Preterm birth among African American and white women: a multilevel analysis of socioeconomic characteristics and cigarette smoking

J Ahern, K E Pickett, S Selvin, B Abrams

Study objective: Research shows that neighbourhood socioeconomic factors are associated with preterm delivery. This study examined whether cigarette smoking and individual socioeconomic factors modify the effects of neighbourhood factors on preterm delivery.

Design: Case-control study.

Setting: Moffitt Hospital in San Francisco, California.

Participants: 417 African American and 1244 white women, including all preterm and a random selection of term deliveries 1980–1990, excluding non-singleton pregnancies, congenital anomalies, induced deliveries, and women transported for special care. US census data from 1980 and 1990 were used to characterise the women’s neighbourhoods, defined as census tracts.

Results: Cigarette smoking increased the risk of preterm delivery among both African American (OR=1.77, 95% confidence intervals (CI) (1.12 to 2.79)) and white women (OR=1.25, 95% CI (1.01 to 1.55)). However, cigarette smoking did not attenuate or modify the association of neighbourhood factors with preterm delivery. Among African American women, having public insurance modified the relation between neighbourhood unemployment and preterm delivery; among women without public insurance, the risk of preterm delivery was low in areas with low unemployment and high in areas with high unemployment, while among women with public insurance the risk of preterm delivery was highest at low levels of neighbourhood unemployment.

Conclusions: Cigarette smoking was associated with preterm delivery, especially among African Americans. Adverse neighbourhood conditions had an influence on preterm delivery beyond that of cigarette smoking. The effects of some neighbourhood characteristics were different depending on individual socioeconomic status. Examining socioeconomic and behavioural/biological risk factors together may increase understanding of the complex causes of preterm delivery.
delivery in both descriptive and multivariable analysis. The non-linear functional form of their relations with preterm variables were included with squared terms to accommodate the risk of each neighbourhood variable alone on preterm delivery defined as delivery before 37 completed weeks of gestation.

We identified neighbourhoods in flux and assessed trends in statistics that have been used to examine individual level SES, as neighbourhood social environment by aggregating characteristics originally defined to encompass neighbourhood areas. We created 12 census tract level neighbourhood variables from the 1980 and 1990 US census.

Table 1: Census tract level neighbourhood variables from the 1980 and 1990 US census

<table>
<thead>
<tr>
<th>Variables from 1990</th>
<th>Variables from the Change between 1980-1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of African American residents</td>
<td>Change in the proportion of African American residents</td>
</tr>
<tr>
<td>Proportion of adults with less than a high school education</td>
<td>Change in the proportion of adults with less than a high school education</td>
</tr>
<tr>
<td>Proportion of unemployed adult men</td>
<td>Change in the proportion of unemployed adult men</td>
</tr>
<tr>
<td>Proportion of people in poverty</td>
<td>Change in the proportion of people in poverty</td>
</tr>
<tr>
<td>Proportion of people in working class occupations†</td>
<td>Change in the proportion of people in working class occupations†</td>
</tr>
<tr>
<td>Proportion of households in poverty</td>
<td>Median income</td>
</tr>
</tbody>
</table>
| *Adults defined as persons 18 years of age or older. †Working class occupation defined as in Krieger 1991.*

METHODS

Data for this case-control study were drawn from a cohort of all live births at Moffitt Hospital, University of California at San Francisco (UCSF) between 1980 and 1990 (17,146 deliveries). Human subjects approval was granted by the University of California at Berkeley and the USCF. We selected all African American and white singleton preterm deliveries as cases and two random selections of singleton term deliveries as controls, stratified into African American and white infants. We excluded two groups from the analysis: (1) women with non-singleton pregnancies, infants with congenital anomalies, and induced deliveries as the aetiology of preterm deliveries in these situations differs substantially from spontaneous preterm singleton deliveries, and (2) women who were transported for special care from other hospitals or regions because they did not represent the population base for this study.

The eligible analytical cohort included 417 African American and 1244 white women. We used standard methods to abstract data from the medical records as previously described. Each woman’s address was linked to census tract data from the 1980 and 1990 US census through geocoding techniques. Census tracts contain about 4000 people and were originally defined to encompass neighbourhood areas.

We created 12 census tract level neighbourhood variables from the 1980 and 1990 US census data. These variables, detailed in table 1, were selected to characterise the neighbourhood social environment by aggregating characteristics that have been used to examine individual level SES, as well as those that might reflect racial segregation. We examined the change in variables between 1980–1990 to identify neighbourhoods in flux and assess trends in neighbourhoods.

The outcome of interest in this study, preterm delivery, was defined as delivery before 37 completed weeks of gestation. The main individual level determinant of interest, cigarette smoking, was measured as cigarettes per day, self reported at the first prenatal care visit. Individual level covariates of the effect of cigarette smoking on preterm delivery considered in the analysis, included insurance coverage as Medi-Cal (California public insurance) compared with other (private insurance or payment by patient), maternal age at delivery in years, maternal height in centimetres, prepregnancy weight in kilograms, and parity.

All analyses were conducted separately for African American and white women. In the neighbourhood level analysis we used regression models with generalised estimating equations to generate parameter estimates accounting for both the individual and neighbourhood levels of the data. We modelled the risk of each neighbourhood variable alone on preterm delivery, controlling for Medi-Cal insurance coverage to adjust for individual level socioeconomic status. Neighbourhood variables were included with squared terms to accommodate the non-linear functional form of their relations with preterm delivery in both descriptive and multivariable analysis. The neighbourhood level variables with 95% confidence intervals on the combined main effect and squared terms that did not overlap the null were presented. The neighbourhood variables included in the initial models were included together in one model for African American women and one for white women.

We used logistic regression for the analysis of the effect of smoking on preterm delivery, including cigarette smoking and potential confounders. Cigarette smoking was modelled as cigarettes per day in all models.

After estimating the effect of neighbourhood and smoking independently on preterm delivery we added cigarettes per day to each of the neighbourhood models to determine whether this would change or remove the effect of the area level variables. We examined all potential cross level interactions of cigarettes per day and Medi-Cal insurance coverage with each neighbourhood variable in the final models for African American and white women. Plots of the odds ratios corresponding to values of the neighbourhood variables over the range of the data were constructed; these plots illustrate the relations between the neighbourhood variables and preterm delivery given the complexity of interpreting squared area level terms and interaction terms from parameter estimates alone.

RESULTS

The bivariate relations between demographic characteristics and preterm delivery for African American and white women are presented in table 2. Among African American and white women, the preterm cases had indicators of lower socioeconomic status and smoked more cigarettes per day, compared with controls. The African American women delivering preterm also had slightly lower non-pregnant weight, and slightly higher parity.

The first contextual model for the African American women contained three neighbourhood characteristics: median tract income in 1990, proportion of unemployed men in the tract in 1990, and the change in the proportion of African American residents between 1980 and 1990 (table 3). These neighbourhood characteristics had significant squared terms, indicating non-linear U shaped relations between the variables and preterm delivery. The first contextual model for white women had only one neighbourhood variable: the change in the proportion of unemployed men in the tract between 1980 and 1990 (table 3). This neighbourhood characteristic had a significant squared term, indicating a U shaped relation between the change in unemployment and the risk of preterm delivery. These associations have been demonstrated in another publication by the authors.

We examined the risk of preterm delivery attributable to smoking in the single level multivariable logistic regression analysis, controlling for Medi-Cal insurance, parity, maternal height, and non-pregnant weight. The model for African American women demonstrated that smoking is a risk factor for preterm delivery. The odds ratio for preterm delivery for every 10 cigarettes smoked per day was 1.77, 95% CI (1.12 to 2.79) (table 4). Smoking also increased the risk of preterm...
delivery among white women. The odds ratio for preterm delivery for every 10 cigarettes smoked per day was 1.25, 95% CI (1.01 to 1.55) (Table 4).

Examining the combined effect of neighbourhood and smoking among African American women, adding cigarettes per day to the neighbourhood model only slightly changed the parameter estimates for median income, proportion unemployed, and change in the proportion of African American residents (Table 3). There was no evidence of interactions between cigarette smoking and these neighbourhood variables. However, there was significant interaction between Medi-Cal insurance and proportion of unemployed male residents in 1990. Among white women, the association between change in unemployment and preterm delivery remained significant when adjusting for cigarette smoking. The parameter estimates for change in unemployment were slightly greater in this model (Table 3). There was no evidence of cross level interaction between cigarette smoking or Medi-Cal status and change in unemployment for white women. Odds ratios corresponding to values of each neighbourhood variable for selected percentiles are presented in graphs, along with 95% confidence intervals (Fig 1A–E).

### Table 2
Demographic and medical characteristics for cases of preterm delivery and controls, UCSF cohort 1980–1990

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>African American women</th>
<th>White women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Case n=116*</td>
<td>Control n=301*</td>
</tr>
<tr>
<td>Maternal age: mean (SE)</td>
<td>25.0 0.50 25.3 0.30</td>
<td>28.9 0.36 28.7 0.17</td>
</tr>
<tr>
<td>Parity: mean (SE)</td>
<td>1.2 0.12 1.0 0.07</td>
<td>0.75 0.07 0.74 0.03</td>
</tr>
<tr>
<td>Maternal height (cm): mean (SE)</td>
<td>163.5 0.63 164.4 0.39</td>
<td>163.8 0.40 164.5 0.22</td>
</tr>
<tr>
<td>Non-pregnant weight (kg): mean (SE)</td>
<td>61.2 1.28 65.3 0.95</td>
<td>59.4 0.76 61.1 0.40</td>
</tr>
<tr>
<td>Smoking (cigarettes/day): mean (SE)</td>
<td>4.01 0.67 1.98 0.29</td>
<td>3.02 0.34 2.20 0.19</td>
</tr>
<tr>
<td>Insurance status: n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medi-Cal</td>
<td>70 64.2 158 53.2</td>
<td>53 23.6 171 17.4</td>
</tr>
<tr>
<td>Private or self pay</td>
<td>39 35.8 139 46.8</td>
<td>172 76.4 814 82.6</td>
</tr>
<tr>
<td>Marital status: n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>28 24.6 99 33.0</td>
<td>171 72.5 742 74.7</td>
</tr>
<tr>
<td>Single/divorced/widowed</td>
<td>86 75.4 201 67.0</td>
<td>65 27.5 251 25.3</td>
</tr>
<tr>
<td>Maternal education: n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-working class</td>
<td>19 21.6 27 10.5</td>
<td>15 6.8 47 5.1</td>
</tr>
<tr>
<td>Working class</td>
<td>69 78.4 231 89.5</td>
<td>205 93.2 873 94.9</td>
</tr>
<tr>
<td>Family occupation: n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working class</td>
<td>84 72.4 196 66.9</td>
<td>86 35.7 293 29.4</td>
</tr>
<tr>
<td>Non-working class</td>
<td>32 27.6 97 33.1</td>
<td>155 64.3 703 70.6</td>
</tr>
</tbody>
</table>

*The number of women described under each characteristic differs because of missing data.

### Table 3
Multilevel logistic models of tract level socioeconomic variables and individual level Medi-Cal: examining the impact of cigarettes smoked per day, UCSF Cohort 1980–1990

<table>
<thead>
<tr>
<th>Variable*</th>
<th>Parameter estimate‡</th>
<th>p Value</th>
<th>Parameter estimate‡</th>
<th>p Value</th>
<th>Parameter estimate‡</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>African American women, n=354</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cigarettes per day</td>
<td>– –</td>
<td>– –</td>
<td>2.9432 0.0006</td>
<td>2.8204 0.0011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medi-Cal insurance</td>
<td>0.4904 0.0726</td>
<td>2.9432 0.0006</td>
<td>2.8204 0.0011</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median income</td>
<td>–0.0177 0.1727</td>
<td>–0.0233 0.0713</td>
<td>–0.0171 0.2243</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median income</td>
<td>0.0020 0.0121</td>
<td>0.0023 0.0002</td>
<td>0.0020 0.0014</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion unemployed</td>
<td>18.7145 0.0002</td>
<td>44.3926 0.0001</td>
<td>43.1257 0.0001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in African American</td>
<td>–69.9021 &lt;0.00005</td>
<td>–138.625 2 0.0002</td>
<td>–129.473 5 0.0003</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in African American</td>
<td>8.1161 0.0020</td>
<td>8.2689 0.0039</td>
<td>8.7025 0.0035</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medi-Cal × unemployed</td>
<td>34.8994 0.0011</td>
<td>31.9562 0.0063</td>
<td>32.3387 0.0093</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medi-Cal × unemployed</td>
<td>– –</td>
<td>–9.9200 0.0049</td>
<td>–38.4063 0.0070</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medi-Cal × unemployed</td>
<td>32.7676 0.0197</td>
<td>79.4757 0.0286</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable†</th>
<th>Parameter estimate‡</th>
<th>p Value</th>
<th>Parameter estimate‡</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>White women, n=1142</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cigarettes per day</td>
<td>– –</td>
<td>– –</td>
<td>0.0169 0.1525</td>
<td></td>
</tr>
<tr>
<td>Medi-Cal insurance</td>
<td>0.3833 0.0368</td>
<td>0.3368 0.0638</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in unemployment</td>
<td>–3.3248 0.1212</td>
<td>–3.5530 0.0917</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in unemployed</td>
<td>76.9932 &lt;0.00005</td>
<td>78.2600 &lt;0.00005</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


†Change in unemployed, change in the proportion of unemployed men >18 years old in the census tract in between 1980–1990. Parameter estimates are interpreted as in a logistic model with squared term, for example, OR=e^(−3.5530 × change in unemployment + 78.2600 × change in unemployed) for the change in proportion of unemployed men among white women.

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neighbourhoods with greater proportions of unemployment (fig 1B). However, African American women who were covered by Medi-Cal were at high risk of preterm delivery at low levels of unemployment, with some reduction in risk at higher levels of unemployment (fig 1C). In neighbourhoods with increasing proportions of African American residents, African American women were at increased risk of preterm delivery, and the relation was reversed in neighbourhoods with decreasing proportions of African American residents (fig 1D). White women were at increased risk of preterm delivery in neighbourhoods with both increasing and decreasing levels of unemployment (fig 1E).

Table 4  Logistic models of the effect of cigarette smoking on preterm delivery for African American and white women

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter estimate</th>
<th>SE</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>African American women, n=346</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>1.67</td>
<td>3.23</td>
<td>0.61</td>
</tr>
<tr>
<td>Cigarettes per day</td>
<td>0.057</td>
<td>0.023</td>
<td>0.015</td>
</tr>
<tr>
<td>Medi-Cal insurance</td>
<td>0.20</td>
<td>0.26</td>
<td>0.45</td>
</tr>
<tr>
<td>Parity</td>
<td>0.073</td>
<td>0.10</td>
<td>0.49</td>
</tr>
<tr>
<td>Maternal height (cm)</td>
<td>-0.013</td>
<td>0.020</td>
<td>0.53</td>
</tr>
<tr>
<td>Non-pregnant weight (kg)</td>
<td>-0.017</td>
<td>0.010</td>
<td>0.097</td>
</tr>
<tr>
<td><strong>White women, n=1153</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>1.14</td>
<td>1.86</td>
<td>0.54</td>
</tr>
<tr>
<td>Cigarettes per day</td>
<td>0.022</td>
<td>0.011</td>
<td>0.046</td>
</tr>
<tr>
<td>Medi-Cal insurance</td>
<td>0.34</td>
<td>0.19</td>
<td>0.072</td>
</tr>
<tr>
<td>Parity</td>
<td>-0.0065</td>
<td>0.076</td>
<td>0.93</td>
</tr>
<tr>
<td>Maternal height (cm)</td>
<td>-0.013</td>
<td>0.012</td>
<td>0.26</td>
</tr>
<tr>
<td>Non-pregnant weight (kg)</td>
<td>-0.0098</td>
<td>0.0072</td>
<td>0.17</td>
</tr>
</tbody>
</table>

*Parameter estimates are on the natural log scale, for example, OR=\(e^{0.057 \times \text{cigarettes per day}}\) for cigarette smoking among African Americans.

DISCUSSION
Our analyses suggest that neighbourhood socioeconomic characteristics may have an impact on preterm delivery for African American and white women that is largely independent of cigarette smoking and may be modified by individual socioeconomic characteristics. Smoking was a risk factor for preterm delivery in adjusted models and had a stronger impact on the likelihood of preterm delivery in African American women than in white women. Neighbourhood socioeconomic factors did not interact with cigarette smoking. Among African American women, the effect of neighbourhood level unemployment was different depending on...
the others in that neighbourhood.

unemployment because they were impoverished in relation to
hoods with higher unemployment. These women may have
with Medi-Cal insurance was somewhat lower in neighbour-
were already at high
women who were covered by Medi-Cal insurance and had
reasons for more prevalent BV among African Americans are
unknown, it may explain part of the differential impact of
smoking on preterm delivery in this racial/ethnic group. This
finding merits further exploration with data on smoking, BV
and preterm delivery.

Smoking could have explained some of the association
between neighbourhood factors and preterm delivery as
economic resources. These women were already at high
risk for preterm delivery. Recurring BV is also far more
common among African Americans. Although the
reasons for more prevalent BV among African Americans are
unknown, it may explain part of the differential impact of
smoking on preterm delivery in this racial/ethnic group. This
finding merits further exploration with data on smoking, BV
and preterm delivery.

Individual level Medi-Cal insurance coverage modified the
impact of neighbourhood unemployment on preterm delivery.
For African American women who were not covered by Medi-
Cal insurance and had more economic resources the risk of
preterm delivery was low when neighbourhood unemploy-
ment was low and increased when unemployment was higher.
This is plausible because women who may not have
experienced major individual level socioeconomic hardship
may still have experienced a negative impact on their birth
outcomes if the neighbourhood was in poor economic
condition. However, the relation was quite different for
women who were covered by Medi-Cal insurance and had
fewer economic resources. These women were already at high
risk of preterm delivery with low unemployment in the
neighbourhood. The risk of preterm delivery among women
with Medi-Cal insurance was somewhat lower in neighbour-
hoods with higher unemployment. These women may have
experienced the highest risk in areas with the lowest
unemployment because they were impoverished in relation to
the others in that neighbourhood. This finding is consistent
with O’Campo’s study of low birth weight, which found that
the increased risk of low birth weight for women on Medicaid
was decreased in neighbourhoods with low per capita income
compared with neighbourhoods with high per capita income.

There are several limitations to this study. The findings of a
hospital based study are not easily generalised to broader
populations. If white women from more prosperous areas who
thought they were at high risk of preterm delivery chose Mof-
Fit Hospital because of its tertiary care capacity, the increased
risk of preterm delivery in neighbourhoods with decreasing
unemployment (a potential indicator of improving social con-
ditions) could be an artefact. Census data are only available for
the beginning of each decade, so it is difficult to know how
well this information represents the conditions of the tracts
throughout the decade. In addition, census data do not
capture all aspects of neighbourhoods that may affect
health, and do not include information about the other com-
munities (for example, workplace, school) to which these
women may belong. Neighbourhood factors have not been
studied sufficiently to determine which factors best character-
ise social conditions; thus, the neighbourhood characteristics
examined in this study are necessarily exploratory. Our meas-
ure of smoking, self reported cigarettes per day at the first
prenatal care visit, is limited because some women may not
accurately report smoking. It is most probable that some
smokers are misclassified as non-smokers and not vice versa
creating a conservative estimate of the effect of smoking on
preterm delivery. Additionally, the small sample size of the
African American subgroup and the modelling of interaction
led to imprecise estimates of the effect of neighbourhood
unemployment.

Notwithstanding these limitations, we demonstrated asso-
ciations between neighbourhood socioeconomic character-
istics and preterm delivery for both African American and white
women that are independent of cigarette smoking and modi-
ified by individual socioeconomic characteristics. In addition,
we found that cigarette smoking increases the risk of preterm
delivery particularly among African American women. A bet-
ter understanding of the differential influence of factors such
as cigarette smoking on African American women may addi-
tionally help elucidate racial disparities in preterm delivery.
Examining neighbourhood and individual socioeconomic fac-
tors in combination with behavioural and biological character-
istics may lead to a better understanding of the complex
causes of preterm delivery.

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Neighbourhood, smoking, preterm