

# Predictors of Inpatient Psychiatric Hospitalization for Children and Adolescents with Autism Spectrum Disorder

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**Abstract** Autism Spectrum Disorder (ASD) is associated with significant healthcare expenditures and a greater utilization of psychiatric health services. High utilization may not be evenly distributed across individuals with ASD. The objective of this study was to identify individual and family characteristics that increase the risk of psychiatric hospitalization. Naturalistic study of two age- and gender-matched ASD cohorts, inpatients enrolled in the Autism Inpatient Collection (AIC) and outpatients enrolled in the

Rhode Island Consortium of Autism Research and Treatment (RI-CART), revealed a number of factors associated with hospitalization. Multiple logistic regression analyses revealed that adaptive functioning, ASD symptom severity, primary caregiver's marital status, the presence of mood disorders, and the presence of sleep problems independently increased the risk of psychiatric hospitalization.

**Keywords** Autism spectrum disorder · Inpatient psychiatric hospitalization · Children and adolescents · Autism inpatient collection (AIC)

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## Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by deficits in social communication and social interaction, and restricted, repetitive patterns of behavior, interests, or activities. Severity of symptoms varies and may be accompanied by intellectual impairment, language impairment, medical or genetic conditions, and neurodevelopmental, psychiatric, or behavioral problems (APA 2013). The presence of ASD has been associated with significant health care expenditures across the lifespan (Barrett et al. 2015; Hamdani and Lunsky 2016; Liptak et al. 2006; Mandell et al. 2006; Shimabukuro et al. 2008; Wang and Leslie 2010). These expenditures are associated with a greater utilization of a variety of medical and psychiatric health services including both inpatient and outpatient care, compared to individuals without ASD (Croen et al. 2006). Between 1999 and 2009 the rate of hospitalization increased significantly for children and adolescents with ASD (Nayfack et al. 2014). With the exception of children less than 5 years of age, the leading cause of hospitalizations was psychiatric conditions. Furthermore, psychiatric healthcare expenditures for children with ASD have been found to be significantly higher than those of children without ASD, children with intellectual disability, and children with other psychiatric diagnoses (Mandell et al. 2006; Wu et al. 2014). Furthermore, children and adolescents with ASD are more likely than their non-ASD counterparts to require emergency room visits for psychiatric reasons, the leading cause being externalizing disorders (Kalb et al. 2012) often presenting as significant aggression, and/or self-injurious behavior (Iannuzzi et al. 2015; Lunsky et al. 2015).

There is reason to believe that service utilization is not evenly distributed across individuals with ASD and that there are certain risk factors that place individuals at a greater risk of requiring more services (Croen et al. 2006; Kalb et al. 2012; Lunsky et al. 2015; Modi et al. 2015; Mandell 2008). The few studies addressing such risk factors of high healthcare utilization in ASD have shown that both individual and family characteristics may increase the likelihood of emergency service department use and inpatient psychiatric hospitalization. With regard to emergency psychiatric care, Kalb et al. (2012) found that having private health insurance increased the risk of emergency department psychiatric visits for children and adolescents with ASD. With regard to psychiatric hospitalization, Mandell (2008) found that the risk of being hospitalized was greater for children and adolescents who received a diagnosis of ASD at a later age, were African American, or were adopted. Mandell (2008) also found that psychiatrically hospitalized children and adolescents with ASD were more likely to come from single caregiver's homes and

their caregivers were more likely to make less than \$40,000 per year and less likely to have graduated from college. These children and adolescents were more likely to display aggression or self-injurious behavior, more likely to have been diagnosed with other psychiatric conditions including ADHD, depression, obsessive-compulsive disorder, and intellectual disability, and more likely to be taking psychotropic medications (Mandell 2008).

The present study seeks to expand prior work by investigating predictors of inpatient psychiatric hospitalization for children and adolescents with ASD. In contrast to the majority of earlier studies that have utilized either surveys or large health care administrative databases, this study examined predictors of hospitalization that were gathered from caregivers' and/or clinicians' report and direct assessment measures. More specifically, this study employs a direct comparison of two large research cohorts, an inpatient cohort from the Autism Inpatient Collection (AIC) and an age- and gender-matched cohort of never-hospitalized participants from the Rhode Island Consortium for Autism Research and Treatment (RI-CART). The utilization of these two large cohorts allowed for the examination of variables that are not usually available in health care administrative databases. In order to provide a framework commensurate with prior literature on psychiatric care utilization (Dhingra et al. 2010; Lunsky et al. 2015), we adopted Andersen's Model of Behavioral Service Utilization (Andersen 1995). According to this model an individual's service utilization pattern is conceptualized in terms of predisposing factors (e.g. demographic characteristics, intellectual disability status, language functioning, adaptive functioning, ASD symptom severity), enabling factors (e.g. individual living situation, family income, family status), and need factors (e.g. medical problems, psychiatric problems) (Andersen 1995). The objective of this study was to determine characteristics that can identify children and adolescents with ASD at greater risk of psychiatric hospitalization.

## Methods

### Participants

Participants for this study were selected from two large prospective, naturalistic studies: the Autism Inpatient Collection (AIC) and the Rhode Island Consortium for Autism Treatment and Research (RI-CART). Both studies use highly related protocols for assessment.

The AIC is a phenotyping and genotyping study carried out in six academically affiliated specialized inpatient psychiatry units for youth with ASD and other developmental disorders. These units are located at Bradley Hospital

(Brown University, Providence, Rhode Island), Cincinnati Children's Hospital (University of Cincinnati, Cincinnati, OH), Children's Hospital of Colorado (University of Colorado, Denver, CO), Sheppard Pratt Health System (University of Maryland, Towson, MD), Western Psychiatric Institute and Clinic (University of Pittsburgh, Pittsburgh, PA), and Spring Harbor Hospital/Maine Medical Center (Tufts University, Portland, ME). Children and adolescents admitted to the six specialized inpatient units are eligible for participation in the AIC if they are between the ages of 4 and 20 years and have a score of  $\geq 12$  on the Social Communication Questionnaire (SCQ; Rutter et al. 2003) or there is a high suspicion of ASD from the inpatient clinical treatment team. Exclusion criteria for participants include having prisoner status, or having no parents available who are proficient in English. Data on all participants included a variety of parent-report and clinician-report measures. Caregivers completed the Parent/Caregiver rating form of the Vineland Adaptive Behavior Scales, Second Edition (VABS-II) (Sparrow et al. 2005) as well as demographic questionnaires including medical history. ASD diagnosis was confirmed by research-reliable administration of the Autism Diagnostic Observation Schedule, Second Edition (ADOS-2; Lord et al. 2012). A minimum of two unit clinicians completed a consensus diagnostic summary form at discharge. See Siegel et al. (2015) for a complete description of the methods and a preliminary description of this sample.

RI-CART is a patient registry of prospectively recruited individuals with ASD and their families. The registry was established in 2013 by researchers and clinicians at Brown University and its affiliate teaching hospitals and community partners. Participants of all ages ("affected participants") are eligible for the registry if they have been previously diagnosed with ASD and/or they have concerns about the presence of ASD. Participants are recruited from Rhode Island and nearby areas of Connecticut and Massachusetts, reflecting the region's healthcare catchment area. Data on all affected participants included the Parent/Caregiver rating form of the VABS-II, and the ADOS-2 administered by a research-reliable assessor. In addition, affected participants and their families were asked to complete demographic questionnaires including a medical and psychiatric history.

Participants were selected from the AIC registry if they had: (1) a confirmed diagnosis of ASD, (2) a completed demographic questionnaire, (3) a completed ADOS-2 with scores above the ASD cut-off, and (4) a completed VABS-II. This resulted in 218 participants to be included in the analyses (77% males, average age = 12.8, age range 4–20). Participants were selected from the RI-CART registry if they met all of the same criteria and had never been hospitalized for psychiatric reasons. Given that prior work has

demonstrated that both age and gender may differentially impact the likelihood of health care utilization (Croen et al. 2006; Mandell 2008), available RI-CART participants were subsequently frequency-matched on the dimensions of age and gender to the AIC sample, which resulted in 255 participants to be included in the analyses (80% males, average age = 12.3, age range 4–20). Frequency matching was carried out in the following manner: the AIC sample was divided into three age ranges: less than or equal to 5 years of age, 6–11 years of age, and 12–20 years of age. RI-CART participants that met the requirements specified above were randomly selected from the first 1000 participants in the RI-CART registry in order to match to the AIC sample the proportion of participants in each age range. Gender frequency matching was achieved without needing further manipulation following age matching, as the two samples contained statistically equivalent proportions of males and females participants. Chi square tests were used to verify matching strategies. See Supplemental Table 1 for more detail.

## Measures

Potential predictors of hospitalization were selected from three categories of factors derived according to Andersen's Behavioral Model of Health Service Use (Andersen 1995): predisposing factors (e.g. individual characteristics), enabling factors (e.g. resources available to individual and family) and need variables (e.g. medical/psychiatric conditions).

Predisposing factors extracted from demographic information forms filled out by caregivers or clinicians included race, ethnicity, and presence of intellectual disability (ID). Predisposing factors extracted from direct assessment measures included adaptive functioning measured by the VABS-II and autism severity measured from the ADOS-2. Calibrated Severity Scores (CSS) were computed from the ADOS-2 as an indicator of overall severity of ASD symptomatology (Gotham et al. 2009; Hus et al. 2014), severity of Social Affect (SA) symptoms, and severity of Restricted and Repetitive Behaviors (RRB) (Hus et al. 2014). Of note, the CSS score is derived from the sum of raw scores across the SA and RRB domains, the SA severity score reflects the severity of the child's social communication impairments and is derived from the raw score in the SA domain alone, the RRB severity score captures the intensity of sensory and restrictive/repetitive behaviors and is derived from the raw score in the RRB domain alone.

Given the lack of direct language assessments available in either registry and the large heterogeneity of verbal ability observed among participants, verbal status was conservatively coded as a dichotomous variable to differentiate nonverbal participants from those with at least

some functional speech. Given that all participants were at least 4 years of age, individuals were categorized as nonverbal if they were administered a Module 1 of the ADOS-2 and obtained a score of 3 or higher on item A1 indicating the use of fewer than 5 words during the ADOS-2 Assessment (Bal et al. 2016).

Enabling factors included total family income, the marital status of the primary caregiver, and the individual's current living situation (prior to admission for the AIC subjects); these variables were extracted from the demographic information forms. In order to obtain comparable groupings in both samples, total family income was coded in the following categories: (1) less than \$20,000 per year, (2) between \$20,000 and \$50,000 per year, (3) between \$50,000 and \$100,000 per year, and (4) over \$100,000 per year. Caregiver marital status was coded as: (1) single, (2) married or domestic partnership, (3) separated, divorced, or widowed. Living situation (prior to hospitalization in the AIC sample) was coded using the following categories: (1) family home, (2) residential facility, (3) other.

Need factors included psychiatric and medical problems. Psychiatric problems were extracted from the RI-CART participant's caregiver report or the AIC participant's clinician report (discharge diagnoses). These were coded in the following categories: total number of psychiatric diagnoses, ADHD diagnosis, anxiety spectrum disorders diagnoses (including OCD), mood disorders diagnoses, and disruptive behavior disorders diagnoses. Medical problems were extracted from caregivers report for both samples and were coded as present or absent in the following categories: sleep problems, seizures, dental problems, hormonal

problems, and gastro-intestinal problems. See Tables 1, 2 and 3 for a full description of participants' characteristics.

## Analyses

Preliminary analyses, including  $\chi^2$  and independent sample t-tests, were utilized to identify factors that significantly differentiated between groups. Predictors that significantly differentiated between groups were entered in a multiple logistic regression model to examine their relative contribution to the likelihood of being psychiatrically hospitalized. Of note, due to the need for 18 planned comparisons, a Bonferroni corrected value of  $p < 0.003$  was used for all preliminary analyses. All analyses were completed in SPSS 23.

## Results

### Group Comparisons

As expected from the matching strategy, no significant group differences were observed on age ( $t(471) = 1.507$ ,  $p = 0.132$ ) and gender ( $\chi^2(1) = 0.761$ ,  $p = 0.426$ ). Whereas both groups were predominantly White ( $\chi^2(1) = 3.1$ ,  $p = 0.083$ ), the AIC sample had fewer Hispanic/Latino participants compared to the RI-CART sample ( $\chi^2(1) = 8.9$ ,  $p = 0.003$ ), but this difference did not meet statistical significance when corrected for multiple comparisons.

Intellectual disability and nonverbal status were significantly more prominent in the inpatient AIC sample than the outpatient RI-CART sample ( $\chi^2(1) = 67.1$ ,

**Table 1** Summary of predisposing factors and differences between participant cohorts

Predisposing factors	AIC sample ( $N = 218$ )	AIC sample range	RI-CART sample ( $N = 255$ )	RI-CART sample range	AIC vs RI-CART ( $p$ value)
Ethnicity (Non-hispanic/latino) N(%)	202 (94.8%)		207 (81%)		0.003
Race (Caucasian) N(%)	187 (85.8%)		232 (91%)		0.083
Intellectual disability present N(%)	101 (46.3%)		58 (22.7%)		<0.0001*
Nonverbal N(%)	46 (21.1%)		25 (9.8%)		0.001*
Vineland-2 M(SD)					
Communication domain standard score	59.5 (17.6)	12–135	71.2 (17.5)	28–131	<0.0001*
Daily living skills standard score	61.3 (19.4)	7–127	72.4 (18.1)	25–128	<0.0001*
Socialization standard score	54.6 (19.4)	29–92	64.8 (15.5)	34–114	<0.0001*
Adaptive behavior composite	57.5 (15.1)	25–118	68 (15)	27–109	<0.0001*
ADOS-2 results M(SD)					
Overall severity score	7.95 (1.7)	4–19	7.37 (1.8)	4–10	0.001*
Social affect severity score	7.9 (1.5)	3–10	7.3 (1.8)	3–10	<0.0001*
Repetitive restrictive behavior severity score	7.3 (2)	1–10	7.3 (2.3)	1–10	0.75

\*Comparisons are statistically significant at a Bonferroni-corrected  $p < 0.003$ \*

**Table 2** Full description of enabling factors and differences between participant cohorts

Enabling factors	AIC sample (N=218) N (%)	RI-CART sample (N=255) N (%)	AIC vs RI-CART (p value)
Living situation			0.05
Family home	204 (93.6%)	248 (97.3%)	
Residential	8 (3.7%)	2 (0.7%)	
Other	5 (2.3%)	1 (0.4%)	
Missing	1 (0.4%)	4 (1.6%)	
Caregiver family status			0.0001*
Single	25 (11.5%)	15 (5.9%)	
Married/domestic partnership	114 (52.3%)	201 (78.8%)	0.0001*
Divorced/separated/widowed	42 (19.3%)	36 (14.1%)	
Missing	37 (16.9%)	3 (1.2%)	
Household income			0.003
Less than \$20,000	40 (18.3%)	21 (8.3%)	
Between \$20,000 and \$50,000	71 (32.5%)	73 (28.6%)	
Between \$50,000 and \$100,000	45 (20.6%)	67 (26.3%)	
Over \$100,000	47 (21.5%)	75 (29.4%)	
Missing	15 (6.9%)	19 (7.4%)	

\*Comparisons are statistically significant at a Bonferroni-corrected  $p < 0.003$

**Table 3** Full description of need factors and differences between participant cohorts

Need factors	AIC sample N (%)	Mean (SD)	RI-CART sample N (%)	Mean (SD)	AIC vs. RI-CART (p value)
Psychiatric diagnoses present	203 (93.1%)	1.7 (9)	149 (58.4%)	1.1 (1.3)	<0.0001*
ADHD	84 (38.5%)		98 (38.4%)		0.98
Anxiety spectrum	67 (30.7%)		97 (38%)		0.096
Mood disorders	101 (46.3%)		34 (13.3%)		<0.0001*
Disruptive behavior disorders	34 (15.6%)		20 (7.8%)		0.008
Medical co-morbidities currently present					
Sleep problems	136 (62%)		88 (35%)		<0.0001*
Seizures	17 (8%)		11 (4%)		0.109
Dental problems	35 (16%)		41 (16%)		0.994
Hormonal problems	9 (4%)		6 (2%)		0.272
Gastro-intestinal problems	81 (37%)		78 (31%)		0.132

\*Comparisons are statistically significant at a Bonferroni-corrected  $p < 0.003$

$p < 0.0001$ ;  $\chi^2 (1) = 11.8$ ,  $p = 0.001$ , respectively). VABS-II Adaptive Behavior Composite score and Communication, Daily Living Skills, and Socialization domain standard scores were all significantly lower in the AIC sample ( $t(471) = 7.8$ ,  $p < 0.0001$ ;  $t(471) = 7.5$ ,  $p < 0.0001$ ;  $t(471) = 6.6$ ,  $p < 0.0001$ ;  $t(471) = 7.9$ ,  $p < 0.0001$ ). Finally both the ADOS-2 overall severity score (CSS) ( $t(435) = 3.5$ ,  $p = 0.001$ ) and the Social Affect (SA) severity score ( $t(325) = 4.1$ ,  $p < 0.0001$ ) were significantly higher in the AIC sample, but the groups did

not significantly differ in Restrictive/Repetitive Behaviors (RRB) severity score ( $t(435) = 0.31$ ,  $p = 0.75$ ).

Within both samples, the majority of participants resided in the family home ( $\chi^2 (1) = 4.8$ ,  $p = 0.05$ ). However, there were significant differences in caregiver marital status ( $\chi^2 (2) = 15.8$ ,  $p < 0.0001$ ), with significantly more caregivers in the AIC sample being unmarried or without domestic partnerships ( $\chi^2 (1) = 15.2$ ,  $p < 0.0001$ ). No significant group differences were observed in household income ( $\chi^2 (3) = 14.3$ ,  $p = 0.003$ ) after correcting

for multiple comparisons. However more AIC families reported income lower than \$20,000 and fewer AIC families reported income higher than \$100,000.

An overall higher number of psychiatric diagnoses per individual was observed in the AIC sample ( $t(471)=5.2$ ,  $p<0.0001$ ). Among psychiatric diagnoses, no significant differences were observed in the prevalence of ADHD diagnoses ( $\chi^2(1)=0.001$ ,  $p=0.98$ ), anxiety disorders diagnoses ( $\chi^2(1)=2.8$ ,  $p=0.096$ ), and disruptive behavior disorders diagnoses ( $\chi^2(1)=6.9$ ,  $p=0.008$ ), but significantly higher rates of mood disorders diagnoses ( $\chi^2(1)=62.7$ ,  $p<0.0001$ ) were reported in the AIC sample.

Among current medical problems, significantly more sleep problems were reported in the AIC sample ( $\chi^2(1)=36.6$ ,  $p<0.0001$ ), but no significant group differences were reported in the prevalence of seizures ( $\chi^2(1)=2.56$ ,  $p=0.109$ ), hormonal problems ( $\chi^2(1)=1.21$ ,  $p=0.272$ ), dental problems ( $\chi^2(1)=0$ ,  $p=0.994$ ), or gastro-intestinal problems ( $\chi^2(1)=2.72$ ,  $p=0.132$ ).

### Logistic Regression

A multiple logistic regression analysis was run to examine the relative contributions of the factors found to be significantly different between groups in the analyses described above. Hospitalization status (AIC vs. RI-CART group membership) was the dependent or outcome variable in these analyses. Of note, only the VABS-II Adaptive Behavior Composite score was included in this analysis due to high correlations between the Vineland domain scores and the adaptive behavior composite score, and high correlations between all domain scores in both groups of subjects. Similarly only the ADOS-2 SA severity score was included in the analysis due to a high correlation with the overall CSS and its lack of association with the RRB severity score. Finally, caregiver's marital status was recoded into 2 categories: married/domestic partnership and single/separated/divorced/widowed, in order to simplify its interpretation.

The logistic regression full model, which was significant at  $p<0.0001$ , showed that the strongest predictor of hospitalization was the presence of a mood disorder (OR = 7.011,  $p<0.0001$ ), followed by the presence of current sleep problems (OR = 2.367,  $p<0.001$ ), and higher SA severity score (OR = 1.131,  $p=0.001$ ). Having a higher VABS-II Adaptive Behavior Composite score (OR = 0.951,  $p<0.0001$ ), and having a married primary caregiver (OR = 0.395,  $p=0.001$ ) decreased the likelihood of hospitalization. The presence of intellectual disability and being nonverbal were not significant in the full model. See Table 4 for a description of the full model results.

**Table 4** Results of logistic regression full model examining the relationship between relevant factors and likelihood of psychiatric hospitalization

Predictors	$\beta$	OR	95% CI	p value
Adaptive behavior composite	-0.050	0.951	0.930–0.973	<0.0001
Social affect severity score (SA)	0.123	1.131	1.049–1.219	0.001
Intellectual disability present	-0.351	0.704	0.383–1.292	0.257
Positive nonverbal status	-0.620	0.538	0.236–1.228	0.141
Caregiver is married	-0.928	0.395	0.225–0.695	0.001
Presence of mood disorder	1.947	7.011	3.882–12.660	<0.0001
Presence of sleep problems	0.862	2.367	1.428–3.924	0.001

### Discussion

Even though children with ASD are more likely to require psychiatric hospitalization compared to children with other neurodevelopmental or psychiatric problems alone (Mandell 2008; Mandell et al. 2006), not all children with ASD are equally likely to necessitate such an acute level of care. To date, few studies have investigated the factors that increase this risk (Mandell 2008; Modi et al. 2015). The present study seeks to expand prior work by examining potential predictors of inpatient psychiatric hospitalization for children and adolescents with ASD using large cohorts of participants prospectively recruited and assessed using direct clinician assessment.

In order to address this question, two cohorts of children and adolescents with ASD were utilized: one cohort extracted from the Autism Inpatient Collection (AIC), which included only individuals with ASD who have experienced at least one hospitalization in a specialized psychiatric inpatient unit for individuals with developmental disorders, and a matched cohort from the Rhode Island Consortium for Autism Research and Treatment (RI-CART), which included individuals with ASD who were frequency-matched to the AIC sample for age and gender, and who have never undergone psychiatric hospitalization. These two samples were compared in order to examine any predisposing, enabling, and need factors that relate to the utilization of inpatient psychiatric care.

Group comparisons revealed several differences across all three categories of factors. Overall, the hospitalized sample contained a higher proportion of individuals with intellectual disability and/or who had very limited or no functional language. Furthermore, the hospitalized sample presented with significantly lower adaptive functioning and a higher severity of ASD symptomatology as measured by the ADOS-2. Notably, the difference in ASD symptom

severity was found on the social-affective items and not the repetitive/restricted behavior items on the ADOS. Similar to prior work by Mandell (2008), group differences were observed in both enabling factors and need factors. For the enabling factors, the hospitalized sample had caregivers who were less likely to be married. Not surprisingly, for need factors, hospitalized individuals presented with an overall higher number of psychiatric diagnoses, a higher prevalence of mood disorders, and a higher prevalence of current sleep problems.

Multiple logistic regression analyses revealed that several of the factors differentiating the two groups were uniquely related to the likelihood of being psychiatrically hospitalized, including lower adaptive functioning, higher severity of social-affective ASD symptomatology, having a non-married/non-domestic partnered primary caregiver, the presence of mood disorder diagnoses, and the presence of sleep problems. Of note, though intellectual disability and nonverbal status were more prevalent in the AIC cohort, they were not found to independently relate to psychiatric inpatient hospitalization when controlling for other factors. These results may seem surprising, but the literature on the relationship between ID and language abilities and severe maladaptive behaviors, such as those that would warrant hospitalization, has produced mixed findings (Dominick et al. 2007; Kanne and Mazurek 2011; Matson et al. 2008; Ruddick et al. 2015). Furthermore, it is possible that the relationship between these factors and hospitalization was accounted for by the adaptive behavior functioning scores used in our analyses, as they capture individuals' abilities across multiple domains.

Regarding prior research, no studies have investigated the relationship between adaptive functioning and psychiatric hospitalization in ASD. Given that the need for hospitalization often requires imminent risk of harm to self or others, it is reasonable to discuss the present findings in the context of the literature on aggressive behaviors in ASD. Prior work has demonstrated associations between lower adaptive functioning and aggression in both children and adolescents with ASD (Farmer et al. 2014; Hartley et al. 2008; Mazurek et al. 2013). Given a previously demonstrated relationship between the presence of aggressive behaviors and the utilization of acute psychiatric services in ASD (Kalb et al. 2012; Mandell 2008; Modi et al. 2015), the observed relationship between adaptive functioning and hospitalization might be mediated by the presence of severe maladaptive behaviors. This relationship may also be a manifestation of the more psychiatrically impaired nature of the hospitalized sample (Matson et al. 2009). Of note, even though adaptive functioning, intellectual functioning, and verbal ability are related in ASD (Liss et al. 2001), the observed relationship between adaptive functioning and hospitalization holds true independent of these other

predisposing variables. Although the present study cannot speak directly to the nature of the relationship between adaptive functioning and challenging behaviors, our findings substantiate the importance of assessing and treating adaptive behavior deficits throughout childhood and adolescence in ASD.

Few studies have examined the relationship between severity of core ASD symptomatology and health care utilization outcomes (Lunsky et al. 2015), but numerous studies have investigated the association between ASD symptoms and aggressive behaviors. This literature has produced mixed results with some studies reporting either positive (Matson et al. 2008) or negative (Hill et al. 2014) relationships, and others revealing null findings (Hartley et al. 2008; Kanne and Mazurek 2011). These differences may be in part due to the utilization of different instruments used to assess ASD severity and the specific sample of individuals examined. In the present study we chose to examine calibrated severity scores obtained from the ADOS-2 as a quantitative index of core ASD symptomatology. The Calibrated Severity Score (CSS) is computed from the sum of scores across social communication and repetitive/restricted behavior domains; the Social Affect (SA) severity score is taken as an indicator of the social-communication abilities observed during the assessment and it encompasses rating of verbal and non-verbal behaviors; the Restrictive/Repetitive Behaviors (RRB) severity score quantifies the restrictive/repetitive behaviors observed during the assessment (Hus et al. 2014). Whereas differences between the hospitalized and non-hospitalized sample were observed on both the CSS and SA severity score, no difference was observed in the RRB severity score. This finding may appear surprising given that the presence of restrictive/repetitive behaviors has been associated with more prominent psychiatric comorbidities (Gabriels et al. 2005; Stratis and Lecavalier 2013). However, in contrast to the present study, most investigations of restrictive/repetitive behaviors have utilized caregiver report measures instead of a time-limited direct assessment. As such, the lack of group differences observed in the present study may be likely due to the methods utilized.

Results of multiple logistic regression demonstrated that higher Social Affect (SA) severity score increased the risk of hospitalization when controlling for the effects of other relevant variables. This relationship may in part be explained by the impact of psychiatric acuity on ASD symptomatology, as the AIC participants are evaluated during their hospital stay. However, this relationship may also be a manifestation of the previously demonstrated association between communication and social skill deficits and challenging behaviors (Chiang 2008; Matson et al. 2013). Further investigations of the relationship between core ASD symptom severity and health care utilization patterns

are warranted. Nevertheless, this finding provides support for the utility of quantifying the ASD presentation according to its core dimensions as well as the importance of providing treatment to ameliorate social communication deficits throughout childhood and adolescence.

As highlighted by Mandell and colleagues (2012), a family may seek acute psychiatric care for their child not only because of the presence of maladaptive behaviors, but also to alleviate the stress caused by these behaviors on the family system. Put another way, the maladaptive behaviors increase the likelihood of hospitalization when their severity exceeds the capacity of the family to cope, and this will be different for individual families. The relationship between family status and hospitalization risk observed in the present study may underscore the need to ensure that a family has adequate resources to cope with significant negative behaviors. Even though a family may ultimately benefit from a variety of resources, caregiver-specific resources may play a pivotal role in decreasing the risk of hospitalization, as shown by a previously demonstrated inverse relationship between the amount of respite care available and hospitalization risk (Mandell et al. 2012).

With regard to the role of psychiatric comorbidity, our results were consistent with prior research indicating that the presence of mood disorders is a risk factor for hospitalization in youths with ASD (Mandell 2008). Although the presence of mood disorders increased the risk of hospitalization, anxiety disorders and disruptive behavior disorders did not. This pattern of findings underscores the need for more attention on the prevention and treatment of mood disorders in ASD, which is still relatively sparse, especially in lower functioning samples (see Matson and Nebel-Schwalm 2007; Stewart et al. 2006 for reviews).

To our knowledge sleep disturbance has not been examined in relation to risk psychiatric for hospitalization in ASD. Sleep problems are highly prevalent in children with psychiatric disorders (Ivanenko and Johnson 2008), and ASD parental reports of sleep disturbance have also been linked to behavior problems (Goldman et al. 2011; Hill et al. 2014; Mazurek et al. 2013) as well as to the severity of ASD symptomatology (Mayes and Calhoun 2009). The results of the present study are in agreement with the literature linking sleep problems with an overall more severe psychiatric presentation, but also suggest that active sleep problems can be an indicator of significant behavioral crisis. Overall, our findings emphasize the utility of thorough assessment and treatment of mood and sleep conditions, to decrease the likelihood of requiring psychiatric hospitalization.

There are aspects of the study design that should be considered when interpreting the findings. Unlike prior research, the current study employed large cohorts prospectively recruited and assessed using direct clinician

assessment as opposed to retrospective medical record review, which is a significant strength. However, due to the cross-sectional study design, the identified risk factors represent associations and firm conclusions about causality cannot be made. Compared to prior work that utilized either large health care administrative databases or survey-only data (e.g. Bryson and Akin 2015; Lokhandwala et al. 2012; Mandell 2008), the size of the sample available is relatively small, and as such it will be important to validate the current findings with larger datasets. As both the RI-CART and AIC study are progressing concurrently, validation in the future will be possible after the next phase of each study. The use of severity scores derived from the ADOS-2 as the sole measure of core ASD symptomatology may be problematic. First, even though there is evidence that the Calibrated Severity Scores are less influenced by demographic characteristics and non-specific behavior problems (Gotham et al. 2009; Hus et al. 2014; Hus Bal and Lord 2015; Louwerson et al. 2015), than the raw ADOS-2 scores, it is not fully clear whether the observed differences in severity scores can be entirely accounted for by true differences in symptomatology between the two groups, or whether the scores are partly inflated due to the more significant psychiatric presentation of the hospitalized group at the time of the ADOS-2. Second, due to the small number of items that make up the RRB severity score and brief period of observation, its ability to capture ASD phenotypic heterogeneity may be limited. Finally, the measurement of psychiatric co-morbidities in the present investigation differed in our two samples, and was derived from caregivers' and clinicians' reports in the RI-CART and AIC samples, respectively, rather than from a structured interview. As such, these findings should be interpreted with caution. Nevertheless, our findings speak to fact that extreme maladaptive behaviors that qualify individuals for an inpatient stay may be linked to a presentation that goes beyond ASD alone.

Lastly, there may be a variety of factors not measured in the present study that contribute to greater risk for hospitalization including outpatient psychiatric care, home-based behavioral services, school setting or day programming, and the availability of other individual and family services.

In spite of its limitations, the present findings reveal indicators that may be useful for identifying children and adolescents at greater risk of psychiatric hospitalization as well as offer potential targets for individual and family intervention aimed at reducing the likelihood of requiring acute psychiatric services. Our results underscore the importance of a multi-disciplinary approach to the assessment and treatment of children and adolescents with ASD that addresses behavioral, psychological/psychiatric, adaptive, sleep, and medical functioning in order to decrease behavioral crises and the utilization of



inpatient psychiatric services. Furthermore, our findings highlight the need to consider the child's functioning in the context of family resources and needs during assessment and treatment, and to provide adequate supports for caregivers.

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**Author contribution** GR conceived of the study, participated in its design, performed statistical analysis and drafted the manuscript; JB participated in interpretation of the data, and helped draft the manuscript; CM participated in the interpretation of the data, and helped draft the manuscript, MS participated in study design and coordination, and helped draft the manuscript; SJS participated in conceiving the study, its design and coordination, interpretation of data, and helped to draft the manuscript; EMM participated in conceiving the study, its design and coordination, interpretation of data, and helped to draft the manuscript. All authors read and approved the final manuscript.

#### Compliance with Ethical Standards

**Conflict of interest** The authors declare they have no conflicts of interest.

**Ethical Approval** All procedures performed involving human participants were in accordance with the ethical standards of the institutional research committees where the data was collected and with

the 1964 Helsinki declaration and its later amendments or comparable ethical standards

**Informed Consent** Informed consent was obtained from all individual participants included in this study.

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