Infant exposure to environmental tobacco smoke: A prevalence study in Australia.

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ABSTRACT

Objective

This study aimed to determine: the prevalence of exposure to environmental tobacco smoke among infants aged 0-12 months in 2 child health care settings; the accuracy of parent report indicators of exposure and the factors associated with exposure to environmental tobacco smoke.

Method

Samples of consecutive parents of infants 12 months of age or younger who attended Hunter Region public child health and immunisation clinics were approached to complete a questionnaire and to allow a urine sample to be obtained from their infant during December and January 1998/99.

Infant urine samples were analysed for the presence of cotinine and information was obtained regarding the smoking status of household members, infant exposure to environmental tobacco smoke during the previous three days and parents and infant characteristics and demographics.

Results

Eighty five (47%) [95% CI:40-54] infants in the combined sample had detectable levels of cotinine. Sensitivity of reported infant exposure of 86% was achieved through the combined measure of parent report of exposure and smoking status of households. The odds of exposure for infants of smoking parents were 14 times that of infants of non smokers [CI: 5.26-50.0].

Conclusions

Almost half of the infants in this study had detectable levels of cotinine in their urine. Future interventions targeting infant exposure to environmental tobacco smoke should incorporate quit smoking strategies for both parents and other household members, as well as strategies for changing the pattern of smoking behaviour around infants.

Implications

These findings suggest that existing community education strategies and passive smoking public policies are failing to protect this vulnerable population group.

INTRODUCTION

Exposure to environmental tobacco smoke during infancy and early childhood is well recognised as a significant public health problem¹. Relative to adults, infants are particularly susceptible to environmental tobacco smoke exposure. The consequences of prolonged exposure in close proximity to smoking parents are exacerbated by infant's underdeveloped immune and pulmonary systems², small body size and higher rates of ventilation³.

Despite their greater vulnerability, infants continue to be exposed to environmental tobacco smoke, resulting in increased risk of chronic childhood otitis media and SIDS^{1,4}. In Australia, exposure to environmental tobacco smoke during infancy and early childhood is responsible for forty six thousand cases of asthma per year and a 60% greater risk of lower respiratory tract illness¹.

Community studies conducted in the United States of America using biochemically validated data suggest that up to 77% of infants less than 12 months of age are exposed to environmental tobacco smoke^{5,6}. However, understanding of the extent and nature of the problem in Australia is limited. Current self report based estimates derived from community surveys in Australia suggest that between 22% to 43% of children aged up to 16 years may be exposed^{7,8}. No biochemically validated data and no data describing exposure of infants less than 12 months of age have been reported. Recent Australian research has indicated an increasing trend in smoke free households⁹, however these estimates are based on non validated self-report measures. Whilst measurement of urinary cotinine, the major proximate metabolite of nicotine is the most accurate indicator of infant exposure to environmental tobacco smoke^{10,11}, it

is not always practicable to obtain and analyse urine samples in community settings. Parent report measures offer a more convenient means of assessing exposure and can provide additional information concerning the circumstances of exposure^{11,12}. However, no parent report measure of environmental tobacco smoke exposure in infants and children has been shown to be sufficiently accurate to replace cotinine as a measure of exposure¹²⁻¹⁴.

Community studies conducted in Europe and the United States of America have suggested that maternal and other household member smoking, marital status and social class are associated with infant/child exposure to environmental tobacco smoke¹⁵⁻¹⁷. No data have been reported that describe whether the same or other factors are independently associated with infant exposure in Australia.

Given the lack of Australian data concerning infant exposure to environmental tobacco smoke, this study aimed to determine: the prevalence of exposure to environmental tobacco smoke among infants aged 0-12 months in 2 child health care settings; the accuracy of parent report indicators of exposure and the factors associated with exposure to environmental tobacco smoke.

METHOD

Sample

Two geographically convenient samples of 5 public child health clinics and 8 public immunisation clinics in the Hunter Region of NSW Australia were approached to participate in the study during December and January 1998/99. The clinics were located in the Newcastle urban area and represented 5 of the 16 child health clinics in

this area and all of the Immunisation Clinics held in this area during the study period. It has been previously reported that up to 98% of Australian mothers attend child health and immunisation clinics at least once in the first six weeks of their baby's life¹⁸.

Consecutive infants attending the clinics during the study period (range 2-6 days for child health clinics and the entire immunisation clinic day) who were 12 months of age or younger were eligible to participate in the study if their parents were capable of completing the study procedures.

Procedures

Prior to the consultation, parents were approached by a research assistant for consent to complete a questionnaire and to allow a urine sample to be obtained from their infant. Parents were informed that the urine sample was to be analysed for exposure to environmental health risks. Cigarette smoke exposure was not specifically mentioned⁶. To obtain a urine sample, a cotton wool pad was placed in the nappy of each infant by the research assistant prior to the consultation¹¹. The pad was removed at the conclusion of the consultation and the urine extracted by compression in a syringe⁶. If a specimen could not be obtained, the research assistant collected the same or a replacement pad from the infant's home on the same day. Urine samples were refrigerated and transported to an accredited laboratory for cotinine analysis.

Ethics approval for this study was granted by the Hunter Area Research Ethics Committee, Hunter Health.

Measures

Prevalence of Exposure to Environmental Tobacco Smoke

Infant urine samples were analysed for the presence of cotinine using capillary gas chromatography¹⁹. The detection limit for cotinine with this method was 6nmol/L. As for previous community studies measuring the prevalence of exposure to environmental tobacco smoke, infants were classified as exposed if they had measurable amounts of cotinine in their urine^{12,16,20}. Single cotinine measures have been shown to be an accurate reflection of an infant's exposure to environmental tobacco smoke^{11,21}.

Breast feeding in mothers who smoke has been associated with significantly higher infant urine cotinine levels⁶. In order to allow for the possible effects of breast feeding on cotinine levels, the breast feeding status of infants was identified.

Parent Report Indicators of Environmental Tobacco Smoke Exposure

Parents were asked; "During the last three days did you or any other person smoke in the following places while your baby was there?". The available response options were: the home, car, child care, at a friend or relative's house, shopping centre, restaurant/hotel or club or any other location.

As previous studies have reported that the smoking status of people living in the household is a useful indicator of infant exposure to environmental tobacco smoke¹², parents were asked to classify the smoking status of each household member aged 16 years and older as a: never smoker, ex-smoker, occasional smoker or regular smoker⁷.

Infant and Parent Characteristics

The questionnaire sought information regarding the age and gender of the infant and of the accompanying parent, details of parental educational attainment (Year 9/10/11, Year 12, Trade Certificate, Tertiary Qualifications), employment status (employed, unemployed), and marital status (single, married/defacto).

Analysis

Prevalence of Exposure to Environmental Tobacco Smoke

The number of infants exposed to environmental tobacco smoke is reported for the 5 child health clinics, the 8 immunisation clinics and all clinics combined with and without breast fed infants of smoking mothers. Intra-cluster correlation coefficients were calculated for 3 exposure outcomes; detectable levels of cotinine, accompanying parents' smoking status and household smoking status²².

Location of Environmental Tobacco Smoke Exposure

Data describing the location of infant exposure are reported as proportions with 95% confidence intervals.

Agreement Between Cotinine Measurement and Parent Report Indicators of Environmental Tobacco Smoke Exposure

Using the combined samples of infants, the presence of urinary cotinine was used as the gold standard to calculate the sensitivity, specificity, positive and negative predictive values of 3 parent report indicators of exposure: parent report of infant exposure in any location over the previous three days; household smoking status, defined as either a smoking household (any household member reported to be a

regular or occasional smoker) or a non smoking household (all household members reported to be ex or non smokers); and a combination of the above indicators. In the latter case, the infant was considered exposed if the parent reported exposure in any location during the three days or that the infant was living in a smoking household. Breast fed infants of smoking mothers were removed from these analyses.

Predictors of Exposure to Environmental Tobacco Smoke

Using the combined samples of infants, associations between environmental tobacco smoke exposure, as defined by measurable urinary cotinine, and two measures of smoking status: smoking status of accompanying parent (regular or occasional smoker versus ex or non smoker) and smoking status of other household members (any smokers versus no smokers), and each of the seven parent and infant characteristics were initially assessed by bivariate analysis. Variables identified as being associated with exposure with a p value of 0.2 or less²³ were then included in a logistic regression model. Potential confounders were removed in a step-wise fashion if their exclusion did not meaningfully alter the co-efficient estimates relating to exposure status. Breast fed infants of smoking mothers were excluded from these analyses.

RESULTS

Sample

All 5 child health and 8 immunisation clinics agreed to take part in the study. Three hundred and thirty five consecutive infant/parent pairs attended the clinics and were approached to participate during the study period. Of these, 129 infants were ineligible, 127 being older than 12 months of age and 2 with parents who could not complete the questionnaire due to language difficulties. Of the 206 eligible

infant/parent pairs, 193 (94%) consented to participate, 102 (53%) from child health clinics and 91 (47%) from immunisation clinics. Ninety eight percent of accompanying parents were female. Table 1 describes the characteristics of the study sample in comparison to data previously reported for infants attending child health clinics in the Hunter Region²⁴ and all babies born in NSW in 1997²⁵.

(Insert Table 1)

The characteristics of the combined study sample were similar to those previously reported for infants attending child health clinics in the Hunter Region for all characteristics other than the sample having fewer female infants. When viewed independently, child health clinics had fewer female infants, a smaller proportion of smokers and fewer parents undertaking home duties compared to the Hunter Region. Immunisation clinics had fewer females, a higher proportion of smokers and a greater number of parents undertaking home duties compared to the Hunter Region. With reference to all babies born in NSW in 1997, the combined sample had: a similar proportion of female infants; a higher proportion of Australian born parents; slightly more parents living in a relationship and a slightly higher proportion of smokers.

One hundred and eighty one (94%) urine samples were collected from participating infants. Of these, seventeen were obtained from infants identified as breast fed by smoking mothers.

Prevalence of Exposure to Environmental Tobacco Smoke

Eighty five (47%) [95% CI:40-54] infants in the combined sample had detectable levels of cotinine. After removal of the 17 breast fed infants of smoking mothers, 70 (43%) [95% CI:35-51] infants had detectable levels of cotinine. Thirty eight (40%) infants from child health clinics (38% upon removal of breast fed infants of smoking mothers) and forty seven (55%) from immunisation clinics (49% upon removal of breast fed infants of smoking mothers), had detectable levels of cotinine. The median concentration of infants excreting cotinine was 43nmol/L, with a range of 6nmol/L to 1890nmol/L.

Intra-cluster correlation coefficients for the three exposure outcomes were found to be not significantly different from zero. Detectable level of cotinine, ICC= -0.03 [CI: -0.05,0.03], accompanying parents' smoking status ICC= 0.01 [CI: -0.03,0.14], and household smoking status ICC= 0.04 [CI: -0.01,0.2].

Location of Environmental Tobacco Smoke Exposure

Of the infants reported to be exposed in the previous three days; 10% [CI:6,15] were reported as exposed in the home, 6% [CI:2,9] were reported as exposed in the car, none were reported as exposed at child care, 22% [CI:16,29] were reported as exposed at a friend or relative's home, 18% [CI:12,24] were reported as exposed at a shopping centre, 8% [CI:4,14] were reported as exposed at a restaurant or hotel and 8% [CI:4,13] were reported as exposed in an outdoor location.

Agreement Between Cotinine Measurement and Parent Report Indicators of Environmental Tobacco Smoke Exposure

Figure 1 details the urine cotinine levels of each infant by each category of parent report indicator of exposure presented as four mutually exclusive groups.

(Insert Figure 1)

Sixty nine parents (42%) reported that their child had been exposed to environmental tobacco smoke in at least one location in the three days prior to the study and sixty one (38%) infants were reported to live in a smoking household. Using measurement of cotinine as the gold standard, sensitivity of 86% was achieved through the combined measure of parent report of exposure and smoking status of households. However this approach resulted in the lowest specificity of 60%. Sixty of the 98 infants (61%) reported by parents as exposed or as living in a household with a smoker had detectable levels of cotinine, whilst 85% of infants reported to have neither form of exposure had no detectable cotinine.(Table 2)

(Insert Table 2)

Predictors of Exposure to Environmental Tobacco Smoke

Bivariate analyses identified that 5 of the 9 predictor variables were associated ($p<0.2$) with biochemically measured exposure to environmental tobacco smoke. Exposure was significantly associated with low level of parental education ($p=0.001$), parent being unemployed ($p=0.039$), single parent ($p=0.002$), parent being a smoker ($p=0.001$) and having other smokers in the household ($p=0.001$). Following inclusion

of all five variables in the regression model and subsequent removal in a stepwise fashion, two variables remained in the model that were significantly associated with exposure. The odds of exposure for infants of smoking parents were 14 times that of infants of non smokers [CI: 5,50]. The odds of exposure for infants from households where a member other than the accompanying parent was a smoker were 8 times that of infants living in a household where other members were non smokers [CI:4,18].

DISCUSSION

Infants less than twelve months of age are perhaps the population group most vulnerable to the effects of passive smoking, yet almost half of the infants in this study had detectable levels of cotinine in their urine. These findings suggest that existing community education strategies and passive smoking public policies are failing to protect this vulnerable population group.

To our knowledge, this is the first Australian study reporting biochemical measurement of infant exposure to environmental tobacco smoke in a community setting. The prevalence of infant exposure to environmental tobacco smoke for the combined sample in this study is nearly double earlier self report based estimates of exposure in Australian children⁷, but are similar to the self reported prevalence of Australian children living with smoking parents⁸. In contrast, the prevalence of exposure is lower than that previously reported in the United States of America using comparable methods^{5,6}. As the prevalence of parental smoking in this study was similar to that reported in these earlier studies, the observed lower prevalence of infant exposure may be due either to increases in child protective behaviour by

parents over time, or to differences in parenting practices between countries. Borland et al (1999)⁹ and Ashley et al (1998)²⁶ have reported increased efforts by parents during the last decade in both Australia and Canada to protect their children from environmental tobacco smoke. Despite such increased efforts, the prevalence of exposure reported in this study remains disturbingly high.

The suggested higher rate of exposure among infants attending immunisation clinics is possibly a result of the greater prevalence of parental smoking and non-employment and the lower levels of educational attainment in this group. These results suggest a need for further research to corroborate these differences and identify immunisation clinics as a potential setting for further intervention.

The most frequent location reported for infant exposure was at a friend or relatives house (22%), followed by at a shopping centre (18%). Ten percent of parents reported that their child had been exposed in the home. Given that 38% of the infants lived in a home with at least one smoker, the data suggest that smoking parents may believe that they are undertaking some protective behaviours to prevent their infant from exposure to environmental tobacco smoke. However the cotinine values suggest that these behaviours may not be adequate. In addition, the data indicate that friends and relatives are an important source of infant exposure and therefore should be considered for future interventions.

Parent report of infant exposure in this study involved the use of a brief 7 item questionnaire. The sensitivity and positive predictive value of this indicator were lower than that previously reported (75% and 82%) for more comprehensive self-

report measures incorporating situational analyses of exposure¹². Similarly, the sensitivity and positive predictive values of household smoking status as an indicator of exposure were lower than that previously reported (75%, 82%) using a more comprehensive measure¹². By combining the two indicators of infant exposure, our questionnaire yielded a sensitivity greater than that reported for each of these more comprehensive approaches. Given the cost and practical difficulties associated with obtaining either biochemical or comprehensive self report measures of exposure, these results suggest the potential for such a combined approach as a simple means of measuring exposure in community settings. Further development and testing of this approach is required to improve the accuracy of this approach without jeopardising the practical advantages of a brief measurement tool.

The bivariate analyses confirm that, as in other countries, Australian infants of parents with lower socio economic status (low education level, unemployed) and those from single parent families are more likely to be exposed to environmental tobacco smoke^{15,17}. Such findings could be expected given the higher rates of smoking in these population groups²⁷. Similarly, the results confirm that Australian infants who live with smokers are more likely to be exposed^{6,13,16,17}. The multivariate analyses identified that the smoking status of the parent or of others in the household are the primary predictors of infant exposure, emphasising the need for future interventions to incorporate quit smoking strategies for both parents and other household members, as well as strategies for changing the pattern of smoking behaviour around infants.

A number of issues need to be considered when interpreting the results of this study. First, given the use of convenience samples from urban child health and immunisation

clinics, care should be taken when generalising to other populations. Comparisons with infant clinic attendees in the Hunter Region and with infants born in NSW suggests that the combined sample had fewer female infants relative to the Hunter Region population and an under representation of parents born overseas and an over representation of smokers relative to the NSW population. As the logistic regression analysis did not identify infant gender as a predictor of exposure to environmental tobacco smoke, the greater prevalence of females is not considered likely to have influenced the estimated prevalence of exposure to environmental tobacco smoke. Given the significant positive association between biochemically measured exposure and parental smoking status, the slightly higher prevalence of smoking in the sample suggests that the prevalence of exposure in the Hunter Region may be greater than that for NSW. Second, whilst the combined sample size was sufficient to estimate the prevalence of exposure in the study population with 7% precision, estimates of the association between predictors and exposure were made with much wider confidence intervals. Nonetheless, even the lower bounds of the latter confidence intervals indicate a sizeable effect. Future studies are warranted to verify these findings using a larger, weighted, representative sample and to assess the risk of exposure in non-English speaking populations.

The introduction of smoke free policies in work places, on public transport, in childcare centres and other public areas has decreased the opportunity for infants to be exposed to environmental tobacco smoke. However, current legislation offers little protection in private environments such as the home or car. Whilst community support exists for current laws that protect the well being of children generally, such private environments remain off limits to legislation regarding parental behaviours

such as smoking²⁸. Community attitudes may however be changing, with public support being expressed for outlawing smoking in private vehicles whilst children are present²⁹. Given the difficulties associated with regulation of smoking in private settings, immediate attention must be given to alternative intervention strategies that focus on increasing parental knowledge and skills in reducing infant exposure to environmental tobacco smoke in such settings.

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Table 1: Characteristics of the study sample and child health and immunisation clinics, compared to the Hunter Region and to all babies born in NSW.

	Study Sample			Hunter Region ²⁴	NSW ²⁵
	Total	CHC*	IC*		
<i>Infants</i>					
Female	43%	42%	44%	50%	43%
Mean age	20 weeks	20 weeks	20 weeks	17 weeks	--
<i>Accompanying Parents</i>					
Mean age	29yrs	29yrs	29yrs	28yrs	--
Australian born	93%	95%	91%	--	73%
Smokers	24%	22%	26%	24%	21%
Married/defacto	91%	90%	91%	92%	88%
Home Duties as occupation	58%	49%	68%	60%	--
Completed Yr12 or post secondary education	57%	61%	53%	--	--

**CHC: Child health clinics, *IC: Immunisation clinics*

Figure 1 - (File attached)

TABLE 2: Association between the biochemical and interview measures of infant exposure to environmental tobacco smoke

Parent Report Indicator	Biochemical Measure (Cotinine)			
		Exposed n	Not Exposed n	Total n
i) Parent report of exposure	Exposed	43	26	69
	Not Exposed	27	68	95
	Total	70	94	164
ii) Any household smokers	Exposed	45	16	61
	Not Exposed	21	78	99
	Total	66	94	160
iii) Parent report of exposure or any household smokers	Exposed	60	38	98
	Not Exposed	10	56	66
	Total	70	94	164

Note:

- i. Sensitivity 61%; specificity 72%; positive predictive value 62%; and negative predictive value 72%
- ii. Sensitivity 68%; specificity 83%; positive predictive value 74%; and negative predictive value 79%
- iii. Sensitivity 86%; specificity 60%; positive predictive value 61%; and negative predictive value 85%