Motivating prepartum smoking cessation: A consideration of biomarker feedback

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Maternal smoking is the single most important modifiable cause of poor pregnancy outcomes in the United States. To further reduce prepartum smoking prevalence, new and innovative treatment strategies have been called for. According to the Public Health Service's clinical practice guideline, one counseling strategy that warrants further investigation is use of biomarker feedback to educate women about the adverse effects of their smoking and the risks it poses to their health and the health of their unborn children. Many women who fail to quit smoking during pregnancy underestimate its risks. Providing tangible evidence of smoking-related risk may help motivate future cessation attempts. This article looks at the rationale and evidence for using biomarker feedback as a cessation aid during pregnancy. Limitations of the existing research and key considerations for future investigations are presented.

Introduction

Cigarette smoke exposure poses significant health risks to unborn fetuses. Smoking is the single most important modifiable cause of poor pregnancy outcomes in the United States (Orleans, Barker, Kaufman, & Marx, 2000). It increases the risk for ectopic pregnancy, prenatal complications, preterm delivery, spontaneous abortion, stillbirth, and neonatal mortality. Maternal smoking also can result in a range of birth defects and is associated with sudden infant death syndrome (for review, see U.S. Department of Health and Human Services, 2001). Despite these risks, 17% of pregnant women in a recent national household survey reported smoking in the previous month (Substance Abuse and Mental Health Services Administration, 2000). To address this important problem, a two-pronged approach is called for: Best-practice cessation interventions need to be integrated into standard prenatal care, and more research is needed to develop new ways to motivate and assist pregnant women in quitting smoking (Orleans et al., 2000).

One new treatment strategy under consideration is the use of biomarker feedback to enhance motivation for quitting. Most smokers acknowledge the health risks of tobacco use, but they minimize their personal risk (Weinstein, 1998). Feedback from relevant diagnostic and screening tests that indicate exposure to harmful toxins or carcinogens, increased genetic susceptibility to disease, or presence of smoking-related disease may increase motivation for quitting by making risk communications more personal and salient (Lerman, Orleans, & Engstrom, 1993). Increasing risk awareness of pregnant smokers could be especially effective because fetal health concerns are commonly cited as a reason for quitting during pregnancy. Women who do not believe smoking is harmful to their unborn child report less intent to quit (Ershoff, Solomon, & Dolan-Mullen, 2000) and are more likely to continue smoking during the prenatal period (Ockene et al., 2002). Providing pregnant smokers with personally relevant, biologically based evidence that smoking is detrimental could increase their motivation to stop smoking, increase their utilization of available treatment services, and ultimately increase their ability to quit and remain smoke free.
to be key to motivation and behavior change (Weinstein, 1993). For example, the health belief model (Becker, 1974), protection motivation theory (Maddux & Rogers, 1983), theory of reasoned action (Fishbein & Ajzen, 1975), and theory of planned behavior (Ajzen, 1991) all assume that the anticipation of a negative health outcome and the desire to avoid this outcome or to reduce its impact creates a motivation for self-protection. The extent to which motivation is affected depends on the perceived likelihood that the negative outcome will occur and an expectation that change can reduce the likelihood of harm (Weinstein, 1993). Applied to smoking cessation, motivation for quitting should be increased if continued smoking is perceived as a health threat and quitting smoking is believed to reduce this threat.

Most smokers are aware of the health risks of smoking, but they underestimate their personal risk (Weinstein, 1998). Providing smokers with evidence of disease risk from personal biomarker screening tests could increase this awareness. Smoking biomarkers are biologically based indices of smoking-related disease risk or harm. Biomarkers include genomic evidence of increased cancer susceptibility (e.g., presence of the CYP2D6 enzyme, absence of the GSTM1 enzyme), markers of carcinogen or toxin exposure (e.g., carbon monoxide, thiocyanate, or cotinine level) that imply increased disease risk, and evidence of physical harm or disease from diagnostic tests (e.g., computed tomography scan). Such feedback differs from traditional health risk appraisals in that it conveys personalized risk information, not presumed risk based on epidemiological data or mortality statistics. Health risk appraisals have not been found to be effective agents of behavior change (Wagner, Beery, Schoenbach, & Graham, 1982), but individually tailored health risk communication and interventions can be. The goal of individually tailoring risk feedback is to provide personally relevant and appropriate information (Rimer & Glassman, 1999). In doing so, the materials become more engaging (DiClemente, Marinili, Singh, & Bellino, 2001). Interventions that use individually tailored materials are better remembered, perceived as more relevant and credible, and more effective than generic interventions (Kreuter, Strecher, & Glassman, 1999; Skinner, Campbell, Rimer, Curry, & Prochaska, 1999). Biomarker feedback is one form of individually tailored health risk communication.

Tangible evidence of relevant harm exposure may be an especially persuasive motivator with pregnant smokers, particularly those who fail to quit smoking spontaneously after learning they are pregnant. Women who continue to smoke during pregnancy believe the risk to their fetus is lower than do women who quit spontaneously (Ockene et al., 2002). In fact, spontaneous quitters rate concern about their babies’ health and a desire to be healthy during pregnancy as
greater reasons for quitting than concern about their own future illness, concern about modeling smoking for their children, or social pressures not to smoke (Curry, McBride, Grothaus, Lando, & Pirie, 2001). Women abstinent during their third trimester report significantly higher levels of pregnancy-related motivation for quitting than do women who continue to smoke (Curry et al., 2001). Together these findings suggest that perceived fetal risk and pregnancy-related smoking concerns are important predictors of cessation during pregnancy.

According to the theories cited above, if the biomarker screening and feedback alters perceived disease susceptibility, motivation for quitting should be enhanced. However, increased risk perception alone will not lead to cessation. According to the health belief model, when perceived risk is high, behavior change is a function of the relative balance between the perceived benefits of taking action and the perceived barriers to action (Becker, 1974). Quitting must be seen as beneficial and the individual must believe that he or she has the capacity to overcome the barriers to this goal. Change is not likely to occur if self-efficacy is low (Strecher, Becker, Kirscht, Eraker, & Graham-Tomasi, 1985). This finding explains why cessation is greatest when smokers receive appropriate action-oriented assistance including social support, skills training, and pharmacotherapy (Fiore et al., 2000). Prenatal biomarker screening creates an opportunity to illustrate the harmful biological impact of smoking, to educate women about the implications of this harm for themselves and their unborn children, and to intervene and provide appropriate cessation assistance. The combination of these activities may enhance motivation and, subsequently, prenatal cessation.

**Empirical evidence for using biomarker feedback as a cessation aid**

**Review procedures**

Published studies were identified through PubMed, PsychLit, and the reference lists of pertinent manuscripts. A MEDLINE search was conducted for articles published between 1966 and March 2003. A PsychLit search was conducted for articles published between 1970 and March 2003. Results of unpublished pilot studies were provided by the Robert Wood Johnson Foundation’s Smoke-Free Families program.

**Evidence for biomarker feedback as a smoking cessation aid**

A recent review of the literature found preliminary empirical support for using biomarker feedback as a cessation treatment aid (McClure, 2001). Smokers who received feedback about their pulmonary functioning, carboxyhemoglobin, and plasma cotinine levels reported increased motivation for quitting (Richmond & Webster, 1985). Combining feedback on smokers’ genetic susceptibility for lung cancer and carbon monoxide level increased their likelihood of making a quit attempt (Audrain et al., 1997). When biomarker feedback was combined with concomitant cessation treatment, abstinence rates were increased relative to treatment without feedback (Richmond & Webster, 1985; Risser & Belcher, 1990).

Similar findings were reported in three recently published trials. Among active smokers in the Early Lung Cancer Action Program who underwent a low-dose helical computed tomographic scan, 74% stated the test made them consider quitting, 26% reportedly reduced their smoking at follow-up, and 23% reportedly quit smoking. Smokers were more likely to cut back or quit smoking if a pulmonary nodule or other abnormality was found (62% vs. 46%, p = .09), especially among women (63% vs. 40%, p = .04) (Ostroff, Buckshee, Maneuso, Yankelevitz, & Henshke, 2001). Bovet, Perret, Cornuz, Quilindo, and Paccaud (2002) examined the effect of physician counseling with and without ultrasonography of the carotid and femoral arteries for peripheral atherosclerosis. A significant treatment effect was observed at 6 months. Abstinence was higher among persons who participated in ultrasonography than among those who did not (p = .03) and higher among persons with evidence of atherosclerotic plaques than among those with negative ultrasonograms (22.2% vs. 5.0%, p = .003). Finally, McBride and colleagues (2002) examined the effects of a multicomponent intervention that combined genetic susceptibility feedback with self-help treatment and nicotine patch. African-American smokers were recruited through a local community health clinic and randomized to receive genetic testing for the GST(3) gene (GSTM1) or not. Participants in the genetic feedback group were called up to four times by a counselor to discuss their test results and sent a booklet explaining the test results. Self-reported smoking cessation at 6 months was greater in the feedback group than among persons receiving treatment without feedback (19% vs. 10%, p < .006). Together this research suggests that biomarker feedback can be a useful cessation aid, especially when used in conjunction with appropriate action-oriented treatment.

**Evidence for biomarker feedback as a cessation aid during pregnancy**

Empirical support for using biomarker feedback as a cessation aid during pregnancy is more limited. To date, only three published studies (Bauman, Bryan, Dent, & Koch, 1983; Haddow, Knight, Kloza, Palomaki, & Wald, 1991; Hajek et al., 2001) and
two unpublished pilot trials funded by the Robert Wood Johnson Foundation's Smoke-Free Families initiative (Hoffman, Flanagan, & Frank, 1998; Webb & Hock-Long, 2002) explicitly included biomarker feedback as a prenatal cessation treatment component. Evaluation of this treatment component was not an objective of all studies. Methodological issues further limit the conclusions that can be drawn from this work about feedback effectiveness (see Table 1 for an overview of each study and relevant design issues). No studies investigated treatment impact on motivation for quitting during the prenatal period. Hajek and colleagues (2001) assessed desire to stop smoking at postnatal follow-up. Women in the feedback group had a slightly greater desire to stop smoking, but because carbon monoxide feedback was part of a multicomponent intervention that was compared with usual care, this finding cannot be attributed to the feedback alone. Only two studies examined treatment impact on maternal smoking behavior (Bauman et al., 1983; Hajek et al., 2001), and neither design permitted evaluation of the effects of the feedback. Hajek and colleagues covaried treatment type and intensity with carbon monoxide feedback, and Bauman et al. provided similar information about carbon monoxide effects to both treatment groups. Neither trial provided more than minimal cessation assistance, thereby limiting the likelihood of enhanced cessation. Finally, both trials combined smokers and nonsmokers in the intervention groups, making it difficult to evaluate the treatment impact on smokers alone.

Findings from Haddow et al. (1991) suggest a treatment effect. Pregnant smokers were recruited during prenatal screenings and randomized to treatment or control. Treatment participants were provided written feedback on their serum cotinine levels at two time points 1 month apart. The reports were presented by physicians and detailed each woman's cotinine levels and the association between cotinine and reduced infant birth weight. Mean birth weight (a rough proxy of smoking cessation and the main outcome) increased significantly but only among women treated by providers who were most compliant with carbon monoxide feedback, and Bauman et al. provided similar information about carbon monoxide feedback to both treatment groups. Neither trial provided more than minimal cessation assistance, thereby limiting the likelihood of enhanced cessation. Finally, both trials combined smokers and nonsmokers in the intervention groups, making it difficult to evaluate the treatment impact on smokers alone.

Considerations for future research

It is unknown whether biomarker feedback is an effective treatment aid with pregnant smokers. The compelling need to develop effective cessation programs for pregnant smokers and the results of studies with nonpregnant populations support further work in this area. The following process and outcome issues are important considerations for any future research.

Barriers to research implementation

The studies reviewed provide important information about potential barriers to implementing biomarker testing and feedback with pregnant smokers. Understanding and planning for these issues could lessen their impact in future research.

Providers believed the biomarker testing created an important opportunity to discuss the risks of smoking with their patients, and patients were receptive to this feedback and felt it influenced their behavior change (Webb & Hock-Long, 2002). A similarly positive response has been reported by others currently testing carbon monoxide feedback (Patricia Cluss, Ph.D., personal communication, August 21, 2002) and cotinine feedback (Mark Doescher, M.D., M.P.S.H., personal communication, August 21, 2002) with pregnant smokers. Despite these endorsements, all but one study reported problems with protocol compliance and had difficulty implementing the interventions within routine prenatal care. Bauman et al. (1983) is the exception only because no effort was made to integrate treatment into standard practice. Women received a brief, one-time intervention (carbon monoxide assessment and feedback vs. informational feedback with no assessment) in large groups while attending a public prenatal clinic orientation. When carbon monoxide or cotinine assessment and feedback, with or without cessation counseling, was combined with ongoing care, poor provider compliance affected participant recruitment, retention, or intervention delivery (Haddow et al., 1991; Hajek et al., 1991; Hoffman et al., 1998; Webb & Hock-Long, 2002). Enhancing provider compliance is a critical consideration for future research.
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<thead>
<tr>
<th>Reference</th>
<th>Sample</th>
<th>Contact and treatment design</th>
<th>Key results</th>
<th>Study considerations</th>
</tr>
</thead>
</table>
| Bauman et al., 1983 | 170 pregnant women (smokers and nonsmokers)                           | Women enrolled during public prenatal clinic orientation visit. Follow-up 6 weeks later.  
  Control: Women read script describing relation between carbon monoxide (CO) and smoking and describing harmful effects of CO.  
  Treatment: Women took CO breath test and were given results in presence of other women (smokers and nonsmokers) and then read same script as controls. | No significant difference in smoking between groups at 6 week follow-up.  
  Mean birth weight was 66 g higher in treatment group ($p < .05$).  
  Treatment group had slightly greater desire to stop smoking at postnatal interview (mean score = 2.75 vs. 2.51, $p < .02$). | No cessation treatment provided.  
  Did not assess impact on motivation for quitting, smoking reduction, or quit attempts.  
  Combined smokers and nonsmokers.  
  Both groups given same information on deleterious effects of CO. |
| Haddow et al., 1991 | 2,848 pregnant smokers in second trimester receiving screening for neural tube defects | Women who smoked 10 cigarettes a day and received maternal serum alpha-fetoprotein screening were randomly assigned to tobacco intervention groups.  
  Control: Usual care from physician.  
  Treatment: Women were provided two written reports on serum cotinine level (1 month apart) explaining the effect of smoking on birth weight, reports were explained by physician, feedback was provided on extent of cotinine change between visits, and standard quit advice was provided. | Among women seen by most compliant providers, mean birth weight was 66 g higher in treatment group ($p < .05$).  
  Birth weight was used as proxy for altered smoking behavior. | No cessation treatment provided.  
  Did not assess impact on motivation for quitting, smoking reduction, quit attempts, or cessation.  
  Birth weight was used as proxy for altered smoking behavior.  
  Poor provider compliance with repeat cotinine assessments. |
| Hajek et al., 2001  | 1,120 pregnant women in final sample (871 current smokers and 249 recent ex-smokers) | Intervention delivered during first prenatal midwifery visit (average = 12th week of pregnancy). Follow-up at 6 months and 12 months postintervention.  
  Control: Standard counseling from midwives.  
  Treatment: Women not interested in quitting were given motivational booklet. Women interested in quitting and ex-smokers were given advice to quit, CO feedback, written self-help materials, blank quit contract, invitation to partner with another pregnant smoker, medical chart note to encourage abstinence at future visits, and additional usual care from midwife. | No treatment effect for smokers.  
  Greater abstinence at postnatal follow-up for baseline ex-smokers in treatment group than control ex-smokers (65% vs. 53%, $p < .05$).  
  Treatment group had slightly greater desire to stop smoking at postnatal interview (mean score = 2.75 vs. 2.51, $p < .02$). | Minimal cessation assistance.  
  Control smokers were more interested in quitting at baseline and less nicotine dependent than were those in treatment group.  
  Intervention components were not uniformly implemented.  
  1,287 women recruited, but 1,120 were included in analyses. Women who moved, miscarried, or were “unsuitable for follow-up” were dropped. |
| Hoffman et al., 1998 | 100 pregnant smokers                                                  | Women enrolled during prenatal visits.  
  Control: Cessation counseling.  
  Treatment: Cessation counseling and repeat cotinine reports with graphic displays of urinary cotinine level plus information on fetal development and stage of pregnancy. | 20% of treatment group and 2% of controls reduced cotinine levels to nonsmoking levels during pregnancy. | Did not assess impact on motivation for quitting, smoking reduction, quit attempts, or cessation.  
  Encountered difficulty integrating study into prenatal clinics. |
Ultimately the goal of personalized risk counseling is to modify smoking behavior, but cessation may not be a valid index of treatment success. Increasing risk perception should enhance motivation for quitting. Motivation is necessary but not sufficient for behavior change. Even when motivated to make a quit attempt, most smokers require appropriate action-oriented treatment to sustain abstinence (Fiore et al., 2000). This may be especially true for women juggling the stressors of pregnancy and quitting without pharmacological cessation aid. In studies assessing biomarker feedback, impact on motivation to quit and utilization of available cessation treatment are better indices of intervention success and warrant consideration in future evaluations.

**Biomarker type**

Research has not addressed whether one type of biomarker is more effective than another. The criteria for choosing an optimum marker should be the type of information it conveys. This is especially relevant in a pregnant population because the type of risk conveyed has bearing on the sustainability of one’s behavior change. Maternal risk is an intrinsic motivator, whereas risk to the fetus is an extrinsic motivator. High levels of intrinsic relative to extrinsic motivation for quitting predict cessation (Curry, Grothaus, & McBride, 1997). Among pregnant smokers, higher baseline levels of intrinsic relative to extrinsic motivation for quitting predict sustained cessation (Curry et al., 2001). In sum, fetal risk may enhance motivation for quitting during pregnancy, but sustained cessation requires women to continue to be motivated by their own health or other intrinsic forces. Thus, the optimal biomarker in a pregnant population is one that has relevance to both the mother and the fetus and will continue to motivate abstinence in the postpartum period.

Given the difficulties of integrating biomarker assessment and feedback into routine prenatal care, pragmatic issues such as assessment ease and cost also must be considered. Two markers that are relatively easy to assess are carbon monoxide and cotinine. Although carbon monoxide level alone has not been effective in previous research (for review, see McClure, 2001), it could be more persuasive with pregnant smokers. In addition to the maternal health risks, carbon monoxide exposure results in fetal hypoxia and carboxyhemoglobinemia, which increase the risk of spontaneous abortion, premature ablatio placentae, reduced birth weight, and deformities such as aortopulmonary septum defects, polycystic kidneys, and skull deformation (Haustein, 1999). If women understand these risks and their association to carbon monoxide exposure, they may be more motivated to change their smoking behavior and sustain abstinence.
monoxide exposure, this information could prove more salient than knowledge of one's own long-term risks from carbon monoxide exposure. Furthermore, because carbon monoxide clears the system within 24 hours, it is responsive to quitting or decreased smoking and can be used to reinforce these positive changes over time.

Cotinine, a metabolite of nicotine, shares many of the advantages of carbon monoxide, although ease and cost vary with the assessment procedure used (e.g., analysis of urine, blood, saliva or hair; laboratory analysis or dipstick testing). Fetal serum cotinine concentrations average 90% of maternal values throughout gestation (Donnenfeld, Pulkkinen, Palomaki, Knight, & Haddow, 1993). Cotinine itself is not harmful, but it is a proxy for exposure to nicotine and smoking-related carcinogens. This information could have increased salience during pregnancy because of the inherent fetal health risks associated with elevated cotinine level. However, cotinine's half-life is shorter and its clearance faster during pregnancy (Dempsey, Jacob, & Benowitz, 2002). As a result, cotinine levels may underrepresent harm exposure during pregnancy, particularly among light smokers.

A final consideration is whether the biomarker conveys modifiable or immutable risk. Risk that is seen as immutable or uncontrollable, such as genetic screening tests, may actually decrease motivation to change one's behavior. Markers that convey modifiable risk may enhance motivation to quit if it is believed that quitting will reduce or eliminate the risk. Motivation to take action arises from the expectation that the action will reduce the likelihood or severity of harm (Weinstein, 1993). If quitting is believed to reduce an individual's risk and that individual believes he or she has the requisite skills or resources necessary to quit successfully (i.e., high self-efficacy), the likelihood of making a quit attempt is increased.

In sum, no research has demonstrated one biomarker to be a more preferable cessation aid than others. However, markers that increase perceived maternal and fetal risk, that are easy to assess, and that represent modifiable risk appear optimal for a pregnant population.

Potential for harm

Informing a woman that she is at increased disease risk or is placing her fetus at risk through her behavior can be psychologically distressing. Distress resulting from genetic screening test results is, for the most part, not clinically relevant and dissipates over time (for review, see Lerman, Croyle, Tercyak, & Hamann, 2002), but harm associated with smoking-related biomarkers has not been well studied. The emotional impact of this feedback will vary depending on the type of biomarker used, the information it conveys, and the population of interest. Markers that are not distressing among nonpregnant populations may be more upsetting in pregnant women or have a different trajectory of impact during pregnancy. For example, distress and guilt may not emerge until after the birth of the child or during early childhood if smoking-related complications or birth defects occur. This issue needs to be evaluated carefully in future research.

Message framing

Finally, message framing is an important consideration in any future research. Message framing refers to the emphasis placed on the positive or negative consequences of adopting a particular health behavior (Rothman & Salovey, 1997). Loss-framed messages convey the costs of not adopting the behavior. Gain-framed messages convey the benefits of engaging in the behavior. According to prospect theory, whether information is presented in terms of gains or losses differentially affects behavior decisions (Kahneman & Tversky, 1979, 1982, 1984; Tversky & Kahneman, 1981, 1992). People act to avoid risks when presented with the gains or benefits of their actions but prefer to take risks when presented with the losses or costs. Consequently, preventive health messages are more persuasive when framed in terms of the potential gains of engaging in the behavior instead of the potential costs (Rothman, Martino, Bedell, Detweiler, & Salovey, 1999). This finding presents a challenge for using biomarker feedback to present personalized risk information. To overcome this challenge, it is important to tie the feedback to a discussion of how quitting smoking can reverse negative test results or lower future health risk.

Summary and conclusions

Prenatal smoking prevalence has declined over the past decade but is far from achieving the national goal of reducing tobacco use in the previous month to 1% of pregnant women by 2010 (U.S. Department of Health and Human Services, 2000). In a nationwide survey, 17% of mothers smoked during the previous month (Substance Abuse and Mental Health Services Administration, 2000). Significantly reducing prenatal tobacco use will require a better integration of treatment into routine clinical care and development of new cessation strategies, especially those that can enhance readiness to quit. A sound theoretical rationale and growing empirical evidence indicate that biomarker feedback can be a useful motivational aid and, when combined with adjuvant treatment, may enhance cessation rates (Bovet et al., 2002, McBride et al., 2002; McClure, 2001; Ostroff et al., 2001). The limited empirical data do not indicate
whether this strategy is effective during the prenatal period, but additional well-designed study is warranted.

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References


