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Using Bayesian Space-Time Models to Understand the Substance Use Environment and Risk for Being Referred to Child Protective Services

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Parental substance misuse has often been cited as a cause of children being referred for investigation of child abuse and neglect. Research on how the substance use environment might affect this relationship is still in its infancy with primarily only cross-sectional studies finding a positive relationship of alcohol outlet density at the level of neighborhoods and alcohol prices at level of states and maltreatment. A longitudinal study shows that increasing female drug-related arrests are related to increasing rates of maltreatment in rural and urban counties. The current study incorporates three aspects of the substance use environment in a panel study of 58 California counties over 4 years ($n = 232$) to study this relationship for referrals to child protective services (CPS) for child abuse and neglect. We use conditionally autoregressive (CAR) Bayesian models to model the spatial and temporal structure in the data. We find that use of welfare benefits, the number of outliers per population, and the number of drug-related arrests per population are positively related to referrals while unemployment and admissions to publicly funded alcohol and drug user treatment programs are negatively correlated to referrals. Significant spatial structure and space-time relationships are also found. The findings indicate that supply of alcohol and drugs (as measured by number of alcohol outlets and arrests for drug use and sales) may increase risk for being referred to CPS, but treatment for substance use does not increase the risk for referral.

Keywords alcohol outlet density; substance use environment

Introduction

Ecological researchers studying substance use and related problems have become quite adept at examining how spatial dynamics of local community and neighborhood conditions affect problems such as traffic crashes, assaults, and child maltreatment. Yet most of these studies are cross-sectional in nature, making it nearly impossible to understand what changes in neighborhood conditions reduce or increase these types of problems. Longitudinal studies have generally been reserved for studying the effects of policy and environmental interventions to reduce substance use and related problems (e.g., underage drinking laws, see Wagenaar and Toomey, 2002). These studies, however, rarely explicitly model or control for the spatial dynamics that may contribute to the evaluation of the effectiveness of these interventions. For example, increased police enforcement of sales to minors in one

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community may reduce problems there, but youth with driver's licenses may begin traveling to neighboring communities to obtain and use alcohol thus increasing problems in those areas. The next generation of ecological studies must combine the techniques from spatial modeling with longitudinal data to understand how local conditions and social mechanisms produce sustainable reductions in substance use and related problems.

In this study we combine elements of both approaches in Bayesian space-time models to study one outcome related to substance misuse: children's referrals for investigation of child maltreatment allegations. Substance use is often a major contributing factor to child abuse and neglect—a general population survey conducted by Straus, Hamby, Finkelhor, Moore, and Runyan (1998) found that 23 per 1,000 children had parents who could not care for them at some point during the previous year because they were too drunk or "high." While not all substance abusing* parents are cited for child maltreatment, child welfare workers cite parental substance misuse as one reason for a steep increase in substantiated reports of child abuse and neglect since the 1970s (Azzi-Lessing and Olsen, 1996; Curtis and McCullough, 1993).

Background

One in 10 children currently resides in the home of a parent who can be considered dependent on alcohol and other drugs (AOD; Gibbons, Barth, and Martin, in press; Huang, Cerbone, and Gfoerer, 1998). While no conclusive national estimate of the number of children entering the child welfare system in the United States due to parental substance use and misuse exists, child welfare caseworkers estimate that 50–80% of parents on their caseload have problems with substance use and that these children are more likely to enter foster care (Curtis and McCullough, 1993; Semidei, Radel, and Nolan, 2001). Parents with a diagnosed substance use disorder are more likely to be physically abusive, commit child neglect, and have a higher child abuse potential than in those without a diagnosed substance use disorder (Ammerman, Kolko, Kirisci, Blackson, and Dawes, 1999; Chaffin, Kelleher, and Hollenberg, 1996). In fact, children in these families are two times more likely to be at risk for child maltreatment (Walsh, MacMillan and Jamieson, 2003).

Mothers involved in the child welfare system who are receiving treatment for substance misuse are more likely to be younger, have more children and more employment problems, and be treated in outpatient programs than other women receiving AOD treatment (Grella, Hser, and Huang, 2006). Substance-abusing mothers involved with the child welfare system are more likely to have their parental rights terminated than non-substance-abusing parents (Marcenko, Kemp, and Larson, 2000).

Very little research on child welfare has been conducted at the county level; instead, the focus has been on understanding how the ecology in smaller environments (e.g., neighborhood) affect child maltreatment (see Freisthler, Merritt, and LaScala, 2006, for a review). However, the demonstration project will be implemented and managed at the county level, making that the ideal unit of analysis for this study. The following reviews the three studies that have previously studied rates of child abuse and neglect at the county level. In 1983, Spearly and Lauderdale found that counties in Texas had lower rates of maltreatment if they had higher percentages of families with incomes greater than $15,000, higher average monthly welfare payments (at that time Aid to Families with Dependent Children), fewer female-headed households, and fewer married women in the labor force with children

*The journal's style utilizes the category *substance abuse* as a diagnostic category. Substances are used or misused; living organisms are and can be *abused*. Editor's note.

under 6. More recently, Weissman, Jogerst, and Dawson (2003) found that areas with greater percentages of singles with children under 18, higher marriage dissolution rate, more substantiated cases of elder abuse, fewer chiropractors, and fewer caseworkers per 10,000 population had higher substantiated rates of maltreatment in Iowa. Finally, a panel study in California examined changes in maltreatment rates over time separately for urban, suburban, and rural counties (Albert and Barth, 1996). None of the measures used in the study predicted rates of maltreatment in the same direction across all three types of counties, thus suggesting that the dynamics for each county vary substantially based on various factors. This study found a negative relationship between number of births and maltreatment for urban counties but a positive relationship for rural and suburban counties. Suburban and rural counties with higher numbers of unemployed persons had lower rates of maltreatment. The number of children in the county was positively related to maltreatment in urban counties and negatively related to maltreatment in suburban counties. Unlike Spearly and Lauderdale (1983), this study only found higher welfare (AFDC) payments to family groups was related to lower rates of maltreatment in rural counties but higher rates of maltreatment in suburban counties.

As for the substance use environment, evidence suggests that drug-related arrests for women are related to rates of maltreatment in urban and rural counties but there was no relationship between drug-related arrests and maltreatment in suburban counties (Albert and Barth, 1996). At the neighborhood level, alcohol outlet densities and drug possession incidents are positively related to higher rates of child abuse and neglect (Freisthler, 2004; Freisthler, Gruenewald, Remer, Lery, and Needell, 2007; Freisthler, Needell, and Gruenewald, 2005). At the state level, Markowitz and Grossman (1998) found that higher state excise taxes on beer significantly lowered the probability of both violence and severe violence on children. The remaining question is whether or not an underlying spatial process exists across counties that may affect a child's likelihood to enter foster care. A similar question was posed by Albert and Catlin (2002), who were interested in whether or not states adjusted their welfare benefits to be more like adjacent states to discourage welfare recipients from crossing state borders in order to receive more benefits. Thus they were interested in understanding both spatial and temporal processes associated with welfare benefit levels used by states, particularly those adjacent to one another.

The studies by Albert and Barth (1996) and Albert and Catlin (2002) highlight some of the same difficulties in conducting longitudinal ecological studies in social welfare as shown by those studies of alcohol consumption-related problems, even though it may be important to do so for policy reasons. For example, in California, the California Department of Social Services is responsible for oversight of the child welfare system; however, daily administration and policy decisions fall under the purview of county directors. In 2006, California began implementing a demonstration project related to Title IV-E eligibility. A Title IV-E waiver allows states to provide additional services other than just payments to maintain children in the foster care system. The premise is that by providing states with flexibility in funding they can tailor programs that may more efficiently serve children and families and reduce maltreatment and emphasize prevention over intervention. The goals of the demonstration project are (a) to improve the array of service for children and families and engage families through more individualized approach that emphasizes family involvement; (b) to increase child safety without an overreliance on out-of-home care; (c) to improve permanency outcomes and timelines; and (d) to improve child and family well-being (Department of Health and Human Services Administration for Children and Families Administration on Children, Youth and Families Children's Bureau, 2006). About 20 counties in California will be participating in the demonstration project. Given

the relationship of substance use to child maltreatment, a better understanding of structural factors related to substance use and child maltreatment may provide some guidance in how to use these funds to better serve children and families. This study uses specialized statistical models that enable us to assess both spatial and temporal trends providing a better estimate of how county of residence over time affects rates of maltreatment. The current study uses conditionally autoregressive (CAR) Bayesian models to determine (a) whether or not a temporal trend exists in CPS referrals from 1998 to 2001, (b) if this temporal trend varies by county for all 58 counties in California, (c) if there is a separate spatial distribution affecting the trend and level of referrals across the counties, and (d) if a subset of variables representing the substance use environment affects these relationships. These findings can provide useful information in determining what counties may benefit from the flexibility in funding provided by the Title IV-E waiver.

Methods

In this study we assess the spatial and temporal variations across the 58 counties in California over 4 years ($n = 4 \times 58 = 232$) using Bayesian models for risk for entering foster care. Referrals to CPS were measured using official data from the Child Welfare System Case Management System (CWS/CMS) from the California Department of Social Services (Needell et al., 2004).

Three variables representing aspects of the substance use environment (AOD resources, treatment needs, and substance use availability) are included as covariates in the full model and have been found in the literature to be related to maltreatment rates (Albert and Barth, 1996; Freisthler, 2004), although these variables have not previously been used together in the same study. The variable representing AOD resources is data on adult admission rates to publicly funded AOD treatment programs that were obtained from the Resource Center Library of the California Department of Alcohol and Drug Programs. While these admissions do not account for all AOD admissions, families who are likely to come to the attention of the child welfare system are those who use public, not private, treatment facilities. Number of arrests for drug offenses is used as an indicator of AOD treatment need and is measured by the Monthly Arrest and Citation Register (MACR) obtained from the Criminal Justice Statistics Center, which keeps arrest data from local law enforcement agencies. AOD availability is measured by the number of alcohol outlets per population and is obtained from the California Department of Alcoholic Beverage Control. All independent measures are per 1,000 population.

Two control variables are also included in the analysis: percentage of households receiving Temporary Assistance for Needy Families (TANF) benefits (i.e., welfare) and the percentage of unemployment within the county. Data for the percentage of households receiving TANF were obtained from the Research and Development Division of the California Department of Social Services, which issues monthly reports of TANF participation for every county. Unemployment data were obtained from the California Labor and Workforce Development Agency.

The data are analyzed using Bayesian spatio-temporal panel models that explicitly model both the spatial and temporal correlations that exist in the data. Bayesian methods model unknown information as random variables with probability distributions. The standard deviation of the probability distribution is the current estimate of the uncertainty regarding that unknown. Prior distributions are specified to describe uncertainty surrounding unknowns prior to the data being observed. Inferences are derived using

Bayes' rule to condition on the values of the observed data giving posterior densities of the unknowns. Computation is routinely implemented using Monte Carlo Markov chain (MCMC) methods.

We model county-level foster care entries as Poisson distributed (Eq. (1)) with county-level temporal trends and spatial structure (Eq. 2); Bernardinelli et al., 1995). This model includes a linear temporal trend parameter for referrals and uses spatial random effects parameters to model spatial structure. Data were analyzed using WinBUGS 1.41 (Spiegelhalter, Thomas, Best, and Lunn, 2003). Algebraically the model is

$$y_{ik} \sim \text{Poisson}(\theta_{ik}) \tag{1}$$

$$\log(\theta_{ik}) = \log(e_{ik}) + \alpha + u_i + \beta * k + \delta_i * k \tag{2}$$

where θ_{ik} is the underlying risk of entering foster care and e_{ik} is the known population at risk. The population at risk is the population of children in county$i$ ($n = 58$). Child population for the 58 counties ranged from 227 to 2.96 million in 2001, with an average of 171,753 residents. Time in years runs from 1 to 4 and we use k to denote the year. Parameterα is the intercept, u_i is the spatial random effects (i.e., spatially correlated heterogeneity) for area i, β * k is a fixed linear time trend for k time periods, and δ_i * k is a random spatial-temporal interaction (Lawson, Brown, and Vidal Rodeiero, 2003) modeling a linear time trend correlated spatially over neighboring counties.

Spatial random effects smooth estimates across neighboring areas using a conditionally autoregressive (CAR) model. Use of these spatial random effects assumes that adjacent areas share similar characteristics (Cliff and Ord, 1973, 1981). The adjacent counties were determined for each county; the number of neighbors varies by county.

The precision parameters controlling the degrees of spatial smoothing (τ_u) and the space-time interaction (τ_v) were modeled a priori with vague gamma prior distributions. A proper but vague normal prior was given to the time trend variable (τ_β). By convention, the intercept is given a flat prior (Thomas, Best, Arnold, and Spiegelhalter, 2002).

Two models were fit, a base model with no covariates and a model that includes all five covariates.[1] For each model, there were 50,000 iterations of MCMC burn-in and the posterior estimates are based on an additional 50,000 iterations. Model fit was assessed using the deviance information criterion (DIC; Spiegelhalter, Best, Carlin, and Linde, 2002). The DIC, analogous to the Akaike information criterion (AIC), is

$$D(\theta|y) + 2p_e \tag{3}$$

where p_e is the number of parameters and the deviance $D(\theta|y)$ is evaluated at the posterior mean $E[\theta|Y]$ of the parameters θ. A lower DIC represents a better fitting model.

Results

Figure 1 plots the estimated county time trend $E[\exp(\beta + \delta_i)|Y]$ across each of the 58 counties in California. Counties where referral rates have been increasing over the 4 years have a time trend value over one, whereas those counties with decreasing rates of referrals over the 4 years have a value less than one. Counties in the northern and central parts of California are showing increasing rates of referrals for child maltreatment over the

[1] A third model was attempted that would assess the effects of outlet type (bars, off-premise outlets, and restaurants) on referrals but because of the large positive correlations between the variables, the model would not converge.

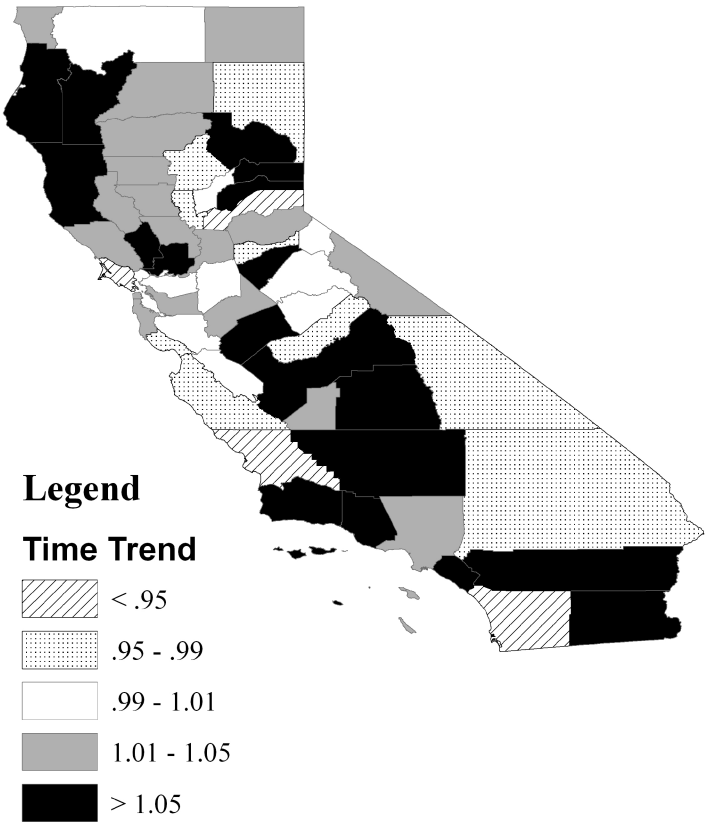


Figure 1. Change in rate of CPS referrals for child maltreatment investigations over 4 years (1998–2001).

4-year study period. Table 1 presents the posterior means, standard deviations, and 95% credible intervals (in parentheses) for the reduced model (Model 1), which includes random effects for the correlated heterogeneity, time trend, and space-time trend. Model diagnostics, including the posterior density plots for each parameter, autocorrelation plots, and history plots (which show convergence of the model) are shown in Figure 2. Model 1 shows a statistically significant positive time trend, positive correlated heterogeneity (i.e., spatial structure), and positive space-time trends. In other words, counties with similar rates of referrals are clustered near each other (see specifically the northern part of California in Figure 1) and these areas are also experiencing similar changes in rates of referrals over time.

Model 2 adds the three covariates for the substance use environment and two control socioeconomic statues variables. The results show that the number of alcohol outlets and drug-related arrests per population are positively related to referrals for investigations of child maltreatment, whereas alcohol and other drug admission rates for treatment are related to decreases in CPS referrals. For the control variables, the percentage of households receiving welfare benefits is related to significant more referrals, while the percentage of unemployment is related to lower rates of maltreatment. As with Model 1, significant spatial structure exists. The lower DIC in Model 2 suggests that Model 2 is a much better fit than Model 1.

Table 1
Spatial-temporal Bayesian model estimates of CPS referrals in California (n = 232)

	Model 1		Model 2	
Variable	Mean	SD	Mean	SD
Constant (alpha)	−2.902	0.005*** (−2.912, −2.893)	−3.075	0.029*** (−3.134, −3.022)
TANF receipt			0.005	<.001*** (0.003, 0.007)
Unemployment			−0.012	0.002*** (−0.016, −0.007)
Alcohol outlets			.019	.005*** (0.010, 0.029)
Drug-related arrests			0.029	0.002*** (0.026, 0.032)
Treatment entries			−0.006	0.001*** (−0.008, −0.004)
Year (beta)	0.028	0.001*** (0.025, 0.031)	0.024	0.002*** (0.021, 0.027)
Spatial structure (sigma.u)	0.777	0.077*** (0.644, 0.943)	0.863	0.086*** (0.713, 1.051)
Space × year (sigma.delta)	0.132	0.013*** (0.109, 0.160)	0.145	0.015*** (0.119, 0.178)
DIC		5059.490		4614.940

Discussion

The current study combines cross-sectional spatial models and longitudinal panel models to examine basic temporal and spatial dynamics of referrals for child maltreatment investigations and how aspects of the substance use environment may be related to those rates. Figure 1 visually shows that CPS referrals in counties in California are affected by both spatial and temporal processes.

Similar to previous studies, we found a positive relationship between alcohol outlet density per population and referrals for child maltreatment investigations (Freisthler, 2004; Freisthler et al., 2007; Freisthler, Midanik, and Gruenewald, 2004; Freisthler et al., 2005; Markowitz and Grossman, 1998) and drug-related arrests (Albert and Barth, 1996; Freisthler et al., 2005). Taken together, these findings suggest that availability of alcohol and drugs may be related to rates of referrals to CPS. It may be that areas with greater availability of alcohol and drugs have higher rates of alcohol and drug use, resulting in behavior that could be detrimental to children (such as supervisory neglect or physical abuse.) Albert and Barth (1996) only studied arrests of women, arguing that as mothers are the primary caregivers of children, their arrests are likely to adversely affect parenting resulting in referrals to the child welfare system. As we find a similar relationship between drug-related arrests and referrals as those authors do, it may be that drug-related arrests, regardless of gender, may adversely affect parenting.

Our study finds a negative relationship between admissions to AOD treatment facilities and entry into foster care. One explanation is that those counties with higher use of treatment

facilities may have greater resources to treat substance use problems or may be areas where other social service interventions are available to assist families in crisis. Further, mothers who may want to retain custody of their children may enter AOD treatment to show the child welfare system they are working to address behaviors that may result in maltreatment.

At the county level, this type of model enables us to monitor county trends in CPS referrals to determine where prevention efforts may be most effective. This is increasingly important in California, where the implementation of the Title IV-E waiver will allow counties more flexibility and funding to develop comprehensive prevention programs, in an attempt to reduce overall costs for child maltreatment and foster care. Similar monitoring of how specific county-level policies affect trends child maltreatment or enables practitioners

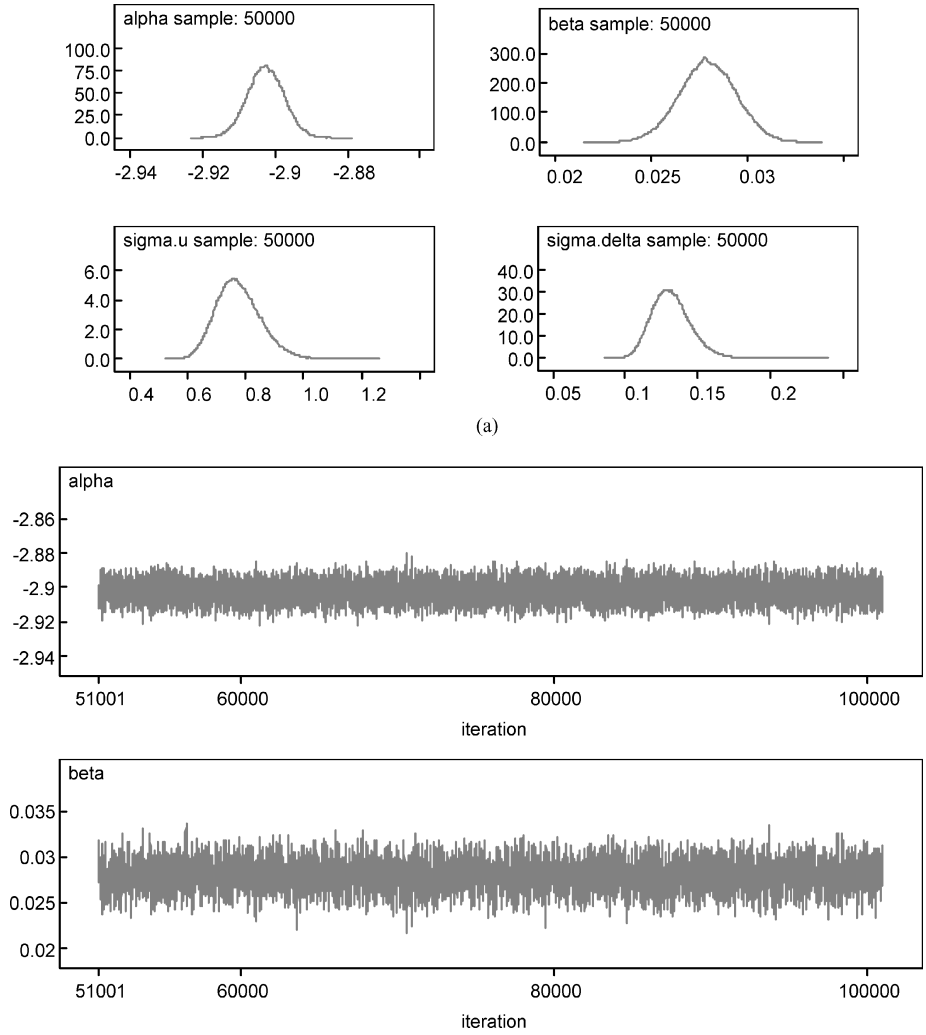
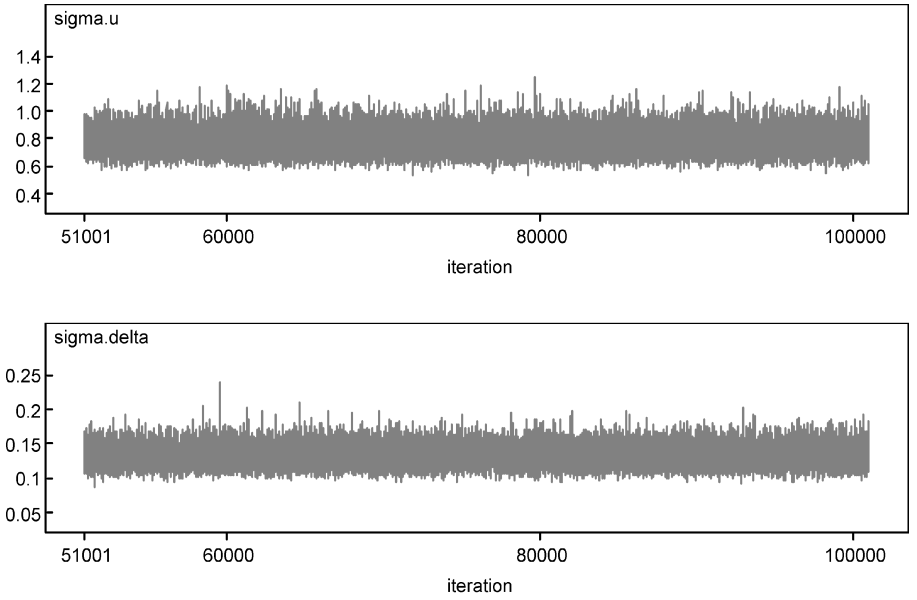
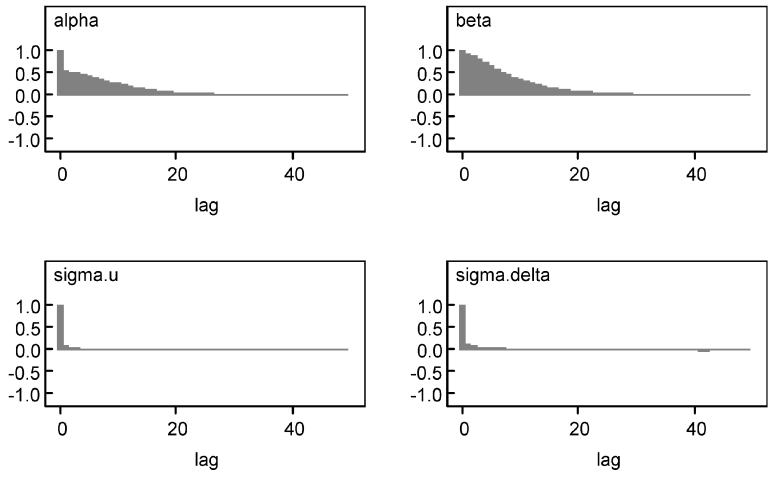


Figure 2. WinBUGS diagnostics for Model 1 examining spatial and temporal structure of CPS referrals for child maltreatment investigations. (a) Posterior density plots. (b) History plots showing model convergence. (c) Autocorrelation plots. *(Continued)*



(b)



(c)

Figure 2. (Continued)

and policy-makers to determine the effectiveness of policies designed to reduce abuse and neglect. Furthermore, these models can track the effect of diffusion of policy interventions across areas to determine whether adjacent counties adopt similar procedures thus affect foster care entry rates in the same manner.

Implications for Substance Use Research

There are several natural extensions of the space-time model used here for substance use research, specifically as they related to the diffusion of intervention activities or policy decisions on substance use and related problems. For example, using this approach, changes

in local policy decisions to reduce alcohol outlet density through land use ordinances can be monitored for reductions in problems. One question to be answered is does limiting densities of outlets in one community or neighborhood increase problems in neighboring communities or neighborhoods where alcohol outlet density may not be regulated in the same manner? Similarly, how do police enforcement patterns and "drug raids" affect the spatial distribution of drug markets? In other words, if police raid a particular neighborhood making several drug busts, how quickly and efficiently do drug distribution systems regroup and locate themselves in other areas of the community? Similarly, when drug markets are distributed in one neighborhood, how are sales and availability of illicit drugs affected across an entire community? Finally, these models can help substance use researchers understand how changing neighborhood conditions (e.g., gentrification) affect migration of populations and the distribution of substance use-related problems across areas. Answers to these questions can inform practitioners' efforts to develop effective environmental prevention programs and policy-makers' attempts to create policies that will reduce causes and consequences of substance use and related problems.

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RESUME

En utilisant les modèles bayésiens d'Espace-Temps pour comprendre la substance employez l'environnement et le risquez pour être des services protecteurs visés d'enfant

L'abus parental de substance a été souvent cité comme une cause des enfants étant référés pour la recherche sur l'abus et la négligence d'enfant. La recherche sur la façon dont l'environnement d'utilisation de substance pourrait affecter ce rapport est toujours dans sa petite enfance avec principalement seulement des études transversales trouvant un rapport positif de densité de sortie d'alcool au niveau des voisinages et de prix d'alcool au niveau des états et du mauvais traitement. Une étude longitudinale montre que cela des arrestations femelles croissantes de drogue sont liées aux taux croissants de mauvais traitement dans les comtés ruraux et urbains. L'étude courante incorpore trois aspects de l'environnement d'utilisation de substance dans une étude de panneau de 58 comtés de la Californie sur quatre ans ($n = 232$) pour étudier ce rapport pour des références avec des services protecteurs d'enfant pour l'abus et la négligence d'enfant. Nous employons les modèles bayésiens conditionnellement auto-régressifs pour modeler la structure spatiale et temporelle dans les données. Nous constatons que l'utilisation des avantages d'assistance sociale, le nombre de sorties par population, et le nombre d'arrestations de drogue par population sont franchement liés aux références tandis que le chômage et des admissions aux programmes publiquement placés de traitement d'alcool et de drogue sont négativement corrélés avec des références. Des rapports spatiaux significatifs de structure et d'espace-temps sont également trouvés. Les résultats indiquent que l'approvisionnement en alcool et drogues (comme mesuré par le nombre de sorties et d'arrestations d'alcool à l'utilisation et en les ventes de drogue) peut augmenter le risque pour être des services protecteurs visés d'enfant, mais le traitement pour l'usage de substance n'augmente pas le risque pour la référence.

RESUMEN

Con modelos bayesian del Espacio-Tiempo para entender la sustancia utilice el ambiente y arriesgúelo para ser servicios protectores referidos del niño

El uso erróneo parental de la sustancia se ha citado a menudo como una causa de los niños que eran referidos para la investigación del abuso y de la negligencia de niño. La investigación sobre cómo el ambiente del uso de la sustancia pudo afectar esta relación todavía está en su infancia con sobre todo solamente los estudios transversales que encuentran una relación positiva de la densidad del enchufe del alcohol en el nivel de vecindades y de los precios del alcohol en el nivel de estados y del maltrato. Un estudio longitudinal demuestra que eso las detenciones femeninas de aumento de la droga están relacionadas con los índices de aumento del maltrato en condados rurales y urbanos. El estudio actual incorpora tres aspectos del ambiente del uso de la sustancia en un estudio del panel de 58 condados de California sobre cuatro años ($n = 232$) para estudiar esta relación para las remisiones a los servicios protectores del niño para el abuso y la negligencia de niño. Utilizamos modelos bayesian condicional autoregressive para modelar la estructura espacial y temporal en los datos. Encontramos que el uso de las ventajas de bienestar, el número de enchufes por la población, y el número de las detenciones de la droga por la población están relacionados positivamente con las remisiones mientras que el desempleo y las admisiones a los programas público financiados del tratamiento del alcohol y de la droga se correlacionan negativamente a las remisiones. Las relaciones espaciales significativas de la estructura y del espacio-tiempo también se encuentran. Los resultados indican que la fuente de alcohol y de drogas (según lo medido por el número de los enchufes y de las detenciones del alcohol para el uso y las ventas de la droga) puede aumentar el riesgo para ser servicios protectores referidos del niño, pero el tratamiento para el uso de la sustancia no aumenta el riesgo para la remisión.

THE AUTHORS

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