettes smoked. However, such interventions seem to be effective in preventing maternal smoking relapse in the postpartum period.

The finding of an intervention effect for maternal smoking relapse prevention is consistent with a Cochrane review focusing on 4 RCTs of postpartum efficacy and effectiveness. Evidence of intervention effectiveness in reducing postpartum relapse is important given that approximately two-thirds of women who quit smoking for pregnancy will relapse. There is potentially a substantial public health benefit if child health care professionals routinely identify mothers who have quit for pregnancy and provide them with support to remain smoke free. The findings of our meta-analysis indicate that such support should consist of brief advice or behavioral counseling delivered over 4 contacts. Furthermore, while general tobacco treatment and maternal health guidelines give some attention to care for mothers who quit for pregnancy, strengthening of recommendations for child health care professionals to prevent maternal postpartum smoking relapse is warranted. Given that research suggests poor adherence to evidence-based approaches to addressing smoking cessation in pregnancy, the adoption of such recommendations should be supported by practice change strategies shown to increase intervention delivery.

In contrast to a meta-analysis of parental smoking cessation interventions by Rosen et al, the present review found no intervention effect on parental smoking cessation when the intervention was delivered by health care professionals who provide routine child health care. The review by Rosen et al included 18 studies, 7 of which were delivered by health care professionals who provide routine child health care, and the remaining 11 were efficacy trials delivered by personnel employed in research settings. The authors reported a 4% absolute difference between parental quit rates in intervention and control conditions of included studies. The discordance in findings between the present review and the review by Rosen et al may be attributable to the lack of child health care provider adherence to intervention delivery protocols in the review herein or to increased intervention delivery expertise of personnel employed in research settings. The lack of an intervention effect on TSE outcomes in children when interventions are delivered by health care professionals who provide routine child health care is consistent with the findings of reviews that have examined efficacy and effectiveness trials. The recent Cochrane review by Baxi et al determined that the efficacy of such interventions has not been clearly established across a range of outcomes, including biochemically verified TSE and parental report. Similarly, a 2014 meta-analysis of 30 trials reported no significant intervention effects on biochemically verified TSE but found a small but significant intervention effect on parent-reported child TSE.

There may be several possible explanations for the lack of an intervention effect on child TSE and parental smoking cessation and reduction. First, the intervention content may not have been adequate to influence change in the outcomes of interest. Evidence from a Cochrane review indicates that NT can increase quit rates by 50% to 70%. However, only 2 studies in the present analysis incorporated the use of NT to support parents to quit, and the uptake was minimal at best. Given that NT was contraindicated during pregnancy and breastfeeding until recently, there may be a need to overcome a reluctance to prescribe NT to mothers. Second, the variation in measurement of child TSE outcomes precluded an overall quantitative meta-analysis, making it difficult to summarize the findings regarding intervention effectiveness. The absence of standardized measures with adequate sensitivity for assessing changes in child TSE outcomes may also have contributed to the lack of demonstrated intervention effect.

<table>
<thead>
<tr>
<th>Source</th>
<th>Experimental Events</th>
<th>Control Events</th>
<th>Total</th>
<th>Risk Ratio (95% CI)</th>
<th>Favors</th>
<th>Control Events</th>
<th>Total</th>
<th>Risk Ratio (95% CI)</th>
<th>Favors</th>
<th>Risk of Bias</th>
<th>Weight, %</th>
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<tr>
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<td>200</td>
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<td>109</td>
<td>417</td>
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<td>A</td>
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<tr>
<td>French et al.</td>
<td>26</td>
<td>121</td>
<td>9</td>
<td>97</td>
<td>2.32</td>
<td>1.14-4.71</td>
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<td></td>
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<td>Phillips et al.</td>
<td>17</td>
<td>21</td>
<td>13</td>
<td>28</td>
<td>1.74</td>
<td>1.11-2.73</td>
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<tr>
<td>Total</td>
<td>243</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>D, E</td>
<td>100.0</td>
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</tbody>
</table>

Heterogeneity: τ² = 0.04; χ² = 3.96; P = .14; I² = 49%

Test for overall effect: z = 2.51; P = .01

Under the Risk of Bias category, A indicates random sequence generation (selection bias); B, allocation concealment (selection bias); C, incomplete outcome data (attrition bias); D, other bias; and E, masking of outcome assessment (detection bias). Green circles represent low risk of bias, red circles represent high risk of bias, and yellow circles represent unclear risk of bias. Risk ratios are by random Mantel-Haenszel test. The study by French et al is a CT, while the other studies are RCTs. CT indicates controlled trial; RCT, randomized clinical trial.

Figure 3. Forest Plot of 2 RCTs and 1 CT (n = 1293) Reporting Maternal Postpartum Smoking Relapse Prevention Outcomes, With Risk-of-Bias Assessment Adapted From the Work by Baxi et al
cent recommendations regarding best practice measurement of TSE\textsuperscript{67-69} should facilitate the future use of standardized measurement of exposure and improved capacity to quantify intervention effectiveness. Third, as noted previously,\textsuperscript{7,9} comparable reductions in TSE were evident across both intervention and comparison groups in 6 of the identified trials. This finding may be associated with the receipt of a “lesser intervention” by comparison groups relative to usual care control groups\textsuperscript{70} or may reflect an intervention effect in both groups because of measurement of child TSE in itself.\textsuperscript{71,72} Fourth, it was difficult to determine adherence by health care professionals who provide routine child health care to trial intervention protocols. Few trials assessed within this review provided information regarding intervention fidelity. Those that did reported that less than 80% of study participants received the intervention in accord with the intended protocol. Increasing treatment fidelity using evidence-based frameworks to inform intervention design and implementation will improve both intervention effectiveness and reporting of behavioral change interventions.\textsuperscript{73} Such improved reporting will facilitate identification of effective intervention components,\textsuperscript{2,3} which is important for informing future practice guideline development.

The outcomes of this review should be considered in light of several limitations. First, variability in outcome measures, length of follow-up, intervention strategies, and unknown intervention fidelity most likely contributed to study heterogeneity. However, an attempt was made to minimize the effect of heterogeneity on the mean effect calculated in the meta-analysis by applying a random-effects model.\textsuperscript{2,4} Second, most trials included in the analysis were conducted in North America or Europe, potentially limiting the external validity of the findings beyond these settings. Third, identification of only a small number of trials that assessed some outcomes and the presence of some level of bias in most studies made it difficult to draw strong conclusions about intervention effectiveness.

Conclusions

Based on this review and meta-analysis, the effectiveness of interventions implemented by health care professionals who provide routine child health care in reducing child TSE or increasing parental smoking cessation remains to be established. These null effects may relate to issues surrounding outcome measurement, appropriateness of the intervention content, or intervention fidelity. Interventions delivered by health care professionals who provide routine child health care seem to be effective in preventing maternal smoking relapse in the postpartum period, suggesting a need to strengthen these guidelines. Further high-quality research in the context of routine child health care is required to improve the effectiveness in reducing child TSE and increasing parental smoking cessation. Such studies should examine the effectiveness of provision of NT to support parental smoking cessation and explore mechanisms for systemizing care through clinical practice change strategies and improving intervention fidelity.

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