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Spatial clusters of autism births and diagnoses point to contextual drivers of increased prevalence

Soumya Mazumdar[a,*], Alix Winter[b], Ka-Yuet Liu[c], Peter Bearman[d]

[a] Australian Primary Health Care Research Institute, Australian National University, Level 1, Ian Potter House, Cnr Marcus Clarke and Gordon Streets, Canberra ACT 0200, Australia
[b] Harvard University, Cambridge, MA, USA
[c] University of California, Los Angeles, CA, USA
[d] Columbia University, NY, USA

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ABSTRACT

Autism prevalence has risen dramatically over the past two decades in California. Although often suggested to have been crucial to the rise of autism, environmental and social contextual drivers of diagnosis have not been extensively examined. Identifying the spatial patterning of autism cases at birth and at diagnosis can help clarify which contextual drivers are affecting autism's rising prevalence. Children with autism not co-morbid with mental retardation served by the California Department of Developmental Services during the period 1992–2005 were matched to California's Birth Master Files. We search for spatial clusters of autism at time of birth and at time of diagnosis using a spatial scan approach that controls for key individual-level risk factors. We then test whether indicators of neighborhood-level diagnostic resources are associated with the diagnostic clusters and assess the extent of clustering by autism symptom severity through a multivariate scan. Finally, we test whether children who move into neighborhoods with higher levels of resources are more likely to receive an autism diagnosis relative to those who do not move with regard to resources. Significant birth and diagnostic clusters of autism are observed independent of key individual-level risk factors. While the clusters overlap, there is a strong positive association between the diagnostic clusters and neighborhood-level diagnostic resources. In addition, children with autism who are higher functioning are more likely to be diagnosed within a cluster than children with autism who are lower functioning. Most importantly, children who move into a neighborhood with more diagnostic resources than their previous residence are more likely to subsequently receive an autism diagnosis than children whose neighborhood resources do not change. We identify birth and diagnostic clusters of autism in California that are independent of individual-level autism risk factors. Our findings implicate a causal relationship between neighborhood-level diagnostic resources and spatial patterns of autism incidence but do not rule out the possibility that environmental toxicants have also contributed to autism risk.

Introduction

Autism prevalence has risen dramatically over the past two decades (Mitka, 2010). In California, the increase has been precipitous – over 600% from the 1992 to 2002 birth cohorts (Keyes et al., 2011). Similar rates of increase have been observed elsewhere in the United States and in other industrialized countries (Baio, 2002; Madsen et al., 2003). Numerous biological, environmental and social factors have been implicated in the rise of autism, but there is no general consensus as to the roles that each have played. The majority of empirical studies have focused on potential genetic causes of autism (Abrahams & Geschwind, 2008) and other individual level risk factors, such as male sex, advanced parental age, prenatal and perinatal complications, and maternal exposures to viruses and other teratogens (Kolevzon, Gross, & Reichenberg, 2007; Patterson, 2009). Although often suggested to have been crucial to the rise of autism, environmental and social contextual drivers of diagnosis, such as local environmental toxicants (Windham, Zhang, Gunier, Croen, & Grether, 2006), diagnostic accretion (King & Bearman, 2009), legislative change (Fountain & Bearman, 2011), neighborhood level resources (King & Bearman, 2011) and increased awareness (Liu, King, & Bearman, 2010), have been studied less extensively.

This article utilizes administrative data from California to consider how identifying the spatial patterning of autism cases at

* Corresponding author.
E-mail address: soumya.com@gmail.com (S. Mazumdar).

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birth and at diagnosis can inform the study of contextual drivers of autism. We have previously identified a spatial cluster of autism cases at birth (henceforth “birth cluster”) located in the West Hollywood (Mazumdar, King, Liu, Zerubavel, & Bearman, 2010). Given that not all families live at the same residences from the time of their children’s births to diagnoses, examining the spatial clustering of autism at these two moments in time can help disentangle the contextual mechanisms involved. For example, it is possible for a birth cluster to form as a result of the neighborhood-level clustering of an autism risk factor that is particularly relevant around the time of birth, such as an environmental toxicant. Meanwhile, a different set of mechanisms that are independent of those generating birth clusters could be responsible for clustering at diagnosis. Such “diagnostic clusters” could be observed if parents who suspect that their children may have autism select neighborhoods based on available services or neighborhoods that parents select to move to are associated with an increased risk of acquiring an autism diagnosis.

In California, salient neighborhood-level characteristics that could be associated with an increased risk of autism diagnosis include: socioeconomic status (SES), pediatrician density, advocacy organization density, and spending by the Department of Developmental Services (DDS). Children residing in high SES neighborhoods are at greater risk of receiving an autism diagnosis (King & Bearman, 2011; Liu et al., 2010), a finding that is consistent with the effect of neighborhood SES on a wide range of other health outcomes. For example, neighborhood SES is a predictor of the stage at which cancer is diagnosed (Breen & Figueroa, 1996; Shipp et al., 2005). The exact mechanisms underlying the associations between neighborhood SES and health outcomes are debated, but a likely component is that neighborhood SES is a good proxy for local resources and the availability of health-related information (Eng et al., 1998). Meanwhile, the number of pediatricians in a neighborhood provides a more specific measure of available resources. There is extensive literature that shows that physician density (Ananthakrishnan, Hoffmann, & Saeian, 2010; Léonard, Stordeur, & Roberfroid, 2009; Roll, 2012) is associated both with the timely diagnosis of certain disorders and with increased consumption of medical services (Menken & Sheps, 1985). While a sufficient supply of pediatricians may be able to address the need for diagnostic services, advocacy organizations are key to spreading awareness of symptoms among caregivers. An increased density of advocacy organizations should, therefore, be associated with an increased likelihood of autism diagnosis in a given neighborhood. In addition, advocacy organizations can influence legislation and funding. Lastly, California’s DDS coordinates autism services through a network of 22 regional centers. Residents of California are assigned to regional centers by zip code, and services are available to children diagnosed with autism and other mental disorders free of charge. It has been argued that the availability of free services may encourage parents whose children exhibit mild autism symptoms to actively pursue a diagnosis (Zarembo, 2011). Yet, variations in regional center funding may increase or decrease this incentive differentially by area. Together, the above characteristics capture neighborhood resources from different perspectives associated with access to diagnostic services and awareness of diagnostic symptoms.

Road map

These potential relationships between neighborhood-level characteristics and autism have specific implications for the spatial patterning of autism incidence. First, whether due to migration, to having been generated by different sets of contextual mechanisms, or a combination of both, birth and diagnostic clusters are unlikely to completely overlap. Therefore, in this study we first identify birth and diagnostic clusters of autism in California and then assess their overlap. It is possible that parents who are at greater risk of having children with autism live in the same neighborhoods or parents whose children are at greater risk for autism similarly select neighborhoods to move to after their children are born. To address these possibilities of residential sorting, we control for individual-level characteristics of parents when identifying the clusters.

Second, if there is substantial overlap between birth and diagnostic clusters, it will not be possible to empirically distinguish which of the two moments in time is more relevant. Given that a substantial proportion of children (>50%) do not move between the time of birth and the time of diagnosis, the presence of birth clusters could lead to clustering at time of diagnosis. Yet, it is equally likely that the presence of diagnostic clusters caused by mechanisms present at time of diagnosis could lead to the observation of clustering at time of birth. We, therefore, use the following tests to help identify the contextual mechanisms most relevant to the rise of autism.

If mechanisms related to diagnosis are responsible for generating diagnostic clusters, they should be positively associated with level of neighborhood resources. We examine whether the four key neighborhood level resources mentioned above are associated with the diagnostic clusters more so than with autism diagnoses in California in general. Next, there is considerable ambiguity in the diagnosis of autism spectrum disorders and, consequently, physicians’ responses to symptom presentation are heterogeneous (Bresnahan, Li, & Susser, 2009; Eyal, 2010; Lecavalier, Snow, & Norris, 2011; Noterdaeme, Wriedt, & Höhne, 2010; Saulnier & Klin, 2007). Even when holding all design and methodological factors invariant, prevalence estimates have varied by a factor of 4.5 from the strictest to the least demanding set of diagnostic criteria (Charman et al., 2009). Therefore, an increased level of neighborhood-level resources in terms of pediatrician and advocacy organization density, regional center spending, and SES would lead to more diagnoses of *high-functioning* autism. We thus test whether autism diagnoses cluster by severity. Finally, focusing on children who have been exposed to varying levels of diagnostic resources allows one to more clearly assess whether they have had an impact on the rising incidence of autism. If they have, children who moved into neighborhoods with higher levels of resources should have a higher chance of being diagnosed with autism relative to children whose levels of resources did not change. We assess whether children who moved into highly resourced neighborhoods are at significantly higher risk of *subsequent* autism diagnosis than children whose level of resources never changed.

Methods

Study population

We obtained information on clients with Autistic Disorder (International Classification of Disease-9 299.0) served by the DDS from 1992 to 2005. It has been estimated that 80% of all children with autism in California are served by the DDS. The remaining 20% have other diagnoses on the autism spectrum, such as Asperger’s, that do not by themselves qualify an individual for DDS services (Croen, Grether, Hoogstrate, & Selvin, 2002). We further confined our analyses to children with “sole autism,” those whose diagnoses are not co-morbid with mental retardation.

Each DDS client is evaluated annually using the Client Development Evaluation Report (CDER) in order to determine appropriate services based on level of functioning. We utilized the average score of three CDER items that relate to communication