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Socioeconomic Status and Pediatric Neurologic Disorders: Current Evidence

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Abstract

Socioeconomic status (SES) is an important risk factor for many neurological disorders and a determinant of health outcomes and quality of life, especially for individuals with neurologic disorders and developmental disabilities. This article focuses on the relationship between SES and pediatric epilepsy, cerebral palsy, autism spectrum disorder, and intellectual disability. Disparities in the prevalence and long-term impact of SES on functioning in persons with disabilities are observed worldwide. Clinicians can use the information presented in the article to target early identification and interventions for improving outcomes in populations most at risk for these disorders and for poor health, social, and economic outcomes.

Introduction

It is an interesting paradox that the more we increase our understanding of the biologic basis for disease and disability, the more we appreciate the contribution of social factors to both the occurrence and quality of life of individuals with neurologic and developmental disorders of childhood. Socioeconomic status (SES) refers to the position of persons or families in society based on a combination of occupation, income and education.[1] SES is a key determinant of health among all ages, but especially among children.[2] Compared to their peers of higher SES, children and adolescents of socioeconomically disadvantaged families are more than twice as likely to experience acute illnesses as well as chronic health conditions such as asthma and obesity,[2] mental disorders,[3] and developmental delay.[4] These associations are no less pronounced for children growing up in low and middle-income countries.[5] The potential associations between SES and the causes of pediatric neurologic disorders are complex, as outlined in Table.

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Here we provide a review of the literature on the relationship between SES and select neurological disorders of childhood, specifically, epilepsy, cerebral palsy (CP), autism spectrum disorder (ASD), and intellectual disability (ID). We describe the prevalence of the disorders by indicators of family SES and the influence of SES on quality of life and other outcomes of children and adults with these conditions.

Methods

Literature Review

An online search of the English-language, peer-reviewed medical literature was conducted in 2017 using MEDLINE and PubMed to examine the relation between SES and specific pediatric neurological disorders. Search terms included socioeconomic status, social class, maternal or paternal education paternal or maternal occupation, family income, or poverty and the outcomes of epilepsy, CP, ASD, ID, mental retardation, or developmental disabilities. Additional selection criteria for studies to review included childhood onset of the disorder (birth to age 18 years), and publication between 1980 and the present. We identified 574 studies based on the electronic search and additional studies through reference tracking of identified studies and personal knowledge of the literature.

We include in this review all studies published since 1980 that provided information on sample size and population characteristics, on data sources and analytic methods, and on both SES and at least one of the 4 pediatric neurological disorders (epilepsy, CP, ASD, and ID). No sample size restrictions were imposed. Articles on treatment or specific causes of developmental disabilities but without information on SES were excluded. In addition, articles reporting on SES characteristics of cases only with no control group or comparison to the general population were also excluded. Among the articles selected for inclusion, 35 focused on epilepsy, 21 on CP, 19 on ASD, and 33 on ID. Study designs included review articles, case-control, cohort and cross-sectional studies, and follow-up studies of clinical samples.

SES and Pediatric Neurologic Disorders: Epilepsy

Epilepsy is the most common neurologic condition affecting all ages.[6] It is a brain disorder characterized by recurrent, unpredictable, and unprovoked interruption of normal brain activity, known as seizures.[7,8] The most recent overall national and state-specific estimates of active cases of epilepsy in the United States (U.S.) are provided from national surveys: the 2015 National Health Interview Survey for adults aged ≥18 years, the 2011–2012 National Survey of Children's Health for children 0–17 years, with data from the 2015 Current Population Survey to describe 2014 income levels.[9] In 2015, 1.2% of the U.S. population was classified as having active epilepsy, that is 3 million adults and 470,000 children.[9] Previous studies have reported that the incidence of new-onset epilepsy is highest in infancy.[6,10,11,12] Epilepsy is a global public health problem, with >80% of the 37 million individuals with epilepsy living in low-income regions of the world where most individuals remain untreated.[13]

SES, prevalence, and risk of epilepsy

There have been inconsistent results from studies examining the association between childhood epilepsy and SES.[12,14–26] In general, however, lower SES has been reported to be associated with increased prevalence or risk of epilepsy [12,14–21,27] and with decreased quality of life (QoL) in individuals with epilepsy.[28–30] In addition, lower educational achievement, higher rates of unemployment and lower income are seen in adults following childhood-onset epilepsy.

In Brazil, a door-to-door survey of all ages found an inverse relationship between the prevalence of epilepsy and SES.[20] In Zambia, individuals of all ages with epilepsy (mean age of 35.5 years) were more likely to be of lower SES, as evidenced by poorer employment status, less education and poorer housing and environment quality, for example, little access to water, less likely to have electricity and greater food insecurity than age-matched controls.[21] A case-control study in Ethiopia found that epilepsy was associated with low level of education, subsistence farming, and poverty as measured by poorer sanitation, more overcrowding, and fewer possessions.[14] Epilepsy was also associated with stunting.[14] Using data from the 2010 National Health Interview Survey, approximately 1% of adults reported having active epilepsy and the prevalence of active epilepsy was almost twice as high in adults with lower incomes.[27]

Other studies have not been as clear about the association between low SES and the incidence or prevalence of epilepsy. A study in southeast England found a strong association between the incidence of epilepsy and socioeconomic deprivation.[15] The authors offered several possible explanations for this association including access to services, differences in other demographic factors, such as ethnicity, and differences in compliance with registries in different areas of the country. They also discussed the effect of familial genetic disorders associated with epilepsy on family income and other related factors that may contribute to lower SES among affected families.[15] In contrast to these findings, a telephone survey of a multiracial and multiethnic community in New York City reported that the highest prevalence of epilepsy was in those with the highest SES, although the numbers were small and the authors described several limitations of the telephone survey methodology.[24]

Whereas these studies of SES and epilepsy have involved individuals of all ages, most have focused on adults, with fewer studies looking specifically at SES factors related to epilepsy of childhood. A study of children aged 5 years and under in a community in Brazil with a high percentage of low SES families found that absence of tap water and poor housing were significantly associated with the prevalence of seizures.[16] A cross-sectional study of children aged 7–17 years in Turkey found that preterm birth and average and low income increased the risk of epilepsy. A history of febrile seizures also increased the risk of a later diagnosis of epilepsy.[17] In Finland, follow-up at age 7 years of a birth cohort of children using data linkage of 6 national health registers found that lower social class (measured by mother's occupation at the time the child was 7 years) was associated with higher risk for more perinatal health problems and more childhood diseases, including epilepsy, and more special education after adjustment for confounders such as mothers' biological and geographical backgrounds.[18] Interestingly, the children of housewives were found to have more health problems than children in general and several possible reasons for this were offered.[18] Using

data from a national survey of children aged 6–17 years, from 2010–2014, children and adolescents with seizures were significantly more likely than those without seizures to live in poverty and low-income families or households (41.6% compared with 28.6%), and were less likely to have mothers or fathers with a bachelor's degree or higher (20.4% compared with 30.6% and 22.4% compared with 34.0%, respectively), or to live in nuclear families or households (30.3% compared with 41.9%). Parents of children with seizures also were more likely than parents of children without seizures to report worrying that food would ran out (34.5% compared with 22.9%) or that food they bought would not last until they had money to get more (30.9% compared with 19.2%).[26] Similarly, another national survey in the U.S. reported epilepsy or seizure disorder was higher in children of lower income families.[31] The survey found that parents reported that their children with epilepsy had more depression (8% vs 2%), anxiety (17% vs 3%), ADHD (23% vs 6%), conduct problems (16% vs 3%), developmental delay (51% vs 3%); ASD (16% vs 1%), and headaches (14% vs 5%). Children with epilepsy were also at greater risk for having unmet medical and mental health needs.[31] An examination of functional difficulties and school limitations of children with epilepsy from the U.S. also noted that children with epilepsy are more likely to live at or below poverty thresholds.[25] In contrast, a cross-sectional study of children from 29 days to 14 years in the UK did not find a social gradient in the incidence of epilepsy in childhood.[19]

In another study, poverty was not found to be associated with the clinical course or long-term outcomes of seizures, but children from poor families were found to have more adverse social outcomes, for example, failure to graduate from high school, unemployment, personal poverty, inadvertent pregnancy, and psychiatric diagnoses.[23] Similarly, a population-based case-control study by Hersdorffer et al[22] in Iceland found that SES is a risk factor for epilepsy in adults but not in children. Several authors of studies of childhood epilepsy point out that most of the studies reporting the inverse association between SES and the incidence or prevalence of epilepsy have been in adults, and posit that this association may not exist in childhood.

Quality of Life (QoU in Children With Epilepsy

A published review of 14 studies found parental education, occupation, marital status, income, and health insurance coverage were associated with QoL in children with chronic conditions, including children with epilepsy.[28] Several measures of QoL were reported from these studies. Children with epilepsy whose parents had a high school equivalency had better QoL than children whose parents had only attained a primary education level. Children with epilepsy whose parents were of lower SES had worse mean QoL scores in the areas of physical functioning, social support, and school behavior.[25] In addition, children with epilepsy whose parents were living together or with other partners had a *higher* overall QoL as compared to children of separated or divorced parents. The authors of the review concluded that SES of parents might be a determinant in QoL for children and adolescents with chronic conditions; specifically, level of educational attainment and household income, 2 of the most often reported indicators of SES, might directly influence QoL.[28]

In a study of children with epilepsy in Iran, researchers used a 92-question parent instrument, the Quality of Life in Childhood Epilepsy, in children 5–17 years and found that

there was an association between parental education and QoL in children with epilepsy.[29] One additional study that analyzed data from the QUALITÉ longitudinal study cohort of children 8–14 years of age with epilepsy in Canada examined extracurricular participation, an influencer of physical and mental well-being, and QoL. The authors selected variables that were hypothesized to be related to participation and were classified according to the International Classification of Functioning, Disability and Health according to body functions, environmental factors, and personal factors. Measures of extracurricular participation were analyzed using regression modeling. The researchers found that not having a 2-parent family was related to a decrease in participation in various extracurricular activities. Other medical factors such as type and severity of seizures were also associated with decreased QoL in children with epilepsy.[30]

Impacts of Epilepsy on Family and Life-Course Socioeconomic Outcomes

Unemployment and low income are consistent findings in studies of individuals with epilepsy.[32–34] U.S. data from 19 states participating in the 2005 Behavioral Risk Factor Surveillance System, an ongoing random-digit-dialed telephone survey of the noninstitutionalized population ≥18 years of age, found that adults with a history of epilepsy and active epilepsy were more likely to experience poor health, be unemployed or be unable to work.[33] Another U.S. multisite study by Fisher[34] reported that the rate of unemployment among individuals with epilepsy was approximately 5 times that of the general population (25% vs approximately 5%). A nationally representative survey in the U.S. from 1998–2009 found only 42% of individuals with epilepsy over 18 were employed compared to 70% of people without epilepsy.[35] This study examined the economic impact of epilepsy and found that productivity due to lost wages in individuals with epilepsy was equal to the combined total wages lost in individuals with diabetes, depression, anxiety, and asthma.

These are rather universal findings. A Dutch follow-up study of individuals with epilepsy, 15 years after diagnosis, found childhood-onset epilepsy was associated with lower educational level and lower income.[36] A cross-sectional study in Kenya using a WHO QoL questionnaire found that the mean QoL was lower for individuals with epilepsy than individuals without.[37] This included lower level of education, higher seizure burden, lower annual income, unemployment, unskilled employment, and living in rural areas.[37] Komolafe et al[38] conducted a cross-sectional survey of women in Nigeria with epilepsy and found women with epilepsy had higher unemployment, fewer years of formal education, lower marriage rates, higher stigma scores, and lower mean personal and household incomes. A cross-sectional study in Spain found patients with epilepsy had employment rates similar to the general population but slightly higher rates of unemployment[39] Unemployment was associated with refractory epilepsy, recent seizure activity (within last 12 months), earlier onset of seizures, level of education, and multiple medications.[39] Holland et al[40] studied employment disadvantage among individuals with epilepsy in the UK and found that individuals with single seizures or “early epilepsy” had lower employment than the general population at the time of study entry and at 2- and 4-year follow up. Yagi[41] in Japan, found, in addition to seizure status, intellectual impairment, psychological and psychiatric disorders and physical disabilities were contributors to employment status.

Beyond the mere presence of epilepsy itself, are there factors associated with worse educational attainment and lower income in individuals with epilepsy? In a study by Berg et al[42] a worse seizure history, poorer medication control, and a history of psychiatric disorders were associated with lower likelihood of college completion, and learning problems were associated with a lower chance of being employed. Long-term employment after childhood-onset epilepsy was studied using a population-based incident cohort in Finland (mean age = 23). Predictors of employment included normal intelligence, onset of epilepsy after 6 years of age, and good vocational education. Employment into middle age was predicted by normal intelligence, having children, uninterrupted remission, and no status epilepticus.[43] A community-based survey in North East England found that patients with epilepsy had an unemployment rate of 46% compared to 19% in those without epilepsy. Closer examination revealed that in individuals with neurological disability, 79% were unemployed; in those with psychiatric disability, 77% were unemployed. Individuals with epilepsy were less likely to leave school with job qualifications or undergo later training. They were more likely to be unskilled laborers and more likely to have difficulty finding work, even in an area of high unemployment.[44]

These studies point to consistent findings of poor educational attainment, which influences employment and income and affects overall QoL for adults with epilepsy. Many studies point to the number and complexity of factors involved and it is recognized that a multifaceted approach that includes individual as well as environmental and community factors will need to be employed to improve these outcomes.

SES and Pediatric Neurologic Disorders: Cerebral Palsy (CP)

CP is a group of lifelong disorders of movement and posture that are attributed to nonprogressive disturbances in the developing brain,[45] and it is the most common cause of childhood physical disability in developed countries.[46] The prevalence of CP among children is often reported to be approximately 2 per 1000, though some studies report prevalence estimates as high as 4–5 per 1000 children.[47–52] Less than 10% of CP cases in population-based studies are attributed to causes occurring after the neonatal period, such as brain infections and trauma.[52,53] The remaining cases are assumed to be due to prenatal or perinatal brain injuries. The leading risk factors for CP include low birth weight or other prenatal or perinatal complications, and between one- and two-thirds of children with CP have a history of such complications. Among most cases not attributed to postneonatal causes, the specific pathophysiology of CP are poorly understood. Clinical classifications of CP are made according to the number and location of limbs affected (eg, quadriplegia, diplegia, and hemiplegia), according to the nature of the motor impairments (eg, spastic, ataxic, and dyskinetic), and according to the levels of mobility or functioning (eg, ambulatory with no assistive devices and requires a wheel chair for mobility).[45] In addition to mobility limitations, motor impairments in CP often result in difficulties with fine motor functioning, feeding and communication. Epilepsy, ID, and other neurologic disorders commonly co-occur with CP.

SES and the Prevalence of CP

The association between SES and the prevalence of CP was examined and summarized in a systematic review published in 2014 by Solaski et al.[46] Eight of the 12 studies reviewed found the prevalence of CP to be inversely associated with indicators of socioeconomic advantage, such as income, occupation and maternal education. The remaining four studies found no significant association between SES and the risk of CP. Among the studies reporting a significant negative association between SES and CP prevalence, 3 found this association to persist after controlling for preterm birth or other risk factors for CP.[46] Overall, the systematic review supported the conclusions that low SES is found to be a risk factor for CP in most studies examining the association, and that the association is not fully explained or mediated by the association between low SES and perinatal complications. After the publication of this review, another large, U.S. population-based study (N = 1570 with CP in a population of 488,027 eight-year-old children) supported these conclusions, reporting a stepwise decrease in CP prevalence among children with increasing SES that persisted after controlling for preterm birth and size for gestational age at birth.[53] This study also found the inverse association between SES and CP risk to be present only among the approximately 80% of CP cases classified as spastic in nature; the frequency of CP cases classified as nonspastic (that is, dyskinetic or ataxic with no spasticity) did not vary by SES.[53] Similarly, a study of CP prevalence in Ireland (N = 258 children with CP in a cohort of 150,189 births) found an association with low SES for hemiplegia and diplegia, but not for other forms of CP.[54] Taken together, published studies of the association between SES and the prevalence of CP largely support the conclusions that socioeconomic advantage as indicated by individual and community indicators of maternal education, parental occupation and household income is protective against the risk of CP, that this protective effect is over and above the effect of SES on preterm birth and other prenatal or perinatal risk factors for CP, and that the elimination of SES disparities in the prevalence of CP will require finding strategies to reduce the risks in low-income communities of both preterm birth and CP among children bom at term and not low birth weight.[46,53]

Evidence of SES Disparities in Functional Outcomes Among Individuals With CP

A large, registry-based, follow-up study of children with CP (N = 483) in the Province of Quebec found low maternal education and neighborhood economic deprivation to be associated with increased motor functional limitations at age 5.[55] After adjusting for other variables, children with CP of mothers who had no high school diploma were nearly 3 times more likely to be nonambulatory (Gross Motor Functional Classification System [GMFCS] levels IV or V) than those of mothers with at least a high school diploma. The investigators found a similar association between maternal education and limitations in manual ability.[55] These finding point to the importance of social determinants of health and disability and suggest that, even in the context of universal healthcare, financial and educational barriers may prevent timely access to the most appropriate therapeutic services for children with CP. It is possible that low SES is both a risk factor for more severe functional limitations in children with CP, and a consequence for families of having a child with nonambulatory CP.

A study of a clinical sample of 49 children with CP in Brazil also found low SES to be associated with higher levels of mobility limitations, and in addition found that among

children with the highest levels of mobility limitations (GMFCS levels IV and V), low SES was associated with greater dependence on caregivers.[56] In contrast, a follow-up study of a clinical sample of 116 Dutch children with CP found litde association between functional outcomes and SES, except for finding lower social functioning scores among children of more educated fathers.[57]

Impacts of CP on Family and Life-Course Socioeconomic Outcomes

A longitudinal, population-based study in Denmark found that, compared to mothers of controls (N = 17,983), mothers of children with CP (N = 3671) were less than half as likely to be employed and had significantly lower incomes.[58] A longitudinal study in The Netherlands found that, relative to the general population of young adults, those with CP and no intellectual disability (N = 74) were significantly less likely to be employed.[59] A follow-up study of 279 young adults with CP in Taiwan found only 23% were employed.[60]

SES and Pediatric Neurologic Disorders: Autism Spectrum Disorder (ASD)

ASD refers to a group of neurodevelopmental disorders with onset by early childhood and involving impairments in social interaction and communication accompanied by restricted interests or repetitive or stereotypical behaviors.[61] In recent decades, following expansion of diagnostic criteria and improved recognition of ASD as a spectrum condition, estimates of the prevalence of autism from around the world increased markedly, from fewer than 5/10,000 (autistic disorder) before the 1990s[62,63] to more than 1% (ASD) in the most recent epidemiologic studies and surveys.[64–69] Although numerous genetic, reproductive and environmental factors that increase the risk for ASD have been identified, the specific causes of ASD are not well understood. The ASD phenotype is extremely variable, and the degree of functional limitations can range from moderately severe to profound. Approximately, 30% of children with ASD are nonverbal[70] and between one and two-thirds have co-occurring ID.[64]

SES and the Prevalence of ASD

Although the prevalence of many of the common pediatric neurological conditions is found to decline with increasing SES, evidence of an association between ASD and SES is less consistent. Early clinical descriptions and epidemiologic studies of autism suggested that it was a disorder seen primarily among children of highly educated and accomplished parents.[63,71,72] The notion that autism is more prevalent among high SES families was disputed in 1980 by British psychiatrist and epidemiologist Loma Wing, who argued that the actual frequency of autism is unlikely to vary by SES, that studies based on data for children receiving clinical diagnoses and services for autism were affected by biased case ascertainment, and that even in the UK, where access to health and educational services was universal, relatively high levels of parental education and resources were necessary to ensure that a child with autism was able to get an accurate diagnosis.[72] Support for this idea is provided by recent epidemiologic studies from countries with universal access and no economic barriers to obtaining autism diagnoses and services that found no excess prevalence of ASD among children of high SES,[73,74] and from countries where autism services are expensive and not universally available that found ASD prevalence (based on health and school records) to increase with increasing SES.[75–80] Studies that examined the

association between ASD and SES separately for children with and without co-occurring ID have found that the positive ASD-SES prevalence gradient is present only for children with ASD and no co-occurring ID. The lack of an association between ASD and SES in those with co-occurring ID might result from counter associations, since the prevalence of ID is consistently found to be elevated among children of low SES, or be due to children with co-occurring ASD and ID being more likely than those with ASD alone to be referred and evaluated early for developmental disorders including ASD and thus less subject to ascertainment bias.[79,80] If the positive ASD-SES gradient found in some studies and settings is the result of services being preferentially accessed by economically advantaged children with ASD, there may be a need to consider policies and resources to ensure that ASD services are accessible and distributed equitably.

SES Disparities in Age at Identification, Intervention, and Outcomes of ASD

Few studies have examined the impact of SES on the identification or outcomes of ASD. A study based on administrative data of children with autism receiving disability services in California (N = 17,185) found that children of highly educated parents received diagnoses and became eligible for services at an earlier age than those of parents with less education.[81] A cohort study of children with ASD (N = 48) in Italy found that those belonging to lower SES families began treatment almost 1-year later and received fewer hours of treatment than those from middle and upper SES families.[82] In addition, a follow-up study of children diagnosed with ASD (N = 80) in India found that higher maternal education was associated with better adaptive behavior scores at follow up of children diagnosed with autism.[83]

Impacts of ASD on Family and Life-Course Socioeconomic Outcomes

Several studies have documented adverse economic and employment effects of ASD over time. One study based on a nationally representative survey of 11,684 U.S. schoolchildren estimated that having a child with ASD (N = 131) resulted in an average 14% loss in household income compared to what would be expected based on parental education and other demographic characteristics.[84] Another study, based on a national longitudinal survey of U.S. households found that parents of children with ASD (N = 261) were more likely than other parents to reduce their work hours and that, controlling for other demographic factors, the average annual earnings of families of children with ASD were 21% lower than families of children with other disabilities and 28% lower than families of children with no health limitations.[85] When combined with the excess healthcare expenses families bear for children with ASD, the effects of ASD on parental work and earning are magnified.[85,86]

Follow-up studies of high school graduates of special education programs in the U.S. found that, compared to other disability categories, young adults who had been served under the autism special education category (N = 620 in one study and 500 in another) were less likely be employed, earned lower wages, and were less likely to attend college.[87,88] These studies also found that higher household income during high school predicted better employment and educational outcomes of young adults with ASD, suggesting that economic disparities could be reinforced and increase over generations.[87,88]

SES and Pediatric Neurologic Disorders: Intellectual Disability (ID)

ID is characterized by significant intellectual deficits identifiable in infancy or childhood, and typically defined by IQ test results more than two standard deviations below the mean (approximately IQ < 70) accompanied by significant deficits in adaptive behavior and functioning.[89] Two approaches to classifying ID are by level of severity and by cause. Historically, the severity of ID was classified into levels exclusively based on IQ, with mild ID (formerly referred to as mild mental retardation) defined as IQ of approximately 50–70, and severe ID (formerly severe mental retardation) as IQ < 50. Current classifications of severity emphasize functional skills and intensity of support needed for daily living. For example, the current American Association on Intellectual and Developmental Disabilities (AAIDD) classification system includes four levels of severity or intensity of support needed, ranging from mild (intermittent support needed during transitions) to profound (pervasive support needed for every aspect of daily routines).[89] Severe ID is typically a lifelong condition, whereas mild ID is often recognized as a disability only during school-age years.

The known causes of ID are numerous and include chromosomal anomalies (of which Down syndrome is the most common), x-linked single-gene disorders (of which Fragile X syndrome is the most common), many other known specific genetic disorders, and damage to the developing brain resulting from specific nutritional deficiencies, brain infections, exposure to neurotoxins, trauma, and perinatal complications (Table). For some of the known causes of ID, such as phenylketonuria and congenital hypothyroidism, secondary prevention of ID can be achieved through early detection and treatment. For others, such as vaccine-preventable brain infections and prenatal iodine deficiency, primary prevention is possible.

In high-income countries, the population prevalence of severe ID in childhood is typically found to be in the range of 3–5 per 1000 children, while a much higher prevalence (2%-3%) has been reported from some low-income countries.[90] The prevalence of mild ID is much more variable and has been reported to be as low as 2–3/1000 children in Sweden and Japan and as high as 8% in low-income U.S. populations.[91–93]

SES and the Prevalence of ID

Poverty and socioeconomic deprivation contribute to the causation of ID inasmuch as they increase the risk of many of the known causes of ID. Virtually all epidemiologic studies that have examined the association between SES and the prevalence of ID report an inverse association (highest prevalence of ID among low SES children) and those that have examined SES effects separately for mild and severe ID generally show the association between low SES and mild ID to stronger than that between low SES and severe ID.[90,94–105] One exception is a large, cross-sectional, population-based study in Pakistan that found a 3-fold increase in both mild and severe ID prevalence among children in the lowest relative to the highest SES group.[106] Cases of mild ID that are not attributed to specific known causes or accompanied by other neurologic impairments may be due to insufficient exposure to early cognitive and social-emotional stimulation. Early intervention programs featuring cognitive stimulation and targeting children from low-income families were designed in

large part for the prevention of mild ID.[107,108] Studies have shown that children with severe ID are more likely than those with mild ID to have co-occurring neurological disorders, and that isolated ID (without other neurological impairments), like mild ID overall, is most common among children of low SES.[109,110] Recent studies of the genetics and birth prevalence of Down syndrome, the most common diagnosed genetic cause of ID, have brought to light 2 important SES effects. One is a consistent finding that low SES is associated with one form of Down syndrome, that resulting from chromosomal nondisjunction errors occurring during maternal meiosis phase II, but not with other forms of Down syndrome.[111] This finding points to the potential role of exposures associated with low maternal SES, such as toxic exposures or stress, in the etiology of Down syndrome.[112] An additional SES disparity in the birth prevalence of Down syndrome has been demonstrated in the U.S. and U.K to arise due to lower rates in economically deprived communities of both antenatal screening for chromosomal anomalies and termination of pregnancy when Down syndrome is detected.[112,113] The net result is a higher prevalence of Down syndrome in economically deprived communities.[112,113]

Evidence of SES Disparities in Functional and Health Outcomes Among Individuals With ID

Few studies have examined the effect of SES on developmental or health outcomes of children with ID. A follow-up study of 538 South African children diagonosed with ID found that low SES children with mild ID were less likely than others to receive referrals for services.[114] A cross-sectional study in Thailand ($N = 100$) and a longitudinal study in Jerusalem ($N = 40$), both of children with Down syndrome, found increasing levels of family income and maternal education to be positively associated with mental development scores in early childhood.[115,116] A study of health outcomes in a nationally representative sample of 12,160 British children found that low SES accounted for 31% of the excess risk of poor health among children with ID.[117]

Impacts of ID on Family and Life-Course Socioeconomic Outcomes

A number of longitudinal studies in diverse settings have shown profound, adverse economic effects of ID on families and individuals. Specifically, mothers of children with ID, on average, are found to experience significantly reduced employment and lifetime earnings relative to their peers.[118,119] In addition, despite policies to increase inclusion of persons with disabilities in work settings, longitudinal studies have found that only between 3% and 12% of adults with ID experience paid employment and that the living circumstances and social conditions of adults with ID are often poor.[120–124]

Conclusion

We found that a literature review of published studies of SES and epilepsy, CP, ASD, and ID revealed complex and important relationships between SES and these neurologic conditions. The prevalence of ID, CP, and epilepsy is with considerable consistency found to be higher in children of lower SES families. Both the consistency of this association and the steepness of the inverse SES gradient in prevalence are greatest for ID. In contrast, findings related to ASD do not follow this same pattern and suggest there may be SES disparities in the age of

identification, access to care, preferential diagnostic labeling, language and cultural barriers to assessment, and other potential factors that lead to under-identification of ASD in low SES children. Clinicians can help eliminate barriers for families of low SES by facilitating early identification of these and other neurologic and developmental disorders and promoting prompt referral of all families, but especially those with less education and fewer financial resources. The financial impacts of pediatric neurologic disorders on families point to the need for resources and supports so that families can avoid poverty and provide optimal care for children with neurologic disorders. In addition, diagnostic assessment can sometimes reveal underlying conditions that are causative or associated with these conditions that warrant treatment and specific interventions that can improve the quality of life for affected children and adults.

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Table

Summary of Causes and Examples of Pediatric Neurologic Disorders and Their Associations With Socioeconomic Status (SES)

Categories of Causes	Examples	Potential or Known SES Associations With the Occurrence or Developmental Outcomes of the Condition
Genetic anomalies Chromosomal Single gene	 Down syndrome Fragile X syndrome	Notable associations with SES. Access to prenatal screening and pregnancy termination is differential by SES in some populations, leading to SES disparities in occurrence. Access to early interventions and treatments may be differential by SES, leading to SES disparities in developmental and functional outcomes.
Nutritional deficiencies Prenatal Childhood	 Iodine deficiency disorder Iron deficiency	Globally, most prevalent in low-income populations without access to fortified foods or supplements. Children of lower SES have a higher prevalence of iron deficiency in infancy, which has been shown to have long-term effects on intellectual functioning. Access to early child development services, special education and healthcare may be limited in populations at greatest risk for nutritional deficiencies, leading to increased SES disparities in developmental outcomes.
Infections Prenatal/perinatal Postnatal/childhood	 Congenital viral infections (eg, rubella and Zika) Haemophilus influenza type b (Hib) meningitis	Potentially most frequent in low-income populations due to lack of access to vaccines and other protective measures. Access to early child development services and healthcare may be limited in populations at greatest risk for congenital infections affecting the nervous system, leading to increased SES disparities in adverse developmental outcomes.
Toxic exposures Prenatal Childhood	 Fetal alcohol spectrum disorder (FASD) Lead poisoning	Low-income communities are at increased risk of lead exposure in water, air, dust and products. The SES of mothers of children with FASD is consistently lower than controls. The concept of “weathering” (cumulative effects of poor living conditions, poor nutrition, discrimination and high levels of stress) is believed to contribute to higher rates of FASD among women of lower SES. Access to early child development services and healthcare may be limited in populations at greatest risk for neurotoxic exposures, leading to increased SES disparities in adverse developmental outcomes.
Perinatal complications White matter damage associated with very preterm birth	 Cerebral palsy (CP), epilepsy, and intellectual disability (ID)	The risks of preterm birth and low birth weight are strongly associated with poverty and socioeconomic disadvantage. At the same time, survival of infants with brain injuries associated with very preterm birth may be associated with economic advantage.
Injury Traumatic brain injury Near drowning	 Postnatal onset CP, ID	Increased risk among infants and children in poverty due to increased exposure to hazardous environments and childcare practices, and lack of access to or use of protective equipment. Access to early child development services and healthcare may be limited in populations at greatest risk for neurotrauma, leading to increased SES disparities in adverse developmental outcomes.
Unknown and multifactoral	Most cases of ID, CP, epilepsy, and autism	Strong and consistent association between low SES and mild ID. Severe ID, CP, and epilepsy are generally but not consistently found to be moderately associated with low SES. No consistent association between autism and SES. In countries with universal access to autism diagnostic and treatment services, the association between SES and autism prevalence has been found to be weakly negative or nil. In countries lacking universal access to autism services, autism prevalence has been found to increase with increasing SES.

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