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Assessment of Racial and Ethnic Bias in Autism Spectrum Disorder Prevalence Estimates from a U.S. Surveillance System

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Introduction

Autism spectrum disorder (ASD) is a developmental disability of increasing public health concern due to its rising prevalence and lifelong impacts on individuals and families (Baio et al., 2018; Zablotsky et al., 2015). It is characterized, in varying degrees, by difficulties in social interaction and communication and repetitive behaviors (American Psychiatric Association 2013). In most cases, the severity of associated functional limitations in ASD can be reduced through early identification and behavioral therapies (Pickles et al., 2016).

In 2000, in response to demands for valid estimates of the prevalence of ASD among U.S. children, the Centers for Disease Control and Prevention (CDC) developed a network of state-based programs to conduct multiple-source, population-based surveillance of ASD and other developmental disabilities. This network, the Autism and Developmental Disabilities Monitoring (ADDM) Network, is an ongoing, active surveillance system for monitoring ASD among children aged eight years residing in multiple geographic areas throughout the United States (ADDM Network Principal Investigators, 2007; Baio et al., 2018). The ADDM Network has applied the same health and school record-review methodology and surveillance case definition of ASD to report ASD prevalence estimates for children aged eight years biannually between 2000 and 2014 (ADDM Network Principal Investigators, 2007). In previous studies, the multiple source case ascertainment protocol of the ADDM Network has been evaluated favorably for its simplicity, flexibility, data quality, reliability and validity (Van Naarden Braun et al., 2007; Avchen et al., 2011; Bakian et al., 2014).

Since 2000, the ADDM Network has reported fairly steady increases in ASD prevalence over time, from 6.7/1,000 in 2000 to 16.9/1,000 in 2014. In each surveillance year it has also reported disparities in ASD prevalence by race and ethnicity, with the prevalence being higher among non-Hispanic white (hereafter referred to as white) relative to both non-Hispanic black (hereafter referred to as black) and Hispanic children (ADDM Network

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Principal Investigators, 2007; Christensen et al., 2016; Baio et al., 2018; National Academies of Sciences, Engineering, and Medicine, 2015). Though the disparities have persisted, they have narrowed somewhat over time. With data from all ADDM sites combined, ASD prevalence among white children exceeded that among black children by 30% in 2002 and by 7% in 2014, and exceeded Hispanic children by 70% in 2002 and 22% in 2014 (Baio, et al 2018). Racial and ethnic disparities in ASD identification and prevalence are not entirely understood but are thought to be due at least in part to disparities in awareness of ASD and access to ASD evaluation and diagnostic services (Mandell et al., 2009; Burkett et al., 2015; Magaña et al., 2012; Magaña et al., 2013). Furthermore, our previous studies have demonstrated that the racial and ethnic disparities in ASD prevalence may be partially explained by racial and ethnic disparities in socioeconomic status (Durkin et al., 2017; Durkin et al., 2010).

The purpose of this study is to assess potential under-ascertainment of ASD in black and Hispanic children due to differential missing demographic information in the surveillance system and differential documentation of ASD in health and education records. More specifically, the study tested the following three hypotheses: (1) relative to children included in ADDM Network prevalence estimates, those excluded based on inability to confirm residency within the surveillance area are more likely to be black or Hispanic; (2) imputation of missing information on residency and race/ethnicity will result in less racial and ethnic disparity in ASD prevalence than when prevalence estimation is restricted to cases with complete information; and (3) the availability of source data (health records, special education records, or both) is differential by race/ethnicity and this influences the probability of potential ASD cases being classified as confirmed rather than suspected ASD cases.

Methods

Study Population

We reviewed combined records from surveillance years 2012 and 2014 (birth cohort years 2004 and 2006) from the Colorado and Wisconsin ADDM Network sites. The surveillance area for Colorado included seven counties in the metropolitan Denver area and for Wisconsin included 10 counties in the southeastern portion of the state. Details on the ADDM methodology and the Colorado and Wisconsin geographic areas have been published previously (Christensen et al., 2016, Baio et al., 2018).

ADDM Case Definition

A child was classified as a confirmed case for ASD if: (a) behaviors described in the records were consistent with *Diagnostic and Statistical Manual of Mental Disorder, Fourth Edition, Text Revision* (DSM-IV-TR) diagnostic criteria for autistic disorder, PDD-NOS (Pervasive Developmental Disorder-Not Otherwise Specified, including atypical autism) or Asperger disorder; and (b) he or she resided in an ADDM Network surveillance area at the age of eight years during a surveillance year. ASD case status for this study was based on DSM-IV-TR criteria, as most of the clinical and school records reviewed were created between 2004 and 2013, before the publication of *Diagnostic and Statistical Manual of Mental Disorder, Fifth Edition* (DSM-5) (American Psychiatric Association, 2000; American Psychiatric

Association, 2013). For the 2014 surveillance year, separate ASD classifications were made based on DSM-IV-TR and DSM-5 criteria and a high level of agreement was found (Baio et al., 2018).

ADDM ASD Case Ascertainment Process

The ADDM surveillance protocol is a two-phase process. Phase 1 consists of review and abstraction of comprehensive developmental evaluations from healthcare and educational facilities for children meeting birth year and residency criteria. Health data include diagnostic and developmental assessments from a wide range of providers including, psychologists, neurologists, developmental pediatricians, child psychiatrists, physical therapists, occupational therapists and speech-language pathologists, while education data include evaluations to determine eligibility for special education services (Baio et al., 2018). For each child eligible for review, information can be obtained from either or both types of data sources and the surveillance record for a child is categorized as: (1) health sources only; (2) education sources only; or (3) both health and education sources.

Selection of eligible children for review is based on year of birth, residency within the surveillance area at some time during the surveillance year and enrollment in special education and/or use of specific *International Classification of Diseases, Ninth Revision* (ICD-9) billing codes in a child's health records (chosen by the ADDM Network based on association with ASD). Records for children meeting these criteria are further reviewed for specific behavioral or diagnostic descriptions defined in the ADDM protocol as triggers for abstraction. Examples of triggers include a previously documented ASD diagnosis or one of several ASD behavioral symptoms such as reduced eye contact or child prefers to play alone when others are present. If a trigger is identified, the child is considered a potential ASD case.

When residency in the surveillance area at age eight is confirmed and an ASD trigger is found in the child's records, all developmental assessments from birth through the current surveillance year from all sources are reviewed and abstracted. Abstracted information on demographic characteristics, ASD and other disability diagnoses, behavioral and developmental descriptions, autism-specific tests and intelligent quotient and other test scores from all data sources is compiled into a single composite record for an individual child.

In phase 2 of the ADDM surveillance protocol, abstracted information is reviewed and coded by qualified, trained clinician reviewers into one of four categories: (1) does not qualify for review due to insufficient information on development and behavior; (2) suspected ASD case; (3) confirmed ASD case; or (4) originally coded as an ASD case but ruled out by clinician reviewer(s). A child was coded as a suspected ASD case if he/she met some, but not all of the DSM-IV-TR criteria for autism. Children identified as suspected ASD cases were further coded as either "probable" or "possible" ASD. The clinician reviewers also coded the degree of certainty of their case code as either high or low. If the coder gave a low degree of certainty, a reason for the low certainty was given, such as "clearly accounted for by another condition", "insufficient information" or "sufficient to rule out ASD". Suspected ASD cases are not included in published prevalence estimates.

Re-Classification of Potential ASD Cases Previously Excluded Due to Unconfirmed Residency

Among those children excluded on the basis of residency, most were confirmed not to have resided in the surveillance area at age eight while a minority might have lived in the surveillance area at age eight but residency information was incomplete. For the present study, we re-reviewed records for children who had an ASD trigger in their records but were excluded from case ascertainment based on inability to confirm residency status at age eight years. We conducted an additional residency check on all of these potential ASD cases using notes from data sources and a residency confirmation service. All potential ASD cases determined from this re-review to have not resided in the Colorado or Wisconsin surveillance area during the respective surveillance year were removed from analysis. Race and ethnicity data for the remaining potential ASD cases were obtained from reviewed records.

We calculated adjusted case counts by adding to the confirmed cases, children who were: (a) determined likely to have resided in the surveillance area based on re-review but excluded due to previous inability to confirm residency; and (b) had a previous ASD diagnosis or evaluation from an autism treatment/evaluation center in their records. The adjusted case counts assume that the added cases would likely have been coded as a confirmed ASD case had they been referred for clinician review (Figure 1).

Imputation of Missing Race/Ethnicity Data

We re-reviewed the abstracted records for confirmed ASD cases that had race/ethnicity coded as “missing” and assigned a possible race/ethnicity classification based on abstraction notes mentioning the child’s race, ethnicity or country of birth. For the cases with no information related to race/ethnicity in their records, we used geocoded 2010 decennial census block data to impute race and ethnicity (United States Census, 2018). ASD cases residing in a census block with greater than 50% of residents in a particular race/ethnicity category were assigned that category (Figure 1).

Re-classification of Selected ‘Suspected’ ASD Cases

We calculated an additional set of adjusted ASD case counts by adding the following to confirmed ASD cases: (1) all suspected ASD cases who were coded as “probable” ASD cases with a high degree of certainty noted by the clinician reviewer; and (2) 35% randomly selected from within each racial/ethnic group (white, black, Hispanic) of those classified by the clinician reviewers as suspected ASD cases with insufficient or conflicting information or with no indications that the symptoms were clearly accounted for by another condition, or who were coded as "possible" ASD cases with a high degree of certainty. We chose 35% as a conservative proportion to re-classify as confirmed ASD cases among children coded by the clinician reviewers as possible ASD cases but for whom information in the records was insufficient to confirm case status. Because we found the probability of being classified as a suspected-possible versus confirmed ASD case to be lower for white children relative to black and Hispanic children, imputing ASD case status for a sample of <35% of those coded as possible cases would be more conservative than 35%, while imputing ASD cases status for >35% of this group would likely lead to greater numbers of black and Hispanic children

being re-classified as ASD cases and go further to diminish the excess ASD prevalence in white relative to black and Hispanic children.

This project was approved by the University of Wisconsin Health Sciences institutional review board and performed in compliance with privacy/confidentiality requirements under 45 CFR 46 and did not require informed consent, as the study consisted of review of administrative records for public health surveillance

Analytical Methods

Comparison of confirmed ASD cases to potential cases excluded due to unconfirmed residency—To determine whether the race/ethnicity of children excluded due to unconfirmed residency differed from confirmed ASD cases, we identified all children excluded from review due to unconfirmed residency who had an ASD diagnosis or evaluation at an autism evaluation/treatment clinic and who, with additional residency information, were deemed likely to reside in the Colorado or Wisconsin surveillance area at age eight years in 2012 or 2014. We then compared their race/ethnicity distribution with that of confirmed ASD cases using chi-square tests corrected for continuity.

Type of Source Data Accessed by Race/Ethnic Groups—We analyzed the frequency of the type of record (health only, special education only or both) reviewed for case ascertainment by race/ethnicity (white, black, Hispanic) and by case status (confirmed ASD case, suspected ASD case). This analysis was restricted to surveillance year 2014 due to changes in data sources after 2012. We used chi-square analyses to evaluate the significance of associations between record source type, race/ethnicity and confirmed versus suspected ASD case status.

Adjusted Prevalence Estimates and Prevalence Ratios—We evaluated the potential additive impact of imputing both missing residency status and missing race/ethnicity data by calculating adjusted prevalence estimates for each racial/ethnic group after inclusion of confirmed ASD cases along with potential ASD cases previously excluded due to unconfirmed residency and after imputation of race/ethnicity for confirmed ASD cases with a missing race/ethnicity. We also evaluated the potential impact on racial and ethnic disparities in ASD prevalence of adding the 35% sample of suspected ASD cases (described above) to the confirmed ASD case counts.

For both the original and adjusted prevalence estimates, population denominators were provided by the National Center for Health Statistics Vintage 2014 and 2016 postcensal bridged-race population estimates for the years 2012 and 2014, respectively. We calculated prevalence by dividing the number of children with ASD (based on the ADDM case definition and the adjustments for missing data) by the number of children aged eight years in the population in each race/ethnicity group, and multiplying the dividend by 1,000. For both the original and adjusted prevalence estimates, we calculated prevalence ratios to evaluate the magnitude of excess prevalence in white vs. black and Hispanic children, respectively. We used *VassarStats* software to obtain confidence intervals around the prevalence estimates and prevalence ratios, and to perform chi-square analyses (Lowry, 2018).

Results

Racial/ethnic differences between confirmed ASD cases and those excluded due to inability to confirm residency:

Eighty-six children had an ASD trigger for abstraction in their files but were excluded from ASD case review due to unconfirmed residency within the surveillance areas. Of these 86, 27 had documentation of an ASD diagnosis and/or treatment in an ASD specialty clinic and were re-classified for this study as a likely ASD case (Table 1). Compared to the 1,886 confirmed ASD cases, the 27 excluded due to missing residency but classified as likely ASD cases were significantly more likely to be Hispanic (44% vs 19%, p <.002), while none of the 27 and 9% of the 1,886 confirmed ASD cases were black (Table 1).

Potential impact of missing residency and race/ethnicity data on ASD prevalence estimates by race/ethnicity:

Table 2 presents two sets of ASD prevalence estimates by race/ethnicity and prevalence ratios indicating the ratio of ASD prevalence in white compared to black, Hispanic and Asian children, respectively. The first set is based on confirmed ASD cases with complete information on race/ethnicity, and the second set is based on adjusted case counts that include confirmed ASD cases with missing race/ethnicity data imputed plus “likely” ASD cases excluded from the confirmed ASD case counts due to inability to confirm residency. Both the confirmed and adjusted ASD prevalence estimates were highest in white and lowest in Asian children (Table 2). Overall, the addition of likely ASD cases excluded due to inability to confirm residency had little impact on prevalence, which was 12.4/1000 (95% CI 11.9, 13.0) when restricted to confirmed cases and 12.6/1,000 (95% CI 12.1, 13.2) when likely ASD cases with missing residency information were added. In addition, the ratios of ASD prevalence in white children compared to black, Hispanic and Asian children were significantly elevated and similar in analyses restricted to confirmed cases and those that included likely ASD cases with imputed residency and race/ethnicity information (Table 2).

Associations between data source type, race/ethnicity and confirmed vs. suspected ASD case classification:

On the basis of the ADDM Network ASD case ascertainment procedures, 1,066 children aged eight years who resided in the Colorado or Wisconsin surveillance areas in 2014 were classified as confirmed ASD cases and 471 children were classified as suspected ASD cases. Among these children, the percentage classified as suspected ASD cases varied significantly by record source type, ranging from a high of 58% when only education records were abstracted to 27% when only health records were abstracted and 19% when both health and education records were abstracted ($p<0.0001$; Table 3). Within each racial/ethnic group (white, black, Hispanic), the percentage classified as suspected was highest when education records were the only source and lowest when both health and education records were abstracted (Table 3).

Among children classified as either confirmed or suspected ASD cases, the percentage classified as suspected also varied significantly by race/ethnicity, ranging from 25% to 35% and 53% for white, Hispanic and black children, respectively ($p<0.0001$, Table 3). The

information in Table 3 also shows that black and Hispanic children were more likely than white children to have only education records for review: 45% and 23% for black and Hispanic children, respectively, compared to 11% for white children ($p<.0002$). Moreover, among those with education records only, black and Hispanic children were more likely than their white counterparts to be classified as suspected ASD cases (73% and 57% for black and Hispanic children, respectively, compared with 44% for white children; $p<.03$).

Potential impact of re-classifying selected suspected ASD cases on ASD prevalence estimates for white, black and Hispanic children:

ASD prevalence estimates based on confirmed cases only for surveillance year 2014 ranged from 11.2 and 11.3 per 1,000, respectively, for Hispanic and black children, to 15.1 for white children, and the ratio of ASD prevalence among white relative to both black and Hispanic children was 1.3 (Table 4). After adding to the confirmed cases, suspected ASD cases considered likely to be classified as confirmed cases had there been sufficient information in the child's records (see Methods above), the estimated prevalence of ASD increased to 13.3, 15.7 and 16.9 per 1,000 in Hispanic, black and white children, respectively (Table 4). On the basis of these adjusted prevalence estimates, the white-to-Hispanic prevalence ratio remained 1.3 (95% CI 1.1, 1.5) while the white-to-black prevalence ratio was no longer significantly elevated (prevalence ratio 1.1, 95% CI 0.9, 1.3; Table 4).

Discussion

Our study showed that potential ASD cases excluded from the surveillance system due to the inability to confirm residency were significantly more likely to be Hispanic, but not more likely to be black, than the included cases. Moreover, the number of potential cases that we were able to identify that were excluded based on inability to confirm residency was insufficient to account for the observed ethnic disparities in ASD prevalence among eight year-old children residing in Wisconsin or Colorado. In addition, imputation of missing data on race and ethnicity of confirmed ASD cases in combination with the addition of likely ASD cases excluded due to missing residency information did not affect the ratios indicating excess ASD prevalence among white relative to black, Hispanic or Asian children. These results provide some indication of the robustness of the ADDM Network methodology and evidence that the observed racial and ethnic disparities in ASD prevalence reported by the Network cannot be readily explained by inability to confirm address information or missing demographic information for some children; the numbers of cases or potential cases affected by these types of missing data were small.

In contrast, our analysis of suspected and confirmed ASD cases indicated that racial and ethnic differences in the type of records abstracted (health, education, both) is a more important contributor to racial differences in ASD prevalence than is missing residency and demographic information. Among potential ASD cases, the percentage confirmed as ASD cases was highest if both health and education records were abstracted and lowest if only education records were abstracted. At the same time, the records abstracted for black children were four times more likely to come from education sources only than was true for white children and nearly twice as likely as was true for Hispanic children. We also found

that if we were to assume that all suspected ASD cases classified as ‘probable ASD’ by the clinician reviewers and a random sample of 35% of other suspected cases were re-classified as confirmed ASD cases, the excess prevalence of ASD in white relative to black children would diminish and the prevalence ratio would no longer be significantly elevated. However, this re-classification of suspected ASD cases did not affect the excess prevalence in white relative to Hispanic children.

In summary, these results suggest that the lower prevalence of ASD reported for black children relative to white children in the U.S. may be linked to racial disparities in access to healthcare and a greater reliance on education records only for identifying ASD among black children than is true for white children. More specifically, the results may point to disparities in access to developmental evaluations by qualified healthcare professionals and reveal greater reliance among black and Hispanic children on the school system to provide evaluation and care. While it has been noted that the ability to obtain a complete count of ASD cases among school-age children in the U.S. requires access to both health and education records (Baio et al., 2018), our findings suggest that, especially for black and Hispanic children, educational evaluations alone may lack the depth and detail necessary to support classification as a confirmed ASD case based on the ADDM Network protocol.

It is notable that even within each category of record source type (health only, education only, and both health and education), the percentage of potential ASD cases with a final classification of ‘suspected ASD case’ and not included in ASD prevalence estimates was higher for black and Hispanic children than for white children. These findings suggest that factors other than record source type contribute to potential case ascertainment biases and to racial and ethnic disparities in ASD prevalence estimates based on public health surveillance. Potential factors contributing to under-ascertainment of ASD in both clinical and school settings include: language barriers; limited economic resources, knowledge and schedule flexibility required of parents to access comprehensive autism assessments for their children; limited parental awareness of ASD and ability to report autism symptoms; and socioeconomic disadvantage (Magaña et al., 2013; Becerra et al., 2014; Durkin et al., 2017).

Our finding that potential ASD cases that were excluded due to inability to confirm residency within the surveillance area were significantly more likely than confirmed ASD cases to be Hispanic points to the possibility that the difficulties of confirming residency within the surveillance area could be especially pronounced for immigrant populations, limiting the ability of the surveillance system to accurately estimate ASD prevalence in such populations. Recent studies from Europe and the U.S., including one from the ADDM Network site in Minnesota, have reported higher than expected ASD prevalence in children of immigrants (Barnevik-Olsson et al., 2010; Becerra et al., 2014; Hewitt et al., 2016; Keen et al., 2010). The Minnesota study, focused specifically on estimating ASD prevalence among children of Somali immigrants, found an ASD prevalence of 3.1% in this population, compared to 2.7% among white children and 1.6% among non-Somali black children in the same community (Hewitt et al., 2016). A limitation of the present study is that we did not have data on immigration status of the surveillance population or of ASD cases.

An additional limitation of our study, stemming from reliance of the surveillance system on existing records, is that children with ASD would not be represented in the absence of documentation in their health or education records of developmental concerns or special educational needs. An assumption of the ADDM Network methodology is that by the age of eight years, given universal access to special education in the U.S., documentation of behaviors and developmental histories consistent with ASD will be available in administrative records for children with ASD. It is possible, however, that disparities exist beyond those captured by available records.

A further limitation of our findings is that they are generalizable only to two ADDM Network sites, Colorado and Wisconsin. Further analysis of data from other sites is warranted to evaluate the generalizability of our findings and to identify strategies for improving access to comprehensive developmental assessments for all children identified as potential ASD cases.

In conclusion, our findings suggest there is under-ascertainment of ASD among black and Hispanic children in the U.S. due to disparities in the documentation of developmental concerns and assessments in administrative records. These disparities may contribute to findings of lower ASD prevalence in black and Hispanic children and may point to the need for strategies to improve health equity and access to developmental assessments, diagnosis and treatment of ASD.

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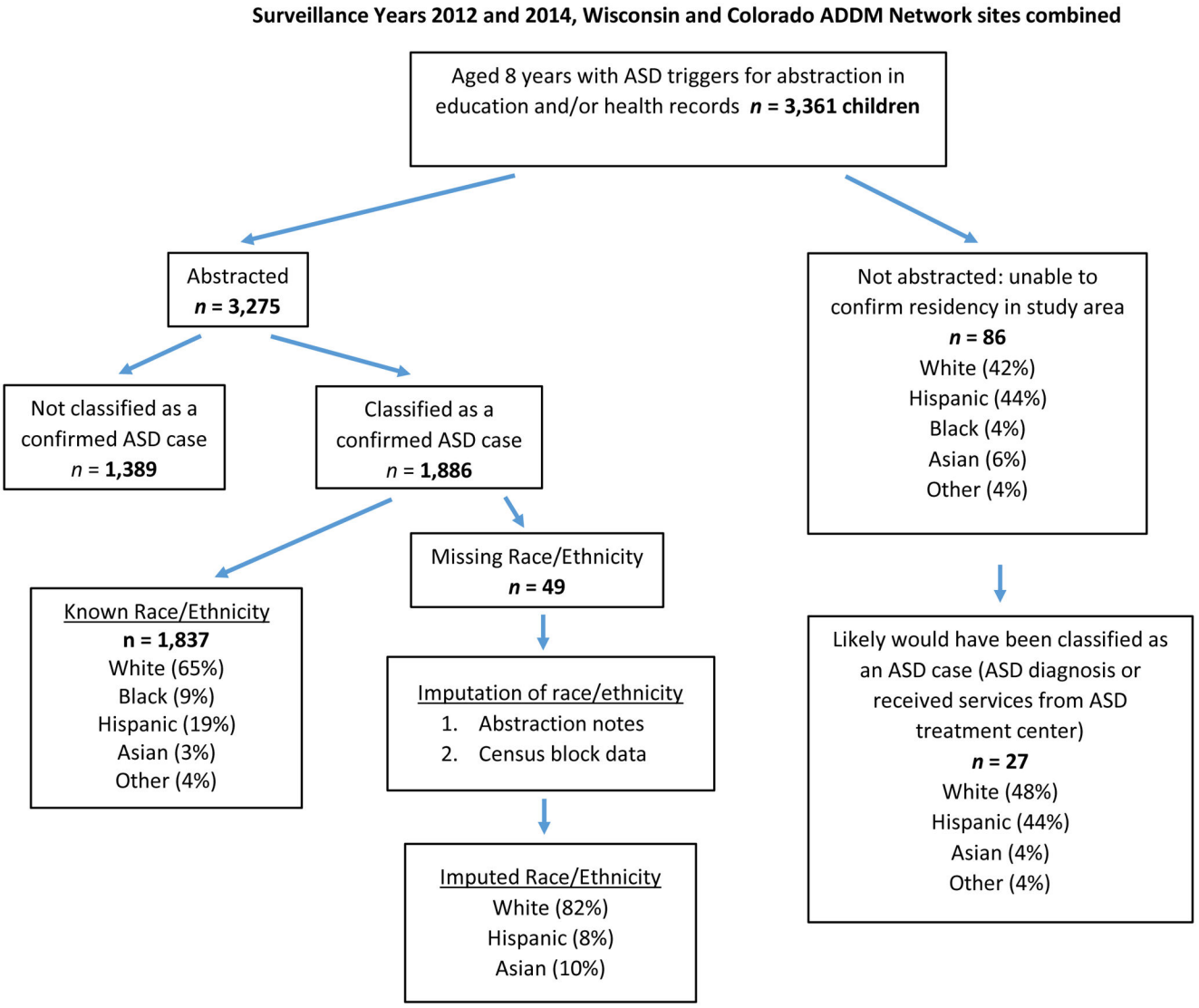

Figure 1.
Flowchart of records reviewed

Table 1.

Racial/ethnic distribution of the surveillance population, of confirmed ASD cases, and of potential ASD cases who did not qualify for review due to missing residency information, Colorado and Wisconsin ADDM Network Surveillance Areas, 2012 and 2014.

	Population of Eight Year-Old Children in Surveillance Area	Confirmed ASD Cases per ADDM Protocol		Likely ASD Cases but did not qualify due to missing residency[#]	
Race/Ethnicity	**N (%)**	**N (%)**	**p-value[*] [^]**	**N (%)**	**p-value[**]**
White	87,270 (57)	1,187 (63)	<0.0001	13 (48)	0.168078
Black	18,021 (12)	167 (9)	<0.0001	0	-
Hispanic	39,279 (26)	354 (19)	<0.0001	12 (44)	0.001803
Asian	6,923 (4)	53 (3)	0.0004	1 (4)	-
Other[^^]	766 (1)	125 (6)	0.0001	1 (4)	-
TOTAL	152,259 (100)	1,886 (100)		27 (100)	

[#] Includes those likely to be classified as a case based on documentation of an ASD diagnosis and/or evaluation/treatment at an ASD center, but who did not qualify for review due to missing residency information.

[*] Significance of difference between observed and expected percentages within each racial/ethnic category, comparing likely ASD cases to confirmed ASD cases, chi-square analysis.

[**] Significance of difference between observed and expected percentages within each racial/ethnic category, comparing likely to confirmed ASD cases, chi-square analysis.

[^] Overall significance of the difference between the observed racial/ethnic distribution of confirmed ASD cases compared to the racial/ethnic distribution of eight year-old children in the population) <0.0001, chi-square analysis.

[^^] "Other" includes multiple race, other selected race, "other" or missing race information.

Table 2.

Impact of imputation of missing race and residency confirmation on the prevalence of ASD* by race and ethnicity, compared to rates reported by the Autism and Developmental Disabilities Monitoring Network, Wisconsin and Colorado, 2012 and 2014 combined.

	Analysis of Confirmed ASD cases as reported previously by the ADDM Network			Analysis based on adjusted ASD case counts, including confirmed ASD cases with missing race/ethnicity imputed plus additional likely ASD cases that were excluded due to missing residency information*		
Race/Ethnicity	**Confirmed ADDM ASD cases N (%)**	**ADDM ASD prevalence per 1,000 (95% CI)**	**ADDM ASD prevalence ratio (95% CI) indicating ratio of prevalence in white vs. black, Hispanic and Asian children, respectively**	**ASD cases inclusive of those with missing data imputed N (%)**	**ASD prevalence per 1,000 (95% CI) inclusive of cases with missing data imputed**	**ASD prevalence ratio (95% CI) inclusive of cases with missing data imputed, indicating ratio of prevalence in white vs. black, Hispanic and Asian children, respectively**
White	1,187 (63)	13.6 (12.9-14.4)	1.0 (reference)	1,240 (65)	14.2 (13.4, 15.0)	1.0 (reference)
Black	167 (9)	9.3 (8.0-10.8)	**1.47 (1.25, 1.73)**	167 (9)	9.3 (8.0, 10.8)	**1.53 (1.31, 1.80)**
Hispanic	354 (19)	9.0 (8.1-10.0)	**1.51 (1.34, 1.70)**	370 (19)	9.4 (8.5, 10.4	**1.51 (1.34, 1.69)**
Asian	53 (3)	7.7 (5.9-10.0)	**1.78 (1.35, 2.34)**	59 (3)	8.5 (6.6, 11.0)	**1.67 (1.29, 2.16)**
Other and missing race/ethnicity	125 (6)	-	-	77 (4)	-	-
TOTAL	1,886 (100)	12.4 (11.9-13.0)		1,913 (100)	12.6 (12.1, 13.2)	

*Likely but not confirmed ASD cases include those with documentation of an ASD diagnosis and/or evaluation/treatment at an ASD specialty clinic, but did not qualify for clinical review due to missing residency information.

Table 3.

Distribution of record source type for children with case status of Confirmed ASD or Suspected ASD, by white, black and Hispanic race/ethnicity, Colorado and Wisconsin ADDM Network surveillance sites, 2014.

	White		Black		Hispanic		Total	
Record Type	**Confirmed and Suspected ASD Cases Combined N (%)**	**% Suspected ASD**	**Confirmed and Suspected ASD Cases Combined N (%)**	**% Suspected ASD**	**Confirmed and Suspected ASD Cases Combined N (%)**	**% Suspected ASD**	**Confirmed and Suspected ASD Cases Combined N (%)**	**% Suspected ASD**
Health only	683 (79)	24	69 (32)	45	183 (53)	30	935 (65)	27
Health & Education	88 (10)	10	51 (23)	24	82 (24)	26	221 (15)	19
Education only	93 (11)	44	99 (45)	73	79 (23)	57	271(19)	58
Total	864 (100)	25	219 (100)	53	344 (100)	35	1,427 (100)	32

Chi-square test of significance of the difference in the distribution of record type by race/ethnicity, $p<0.0001$.

Chi-square test of significance of the difference in the distribution of the % Suspected ASD by record type, $p<0.0001$.

Chi-square test of significance of the difference in the distribution of the % Suspected ASD by race/ethnicity, $p<0.0001$.

Table 4.

ASD prevalence per 1,000 (95% CI) and prevalence ratios (95% CI) by race/ethnicity based on Confirmed ASD Cases only (Autism and Developmental Disabilities Monitoring Network reported) and based on Confirmed and Selected Suspected ASD Cases* Combined, Colorado and Wisconsin sites, 2014.

	Confirmed ASD Cases		Confirmed and Selected Suspected* ASD Cases	
Race/Ethnicity	**ASD prevalence per 1,000 (95% CI)**	**Prevalence ratio (95% CI) indicating ratio of prevalence in white vs. black and Hispanic children, respectively**	**ASD prevalence per 1,000 (95% CI)**	**Prevalence ratio (95% CI) indicating ratio of prevalence in white vs. black and Hispanic children, respectively**
White	15.1 (14.0-16.3)	1.0 (reference)	16.9 (15.7-18.2)	1.0 (reference)
Black	11.3 (9.3-13.7)	**1.3 (1.09, 1.64)**	15.7 (13.4-18.4)	1.1 (0.90, 1.28)
Hispanic	11.2 (9.8-12.8)	**1.3 (1.16, 1.57)**	13.3 (11.8-15.0)	**1.3 (1.11, 147)**

*Selected Suspected ASD cases for this analysis included all children coded as "probable" ASD with high degree of certainty by the clinician reviewer and 35% of suspected ASD cases coded with insufficient or conflicting information, or indications that the symptoms could be accounted for by another condition, or coded as "possible" ASD cases with a high degree of certainty.