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A thesis submitted to the Faculty of the
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Abstract

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Objective

Despite autism spectrum disorder (ASD) being detected globally, many low- and middle-income countries (LMIC) do not have information about domestic ASD prevalence, hindering efforts to build efficient detection and assistance infrastructure. Many LMICs have completed UNICEF's Multiple Indicator Cluster Survey v6 (MICS6), containing an Under 5 questionnaire (U5) with questions about young children's development like those present in ASD screeners. The MICS6 may be utilized to create a population-based screener similar to a level-1 ASD screener focused on early social, communication, and behavioral development. The objectives of this study are to, using this tool, describe prevalence of potential social developmental delay associated with ASD, identify which characteristics of interest associated with ASD may be acting as predictors, and define any associations additional socio-economic variables may have with potential social developmental delay.

Methods

Analyses were performed on data from 1723 4-year-old respondents to the U5 of the Honduras 2019 MICS6, with consideration for complex survey design. A 10-point measure (Social developmental delay proxy score (SDDPS)) was created, with a cut-off set at ≥ 3. Descriptive analyses described the distribution of the SDDPS while linear and Poisson regressions described the association between three characteristics associated with ASD (early education attendance, sex, and urbanicity) and the SDDPS. Socio-demographic variables included in the analyses were age in months, sex, urbanicity, caretaker's education level, translator usage, mother's age, number of siblings, stunting, and wealth.

Results

A nationally representative 4.6% of 4-year-old children scored above the cut-off. Of the three associated characteristics, only urbanicity predicted on average a 0.13-point lower score on the SDDPS ($p=0.017$) compared to rurality. Among the additional socio-demographic variables, on average higher parental education was associated with a 0.14-point lower score ($p=0.049$) and children with one more sibling were 16% more likely to score above the cut-off compared to those with one fewer sibling ($p=0.027$).

Conclusions

The SDDPS found a prevalence within the expected range and defined several associations similar to those observed with ASD. While promising for its utility for detecting social developmental delay potentially indicative of developmental delays and differences associated with ASD among young children, further validation is necessary.

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Introduction

Since first described, the presentation of autism has been expanded to a complex spectrum disorder referred to as autism spectrum disorder (ASD). Accordingly, there has been a significant rise in prevalence, particularly in recent decades. Each new estimate released by the CDC has displayed higher rates and global estimates of ASD have more than doubled (1–4). This has led to an increase in interest and attention from both the public and researchers and great strides have been made in both early detection and intervention as evidence indicates early supportive intervention can greatly improve long-term developmental outcomes (5,6). Unfortunately, most of this research and application is confined to high-income countries; although, ASD being known to exist in every country in the world with a recent study estimating a global prevalence of 1/100 (7). Currently, many low- and middle-income countries (LMICs) lack any formal means for detecting and measuring ASD or other social developmental delays. This may hinder public planning for detection and response as ASD rates can vary considerably between states and regions, let alone countries.

Diagnosis of ASD is a high-skill, time intensive process, but screening for young children showing warning signs for potential ASD, particularly in the realm of social development, can and has been done quickly, cheaply, and with high validity (8,9). Unfortunately, when measuring child functioning and development, the social development domain may go unmeasured. This means that planning and implementing any intervention for these children can be difficult. However, there are large, representative, national surveys administered in many LMICs which gather important data that may help to fill in some of these gaps. One such survey is UNICEF's Multiple Indicator Cluster Survey version 6 (MICS6) which includes components in the questionnaire focused on children under age 5 (U5) that ask about child functioning and early childhood development. Some questions from these sections may be sufficiently similar to existing screening tools that they could function as a population-based screener for social developmental delay. While not diagnostic for disability nor specific to ASD, a measure of potential social developmental delay as a proxy for ASD administered to representative sections of the population could be used by the many countries who have successfully completed the MICS6 survey but don't currently have the means to detect ASD to gain a more accurate estimate.

Gaining a better understanding of the prevalence of potential social delay within their borders is of great public health significance to many countries because it could serve as guidance for programmatic and logistical planning for identification and intervention for these children. Furthermore, identification at an early age is key, as intervention for ASD and social delay has been shown to be most effective in the first few years of life (5,6,10,11). Therefore, any action taken based on this information would be well-served to have information about early education attendance of the children identified as having social developmental delays. Knowing early education attendance, may have implications for the planning of intervention for the children, along with other key characteristics like sex and urbanicity.

The goal of this study is to determine 1) if data collected in the MICS6 on early childhood developmental social behaviors can serve as an indicator of potential social and behavioral flags associated with autism spectrum disorder, and 2) describe the relationship between potential social developmental delay and characteristics of interest including early education attendance, sex, and urbanicity in a lower middle-income country.

Literature Review

Over the past century, much of our concept of human development has changed. A plethora of new disabilities, illnesses, and conditions have been recognized and evolved, changing how we understand ourselves and those around us. New definitions and understandings are being challenged every day, evidenced in part by the updates made to each new edition of the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders (DSM). Autism spectrum disorder (ASD), a complex developmental disability sometimes simply referred to as autism, is of particular note. Diagnosed with increasing frequency over the last few decades, our definition of ASD has expanded from a narrowly defined developmental disability into a broad spectrum encompassing a variety of conditions. In fact, in 2013, the DSM-5 expanded the definition of Autistic Disorder into Autism Spectrum Disorder, redefining a variety of different disorders under a single spectrum of conditions, resulting in the spectrum we have today (12).

Currently, ASD is characterized by a combination of both a delay and difference in social communication and interaction as well as the presence of restrictive repetitive behaviors (RRB). While both of these elements, as defined during an intensive evaluation by a trained professional, are required for diagnosis, population-level screening for ASD is often accomplished to great effect by the detection of delays in social development alone (13,14). Often overlooked when considering the healthy development of a child, social development refers to the evolution of a child's social competence, or the development of their ability to integrate cognitive, affective, and behavioral states to achieve goals in an interpersonal context (11). This is often evaluated within the context of a child reaching social, emotional, and communication milestones over their first few years of life. While social developmental delay may be observed on its own, it is frequently observed as a symptom of a broader neurodevelopmental disorder like attention deficit hyperactivity disorder (ADHD) or autism spectrum disorder (ASD), and is therefore commonly utilized as a marker for potential developmental disability in these areas (13,15).

Autism Spectrum Disorder

ASD is a complicated spread of conditions, and as a result, providing a simple definition can be challenging. The CDC briefly defines autism spectrum disorder as a "developmental disability caused by differences in the brain"(3). The American Psychiatric Association further states that "autism spectrum disorder (ASD) comprises a group of neurodevelopmental conditions characterized by the presence of stereotypical, restricted behaviors, and impaired communication and social interaction skills" (14). More specifically, the DSM-5's diagnostic criteria require a person to exhibit "Persistent deficits in social communication and social interaction across multiple contexts" as well as at least two examples of "restricted, repetitive patterns of behavior, interests, or activities…currently or by history" (17). It is required that these symptoms, even if not recognized at the time, are present in early childhood, significantly impair the individual's ability to function in daily life, and are not better explained by some other disorder or disability (17). This two-factor definition of ASD includes both restricted, repetitive behaviors (RRB) and the presence of social developmental delay for diagnosis, but the presence of social developmental delay has reliably been used alone when screening for autism (13,18,19). ASD also frequently, but not always, manifests concurrently with such disabilities as Attention-Deficit/ Hyperactivity Disorder, Obsessive-Compulsive Disorder, seizure disorders, and intellectual disabilities (17,20). Finally, ASD can present in a wide range of severities, from highly functioning adults that require little or no support, to individuals with disabilities so severe they require assistance with even the most fundamental of tasks (20,21). Clearly, these diagnostic criteria are wide-reaching and can describe a large variety of individuals with a plethora of conditions. This is by design and well-reflects our evolving understanding of ASD.

Prevalence of Autism Spectrum Disorder

Autism was first identified in 1943 by Dr. Leo Kanner and then described formally in terms we would recognize today in 1964 by Dr. Bernard Rimland (22,23). Children with autism-like symptoms had been described for the past few decades, but Dr. Rimland's book began the era of understanding of autism as a neurodevelopmental disability (24). Since then, many studies have attempted to describe autism prevalence both in the US and globally and have seen prevalence estimates steadily rise. Naturally, as our understanding of autism spectrum disorder has expanded along with the spectrum of symptoms encompassed by the definition, so too has the number of diagnoses. This goes hand-in-hand with the improvement of detection and diagnostic capacity and tools which likely accounts, at least in part, for the increasing wave of autism diagnoses that communities around the world have seen.

Prevalence of Autism Spectrum Disorder in the United States

In the United States, autism was little known even a few decades ago. The groundbreaking report in 2003 described the US's first major efforts to quantify the prevalence of autistic disorder. Previous prevalence studies had been undertaken, but Yeargin-Allsopp et. al.'s MMWR publication described the US's first large-scale, in-depth study of autism prevalence in a major metropolitan area. Their study found an unprecedented autism rate higher than any previous study, at 34 cases per 10,000 children (1). Since then, interest in autism has increased and the CDC's capacity to detect, diagnose, and report autism prevalence has expanded to include the Autism and Developmental Disabilities Monitoring (ADDM) Network. This network operates in 11 states and major metropolitan areas to obtain in-depth data on the population generalizable to the rest of the country. The most recent reports in 2021 described the highest rates of autism prevalence to date, describing the analysis of the 2018 data in 8-year-olds and 4-year-olds. Among 8-year-olds, an age at which it is anticipated that most children with ASD would have been detected and diagnosed, prevalence was found to be 230 diagnosed children in 10,000, or 1 in 44 (2). Among 4-year-olds, detection was not yet so extensive, but a prevalence of 170 diagnosed children per 10,000 was found, or an increase to 1 in 14 from 1 in 9 in the 2014 data (3).

There are many theories as to why this trend of increasing prevalence has been detected, including the expanding definition of ASD and improving detection tools and networks. Importantly, these increasing numbers are reflective of the US's extensive resources to detect, diagnose, and report data within the country's population. It is well known that autism has been detected around the world, but many countries do not have the same resources and infrastructure to collect data on their own populations. This has made estimating global autism prevalence challenging.

Global Prevalence of Autism Spectrum Disorder

There have been many attempts since the 1980s to describe autism prevalence rates globally. This has been made extremely challenging by the majority of countries not having official prevalence rates. This problem persists to this day, largely due to the difficulties of detection and diagnosis that will be described later. Despite this, many estimates have been made from the existing data and a similar increasing trend has been described. One of the earliest studies in 1993 was able to include only 16 estimates from 9 countries, all of whom were high-income. They found rates of diagnosed autism under different accepted measures ranging from 3.3 diagnosed children per 10,000 to 16.0 diagnosed children per 10,000 (4).

In line with the trend observed in the United States, a following study in 2012 found an average rate of autism of 62 diagnosed children per 10,000 (25). This study was able to include 36 estimates from 24 countries. These estimates were still largely from high-income countries, but a few middle-income countries had relevant reports that were able to be included. Most recently, a large study including 99 estimates from 71 studies encompassing 34 countries (7). As with previous studies, Zeidan et al. found a wide range of prevalence estimates, and an average global autism prevalence estimate of 100 diagnosed children in 10,000. The majority of these estimates were still from high-income countries, but the team was able to include a larger number of low- and middle-income countries in their analysis.

In all, just as in the United States, global autism prevalence estimates have crept steadily upward over the last few decades. However, unlike in the United States, estimating global autism prevalence is hampered by the dearth of data from most of the countries from which data is sought. This is due largely to the fact that many countries simply do not have the infrastructure to conduct internal surveillance, especially for a condition so complicated to detect as autism spectrum disorder.

Autism Spectrum Disorder in Honduras

One of the many countries with no official autism prevalence estimate is Honduras. As one of the lowest-income countries in the western hemisphere, second in Latin America and the Caribbean, Honduras has faced many challenges in building both their education and healthcare systems (26). Hurricane Mitch in 1998 destroyed an estimated 25% of all schools, a blow from which the country is still struggling to recover (27). More recently, two Hurricanes and the COVID-19 pandemic in 2020 stalled the consistent economic growth that Honduras had been experiencing over the last decade, greatly impacting progress toward more stable and equitable infrastructure (28). To date, no literature has been published on autism rates in Honduras. Some research exists about attitudes toward and educational opportunities for children with disabilities, but these studies are more general in nature and do not include official national prevalence rates (27,29). The lack of information in this area can be attributed to many causes and is certainly not aided by the difficulty inherent in detecting and diagnosing autism, which will be described in further detail in the next section.

Diagnosing and Detecting Autism Spectrum Disorder

Diagnosing Autism Spectrum Disorder

Diagnosis of autism is a complicated process. It can be completed by a professional with adequate training, usually by a psychologist, psychiatrist, or pediatrician. As expected with the evolving understanding of autism spectrum disorder, there are many different tools that a professional may use. A recent systematic review identified 41 separate instruments that a professional may choose from, all with different strengths (30). Most commonly used in the US are the Autism Diagnosis Observation Schedule (ADOS) and the Screening Tool for Autism in Toddlers and Young Children (STAT) (20). Both tools, like many others, involve a combination of an interview with the child and their caretaker as well as an extensive diagnostic checklist. These are both heavily researched and allow for diagnosis in children as young as 12 months but require extensive training of the interviewing professional, take over an hour to administer, and are expensive to use (8). No matter which tool is used, however, they all focus on the two major domains common to autism: social and communication and interaction impairment and restricted and repetitive behaviors.

Screening and Detection of Autism Spectrum Disorder

With the complicated nature and high time, training, and resource requirements of diagnosis, as well as the increasing interest in detection of autism spectrum disorder, it follows that there are many useful screening tools to help quickly and easily identify which children may benefit from further evaluation. There is an ever-expanding and evolving repertoire of level 1 and level 2 screening tools that professionals of many levels may utilize to help identify at-risk children (9). These screening tools, particularly level 1, are excellent time and cost saving tools for children with autism because, even though they tend to also detect many children with similar developmental and social concerns beyond just those with ASD, they help to identify a much smaller set of children to receive a more expensive, in-depth evaluation (9). Streamlining the early detection process by implementing faster, cheaper, and more wide-spread screening tools is key to implementing effective intervention for children with ASD in any setting, as known interventions are most effective in the first five year of life (31).

The available screening tools range in efficacy, length, training requirements, and transferability to non-western cultures, as well as in cost for usage (8,9). Recent studies have found that even with the few screening and detection tools that have been shown to have efficacy in a non-western setting, the costs of utilizing the tools is four times the annual healthcare costs for most children (32). Unsurprisingly, there has been much effort made to identify faster, easier, more cost-effective options for level 1 screening to identify at-risk children. One is the development of open-source screening tools or adaption of existing methods (32). Others have been working to abbreviate existing screening tools that are already in use (33,34). Promisingly, some common measures have been shown to maintain acceptable levels of sensitivity and specificity in practice when shortened to only 6 or 7 questions (33). Interestingly, these tools maintained efficacy for detection when abbreviated to only contain questions focused on social and communication concerns, rather than the entire range of ASD symptoms (33). This has promising implications for the development of new screening techniques that may be administered to children around the world.

Currently, routine screening exists in many parts of the world, primarily in HICs (8). There, many physicians, teachers, and other professionals administer screening tools to the children they encounter at regular intervals. For instance, the M-CHAT screening has been integrated into the well-child exam schedule and is given to parents to fill out at their child's 18-month and 2-year check-ups in many parts of the United States. Unfortunately, screening can be imperfect and not every child encounters routine screening. Additionally, even with routine screening in place, since ASD symptoms can be so diverse and difficult to detect in young children, it is often necessary for a caregiver or physician to already have suspicion of autism or some other developmental disability or delay in order for a child to be identified for further diagnosis (20). The many tools currently available for use vary widely in their supporting evidence, validity, and requirements, but the Modified Checklist for Autism in Toddlers (M-CHAT), Communication and Symbolic Behavior Scales (CSBS), and Brief Observation of Social Communication Change (BOSCC) are all solid evidence-based tools that are used widely in the US and UK (20,30). The Social Responsiveness Scale (SRS), however, has comparable supporting evidence and has shown promise for utilization in multiple cultural settings.

The SRS is a screening tool originally designed to supplement autism diagnosis by gauging severity of symptoms and has since evolved into an especially effective screening tool that can be easily administered by parents, teachers, or healthcare workers in 20 minutes or less (35). It consists of 65 questions split into two major categories designed to measure social responsiveness and restricted repetitive movements (36). It has been expanded and updated from its original format to include a module for preschool children as young as 3 years old (37). This screening has been validated across many populations in very different parts of the world and has shown great efficacy in identifying children with possible autism (35,38–40). It has also been shown to have validity when shortened and modified to measure social responsiveness and autism-associated symptoms in special populations (34,41,42). The success of the screening tool has great implications for simple, easily transferrable methods that could be designed and implemented in many countries and populations where ASD and social development are still largely unmeasured.

Common Symptoms of Autism Spectrum Disorder

As stated, definition of autism spectrum disorder is very broad which reflects the multitude of symptoms that may be observed and considered when detecting and diagnosing ASD. The variety of tools available for this purpose categorize and define these symptoms in different ways. The DSM-5 requires difficulties, either at the time of diagnosis or previously, in each of the social communication domains, and in at least two of the four domains of restricted, repetitive patterns of behavior (RRB) (14). The following sections broadly and non-exhaustively detail common symptoms of autism spectrum disorder within the context of these domains, particularly those symptoms to do with social development, as social competence is a core feature of ASD and is the strongest factor in distinguishing ASD from other neurodevelopmental disorders (17). The first three categories detail impairments in communication and social interaction, which tend to manifest as difficulties in verbal and nonverbal communication and the use of language in reciprocal social communication (14).

Social-Emotional Reciprocity

A deficit in social-emotional reciprocity is defined as “abnormal social approach and failure of normal back-and-forth conversation; or reduced sharing of interests, emotions, or affect” (14). This could manifest as difficulty understanding or being understood by a caretaker or other children or as difficulty or delay in learning to communicate. Additionally, adults may experience difficulty in understanding social cues and contexts and a lack of mirroring behaviors or expressions may be observed in young children (14).

Non-Verbal Communicative Behaviors

A deficit in non-verbal communicative behaviors is defined as “poorly integrated verbal and non-verbal communication, abnormalities in eye contact and body language, or deficits in understanding and use of gestures” (14). This may include gestures, facial expressions, body language, or gaze that does not match the situation or context. This may manifest in many different ways, but a hallmark is its impediment on social communication (14).

Developing, Maintaining, and Understanding Relationships

A deficit in developing, maintaining, and understanding relationships is defined as “difficulties adjusting behavior to suit various social contexts; or difficulties in sharing imaginative play or making friends” (14). This may manifest as a difficulty in forming friendships, learning, or playing compared to other children. A child may seem aggressive or disruptive, hitting or throwing tantrums when upset and not having other ways of communicating their feelings, and may find it difficult to engage in imaginative play or understand the social demands of different contexts.

Restricted, Repetitive Patterns of Behavior, Interests, or Activities

The final category to be considered represents the second category necessary for an autism spectrum disorder, beyond social and communication impairments. These restricted, repetitive patterns of behavior (RRB) could include repetitive motor movements, use of objects, or speech, insistence on sameness, or inflexible adherence to routines or ritualized behaviors, highly restricted, fixated interests that are abnormal in intensity or focus, and hyper- or hypo-reactivity or interest in sensory input from the environment (14). This could coincide with a child having difficulty paying attention to subjects outside of their interest or playing a game or with toys in the expected manner.

Barriers to Detection and Diagnosis of Autism

Autism and similar social developmental delays and disabilities can be difficult to detect and measure, leading to the dearth of information detailed in previous sections. This has to do with many factors, including the complexity of detection and the diagnosis itself. As noted, there are many tools available for detection and diagnosis, but in many parts of the world the tools and the training to utilize them may not be available. Additionally, many LMICs are facing a severe shortage of pediatricians, psychologists, and other professionals, as well as a lack of supportive infrastructure that would allow a child and their family to seek out evaluation or supportive services (7). In the United States, like in many high-income countries (HICs), the education system is developed and regulated enough that it often is able to serve as a source of detection and intervention for many children with ASD or other developmental disabilities and delays (3,43,44). This allows schools and teachers to act as an adjunct and support for the larger system. Unfortunately, as with the healthcare system, many LMICs are lacking the staffing and infrastructure to allow their education to reliably function in this way (45). This disparity between the systems available in HICs where the vast majority of ASD and developmental disability research is conducted and the realities of LMICs poses some difficulties when considering common barriers and covariates. Despite this, there are a few variables that are commonly considered when collecting and analyzing data related to autism and developmental delay in most settings.

Education of the parent or caretaker

Education of the parent or caretaker commonly has an impact on the detection and potential diagnosis of a child with autism. In the United States, many studies have found that children with autism whose caretakers have lower levels of education are, on average, detected later in life and less often (43). This is likely due to a combination of factors, like parents being more aware of autism and its characteristics but is also largely intertwined with socio-economic status. Additionally, those parents with higher education tended to be able to seek out detection and diagnosis services from a healthcare-based source rather than an education-based source, which tends to lead to an early diagnosis and access to services (46). This is a factor that has been frequently considered in studies investigating early childhood development in low- and middle-income countries (LMICs) as well (47–51). While maternal or parental education is not always found to vary significantly with measures of early childhood development in these studies, it is well understood as a potential predictor and common protective factor against early childhood developmental delays.

Income or Socioeconomic Status

The income or socio-economic status (SES) of a family frequently has an impact on if and when a child with autism may be detected in high-income countries. This has been reported in multiple studies from different parts of the United States and is considered a well-known barrier (43,46,52,53). Common explanations for income's influence on autism detection include its relationship to parental education, as well as the stability and flexibility (access to transportation, ability to leave work, etc.) afforded to more affluent families. A higher income family is more likely to have a physician that the child regularly attends and is therefore more able to have discussions about development and be exposed to routine screenings at these visits (53). This also means that higher-income families are more likely to be able to access health-based diagnostic and support services which is associated with earlier and more sensitive detection, frequently resulting in a higher level of autism detection in high-income groups (46). Naturally, this also means that higher-income families are more likely to be able to access specialized supportive services, which may be able to more easily detect less severe presentations as well as improve outcomes through treatment (53).

When attempting to measure any childhood developmental outcome in LMICs, including ASD, the income or SES of the family is naturally also a consideration. Most common measures of income utilized are wealth indices or percentiles either relative to an internationally recognized poverty level (e.g. WHO) or to intra-country levels of wealth (47,49). The measure of a family's wealth in LMICs, as in high-income countries (HICs), is generally expected to be a protective factor if a significant association is found. This is likely a measure of a family's access to resources, both to provide for the child's development (e.g., nutrition, books, etc.), and to seek treatment and support should any concerns arise.

Geography

The geography of where a child is living is also a major barrier to equitable detection and diagnosis. The physical location of the family can influence whether a child is more likely to be seen by a physician or wait until they come into contact with the educational system for evaluation, the latter of which is associated with later and less-sensitive detection (46). In studies within LMICs, geography frequently manifests as a measure of urbanicity. In countries like Venezuela, Costa Rica, or Honduras, resources available to families vary widely between urban regions within or near to cities, and more rural areas which may have little to no formal health or education facilities within easy access (54–56). Naturally, this factor is frequently considered when attempting to measure developmental disabilities in LMCIs, as delays in identification and access to services are well known to have significant impacts on a child's outcomes (57,58).

Race and Ethnicity

In the United States, race is a major factor in autism detection and diagnosis. Although the gap is decreasing, black children are more likely to be detected later and black children with more severe symptoms and co-occurring intellectual disability are overrepresented compared to white children (43,52). This is due to a lack of sensitivity in screening and indicates that more black children with less severe presentation of autism spectrum disorder are going undetected. Even more so than black children, Hispanic children are systematically under-detected and diagnosed at later ages (52). As race is a complicated social construct largely referenced to serve as a measure for exposure to racism, it follows that the factors influencing these disparities are complicated, vary, and are tied to context. Race in the United States is frequently intertwined with socio-economic status, so the same factors impacting lower-income children are disproportionately impacting black and Hispanic children (43). Additionally, race is frequently correlated with living in certain geographic regions which tend to be lacking in health and educational resources (53). Furthermore, cultural and family values as well as attitudes toward disabilities or pursuing a diagnosis common to racial or ethnic groups can have marked impacts about whether a family might recognize or raise concerns about a child's development or pursue a diagnosis (43). These are just some of the many complicated elements contributing to the disparities in detection and diagnosis observed between racial and ethnic groups within the United States.

Outside of the US, dynamics of race and ethnicity can be very different, and while the impacts of race and ethnicity should be considered, the measure may not translate well between cultures. In Honduras, for example, while the vast majority of the population is known to identify as Mestizo/ Misquito, the Multiple Indicator Cluster Survey (MICS) in 2019 attempted to gather data on ethnicity in 5 categories (Garifuna, Lenca, Maya Chortí, Misquito, and Other), 86.7% of respondents declined to identify the ethnicity of the head of household (59). Caution should be taken when attempting to take race and ethnicity into account within differing cultural contexts.

Health Insurance

Accessing autism diagnostic and supportive services can be expensive. Some services are provided free of charge through government programs, but when the financial burden falls on the families, health insurance can be a major barrier to equitably accessing services (52). Parents of children may choose to delay or avoid seeking services if they are unaffordable due to insufficient health insurance, while the services accessed may simultaneously be of differing quality depending on what insurance the family has (53). In the US, for example, there are free services provided to children on Medicaid, but they are often associated with poorer quality than their more expensive counterparts (53). The nature of health insurance and paying for health services naturally differs around the world and depends highly on the country of interest. In Honduras, for instance, healthcare availability varies widely as does health insurance coverage, so care should be taken when considering insurance status in the country (60).

Evaluation at a Health or Education Source

As previously described, developmental disability, including ASD, may be evaluated in either a healthcare or education setting (44). This is a useful intersection of the healthcare and education systems, but children who access services through the education system often do not receive diagnostic or support services equitably to those children utilizing services through the healthcare system. On average, children who utilize education-based services for diagnosis are identified later or are more likely to not receive evaluation if they have milder symptoms or are lacking co-occurring intellectual disability (44). For this reason, when attempting to identify autism or a similar developmental disability, it is important to be aware of the source of evaluation and diagnosis. This measure may not be available in or transferable to all settings but should always be considered.

Type of Symptoms and Co-occurring Intellectual Disability

Autism spectrum disorder encompasses a wide range and combination of symptoms, some more easily recognizable than others. ASD often co-occurs with intellectual disability (ID), although the rate at which this happens varies widely between populations from 11% to as high as 65% in one study (20). When a child has more severe symptoms, particularly when paired with intellectual disability, they tend to be more readily identified for evaluation than their peers with milder or subtler symptoms, particularly in education settings (2,3,44). This leads to earlier identification, diagnosis, and reception of early intervention and services (44). It may also lead to a skewed understanding of ASD presentation in a population, like the higher severity of symptoms consistently reported in black children in the United States due to the under-detection of black children with milder symptoms (43). For this reason, symptom severity and presence of intellectual disability are factors frequently considered, when possible, when measuring ASD in a population.

Biological Sex of the Child

The biological sex of a child is a factor known to have a great deal of influence on ASD presentation. Autism spectrum disorder consistently presents more frequently in male sex children than in female sex children, with an estimated risk in boys about 3-4 times higher than in girls observed consistently in many populations (20,25). From this, female sex could be viewed as a protective factor with females being identified consistently less frequently, and often times with a disproportionately high concentration of ID, as the phenotype is more recognizable (7). Additionally, female sex is a risk factor for co-occurring epilepsy in children with ASD (20). When considering developmental delays or disabilities beyond simply ASD, male sex is also known to be associated with lower developmental scores in LMICs, with higher functional difficulty in low-income countries, and with functional difficulty associated with learning in LMICs (49,61). Male sex has also been shown to be positively associated with difficulty in language learning in LMICs (62). Clearly, there is evidence that, when attempting to measure autism spectrum disorder or related developmental disabilities, biological sex must be considered.

Nutrition and Stunting

The impact that nutrition has on development and its importance when measuring developmental delays is well known. Low birthweight and malnutrition during the first few years of life have been consistently shown to have a significant hazardous impact on the development of cognitive and language abilities, as well as in other areas of development (63). Nutritional status can be difficult to measure on a large scale, however, so stunting, defined by the WHO as more than 2 standard deviations below average height-for-age (64), is often used as a measure of the malnutritional impact on a child's development (49). Nutritional status is not standard to consider when looking at ASD prevalence, but, as it has a known association with early childhood social and cognitive development, it would be wise to consider it as a potential confounding factor in the child's outcomes.

Number of Siblings

The number of siblings of a child, while not related directly to social development or ASD, has been researched extensively as it relates to generalized development, typically defined either through adult height or academic achievement (65,66). Having a greater number of siblings, or a larger sibship, is thought to either be responsible for diluting the amount of resources the parents have available to nurture a child's development, or else be intrinsically associated with additional factors related to poorer developmental outcomes (66). The theory of resource dilution via sibship size has been associated with intellectual development (67), and, although the evidence on the relationship of sibship size and developmental outcomes is competing (65,66), it may be beneficial to take the number of siblings into account as a potential cofounding exposure.

Early Intervention

Early intervention (EI) is considered to be a treatment, therapy, or some other behavioral or intentional intervention that occurs at or before preschool age, and is therefore often administered in an early childhood education setting (68). The targeted age group is children under the age of five, as that is when neuroplasticity is at its highest and treatment for social developmental delays and disabilities, and autism spectrum disorder in particular, have been found to be most effective (5,6). Beyond the treatment of ASD or other developmental disabilities, early intervention is also a recognized and effective method for supporting a child whose development has been disrupted or delayed in many domains. In particular, a child with a delay in their social development could benefit significantly from early intervention, whether or not that delay is related to ASD (10,11,69).

Early intervention can have many forms and at this time there is no one gold standard that is most effective for all children diagnosed with or showing signs of autism spectrum disorder. However, there are a variety of techniques and actions that can be taken that have been found to be effective in encouraging language skills and social development which will be elaborated upon in the next section. Fundamentally, these techniques require the child to interact socially to develop their skills, perhaps through interaction with other children, teachers, therapists, or other professionals. This often, but not always (as in the case of home-based interventions), requires the child to attend school where many interventions can, and do, take place. Therefore, when considering a child's social development and any early intervention for possible ASD or social developmental delay, it is vital to understand whether an at-risk child is being presented with the opportunity to attend school within the key age range.

Early Intervention Techniques

There are currently two main schools of thought when it comes to early intervention, administered either by the parents, clinicians and/or teachers, or, preferably, both. These are Naturalistic Developmental Behavioral Interventions (NDBI) and the two methods with a very similar approach and so often grouped into a single category: applied behavior analysis (ABA) and Early Intensive Behavioral Intervention (EIBI) (6). These methodologies are evidence-based and have demonstrated improvement, although mixed, in outcomes related to ASD in children at risk of autism and those with an autism diagnosis alike (6). These techniques both require specialist training, but can then be administered either in a clinical or community setting, although community settings have shown to have less dramatic impact on a child's outcomes (6,70). These techniques are both best administered as early as possible and therefore are most effective if started when a child is first showing warning signs in their social or language development, whether or not that child eventually receives a diagnosis of ASD or similar disability (6,70–72).

On major draw-back about the current evidence-based treatments is that both NDBI and EIBI/ABA require large amounts of time to implement, sometimes up to 8 per day, in order to have the maximum impact (6,21,72). In fact, the ongoing standard laid out in 2001 by the National Research Council recommends at least 25 hours of intervention per week all-year-round (73). This can understandably be difficult for a parent to manage, and usually requires the attendance of a specialized program or preschool, whether within the community or a local clinical setting (6,70). Usually, these treatments also involve parental training and engagement (6,72). This allows for the most effective engagement of the child during all parts of their life and encourages development of social, cognitive, and language skills that they may otherwise have missed; the parents additionally gain new skills to understand how to interact with and engage their child throughout their life, even beyond the duration of the child's therapy (6,21,70,71).

Impact of Early Intervention

As the symptoms of ASD and autism-like disabilities and delays can encompass a wide spectrum of delays and disabilities, the measurement of the efficacy of interventions is naturally determined by measuring a variety of outcomes. The most common of these included cognitive functioning (frequently quantified as IQ (Intelligence Quotient)), social responsiveness (how well a child is able to interact with peers and adults socially), adaptive functioning (a measure of a child's skills necessary to function independently, including living skills, social skills, and communication skills among, especially among older children) , and communication/language skills, (frequently measured in young children by the size of their vocabulary)(5,6,72,74). These categories are not all-inclusive, vary between age groups, and in some cases overlap, and so are defined in different ways depending on the measure and the study. Despite the complicated nature of defining discrete categories, however, significant improvement in these domains has been shown with effective implementation of early intervention (6,21,71,72,75).

If started early enough, generally under the age of 5 when neuroplasticity is the highest, significant gains in IQ, social, communication, and adaptive functioning have been shown to be possible, especially in the first year of intervention (5,6,75). As with most interventions, these gains are seen non-uniformly between children, varying most commonly depending on age of intervention, severity of symptoms when starting treatment, and intensity of the treatment received (21,71,75). Despite this, variability, improvements, on average, are still observed in both NDBI and EIBI/ABA treatment types (6).

While there is currently no known cure or true definition of recovery for Autism Spectrum Disorder and related disabilities, there is the possibility for increased IQ, improvements in ability to communicate and understand the demands of interacting socially, and the ability to care for oneself independently (5). These gains, especially for children with less-severe expression of ASD, can translate into an increased ability to function independently as an adult (5). This is important for the well-being of the child and their family, as well as to reduce financial burden on the healthcare system of supporting and caring for people with ASD (76).

Delivery of Early Intervention in High-Income Countries

As mentioned previously, early intervention can be administered by a variety of providers (clinicians, teachers, parents, etc.) and in a variety of settings (clinical, community, school, home) (6,75). The amount of intervention recommended (at least 25 hours/week, 12 months a year) can be restrictive, and so generally requires an established institution to manage (73). In the United States, there are a variety of programs and methods for accessing these services, which include remote services, in-home services, school-based services, and center-based services (77). This can be achieved through private, non-profit, or government sources, and often some combination of the three (77). To ensure availability and accessibility, the United States government mandated in the Individuals with Disabilities Act (IDEA) that free and appropriate education be available to all children in the least restrictive environment possible (77). While this is an important supportive measure, especially for those children attending school, not all children in the United States are able to access all the resources for appropriate intervention equitably (43,44,52). As described in an earlier section, outcomes for children with ASD, at risk of ASD, or with related disorders are not always equitable and can vary widely based on a number of factors including race, SES, and geographic region (44,46,53). This remains true for access to early intervention services throughout the United States and other higher-income countries (78).

Delivery of Early Intervention in LMICs & Honduras

Beyond the borders of high-income countries, there remains much work to be done to understand early intervention and expand access to services to children with developmental disabilities (79,80). Unsurprisingly, most of the research into this area has been concentrated in high-income countries (80,81). In response to this dearth and the high estimated global burden of disease attributable to ASD (4.31 million DALYs in 2019) and other intellectual disabilities (4.39 YLDs in 2019), the World Health Organization has declared research into this area a priority (82–84). Recent studies have shown that early childhood education attendance and engagement of families in programs has strong potential to address these needs in LMICs, although more research is certainly needed (79). Honduras has a population of about 10 million people living across the Central American country's 43,433 square miles. It has a GDP of $28.49 billion, with 59% of the population living in urban settings (85). There is a clear need to expand the understanding of ASD and early intervention services available in Honduras and similar countries to serve the children of these populations.

Conceptual Framework

Research Question: 1) Describe the prevalence of potential social developmental delay, indicative of autism spectrum disorder using data collected in the MICS6 on early childhood developmental social behaviors, and 2) describe the relationship between symptoms of social developmental concern in 4-year-old children in Honduras and key characteristics of interest, including attendance of early childhood education, urbanicity, and sex.

Potential autism spectrum disorder (ASD) could be estimated by means of a social developmental delay proxy indicator. This measure was developed from questions taken from the child functioning and early childhood developmental index sections of the Under Five (U5) MICS6 survey that were chosen and modeled after questions from the Social Responsiveness Survey-2 Preschool (SRS-2P), described further in Methods. This proxy indicator may be used as a population-level level 1 survey from potential ASD or related social developmental delay. This score, from 0-10 with a projected cut-off for social developmental concern at 3, is considered to be the outcome of interest for this analysis.

For population-wide information to be useful and actionable for a country, it is important to have more granular information about the portions of the population in which the social developmental delay (potential ASD) is occurring. Prevalence and severity of ASD has been linked to a variety of factors that were measured in the MICS6 U5 questionnaire. Many of these factors may be acting as hazardous or protective exposures for a higher social developmental delay proxy score (SDDPS) and should be analyzed as possible predictors. For this analysis, 3 characteristics of interest were chosen based on their relevance to the subject material and prevalence within the population. These were: early childhood education attendance, sex of the child, and urbanicity.

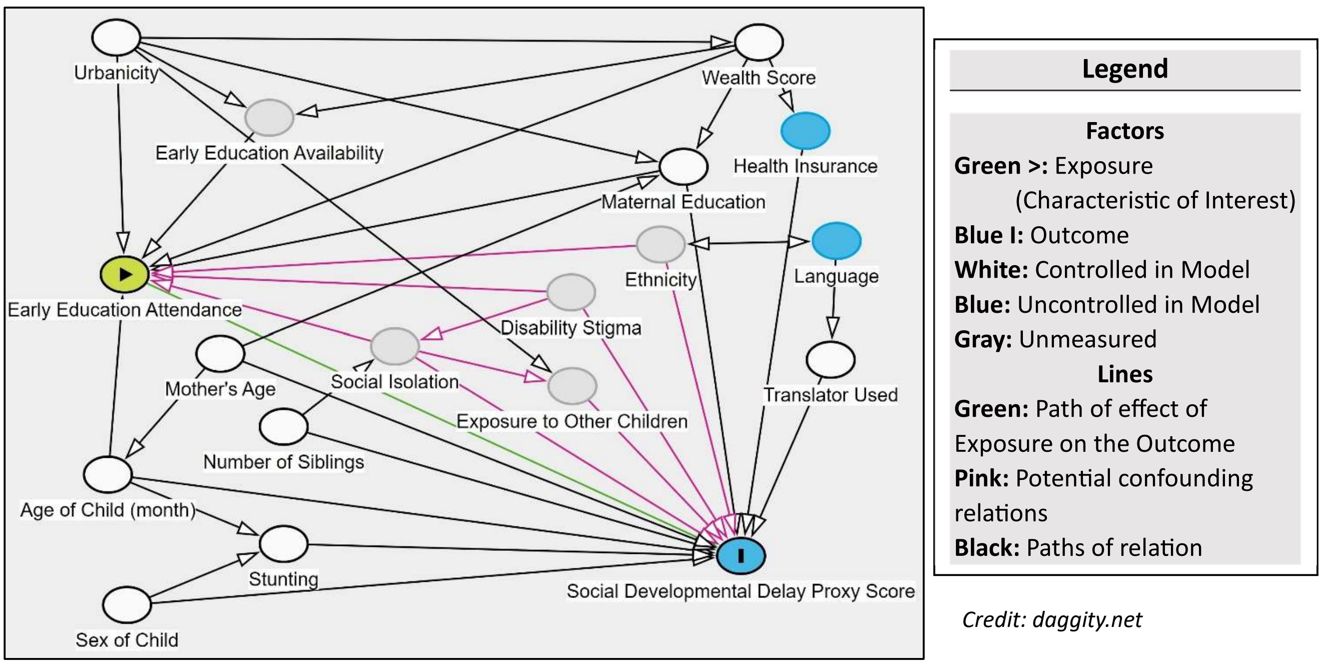
In addition to the 3 characteristics of interest, additional socio-demographic exposures that may be influencing or confounding the relationship between the key characteristics and the SDDPS should also be taken into account. These additional factors included: the child's age in months, number of siblings, mother/caretaker's age, the wealth of the child's family (measured as a continuous wealth score), the highest level of education reached by the child's mother, the presence of a translator during the interview, and the presence of stunting. While children analyzed were restricted to 48-59 months of age (age=4), the age of the child (in months) is still vital to consider when looking at development as development happens rapidly during the first 5 years of life. Stunting due to such factors as poor nutrition has been found to influence developmental outcomes like social development (63). It could have a direct influence on the SDDPS, which may be also influenced by the age and sex of the child (49). However, due to low observed prevalence within the population, stunting was removed from analysis when the outcome was measured binarily. Ethnicity of the child (measured as the declared ethnicity of the head of the household) should also be considered as a potential confounder, but with only a 19.85% response rate, the variable was considered to be unmeasured. Similarly, the presence of stigma against disability, ease of access to early education, and the social isolation and/or the exposure to other children of the child would ideally have been considered in the model but were not adequately measured to be considered in the model.

Model 1: Early Childhood Education Attendance

Whether a child attends early education before the compulsory age of 6 is important to understand. The school system may serve as a point for identification and intervention for children experiencing social developmental delay and would be key in developing any programs to detect and address ASD within a country. Early education attendance may have a direct impact on the SDDPS as the child may be receiving education and social stimulation that may impact responses to the questionnaire

(6,11,69). When considering early childhood education attendance as a potential predictor of SDDPS, its direct effect is important to consider, as well as how the relationship is impacted by other factors. Whether a child attends early education before compulsory age and their SDDPS is likely to be influenced by urbanicity, sex of the child, child's age (in months), presence of stunting, highest level of maternal education, mother's age, number of siblings, wealth of the family, and whether a translator was used. Any social isolation experienced by the child as well as race or ethnicity of the child and the availability of education would also be considered if data were available (Figure 1).

Figure 1. Directed Acyclic Graph of Relationship between Exposure to Early Childhood Education Attendance and the Social Developmental Delay Proxy Score

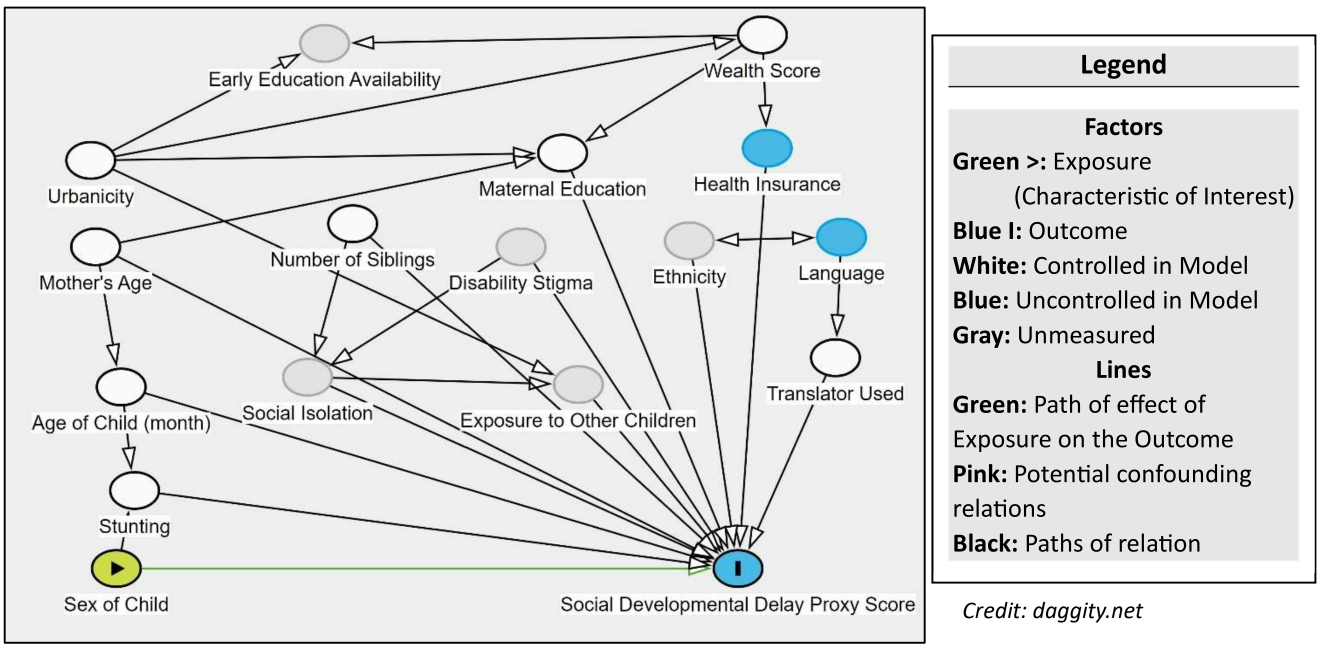


Credit: daggity.net

Model 2: Child's Sex

The sex of the child is a key factor to consider when attempting to measure ASD or similar developmental disabilities as ASD has been consistently observed at a 4:1 ratio among boys to girls (2,3,7). This sex of the child would be expected to have a direct influence on SDDPS, to the exclusion of early childhood education attendance. In addition to measuring a direct effect, it would be important to consider other factors influencing SDDPS. These would be the age of the child, number of siblings, mother's/caretaker's age, stunting of the child, urbanicity, maternal education, wealth of the family, and whether a translator was used in the interview. Any social isolation experienced by the child as well as race or ethnicity of the child and the availability of education would also be considered if data were available (Figure 2).

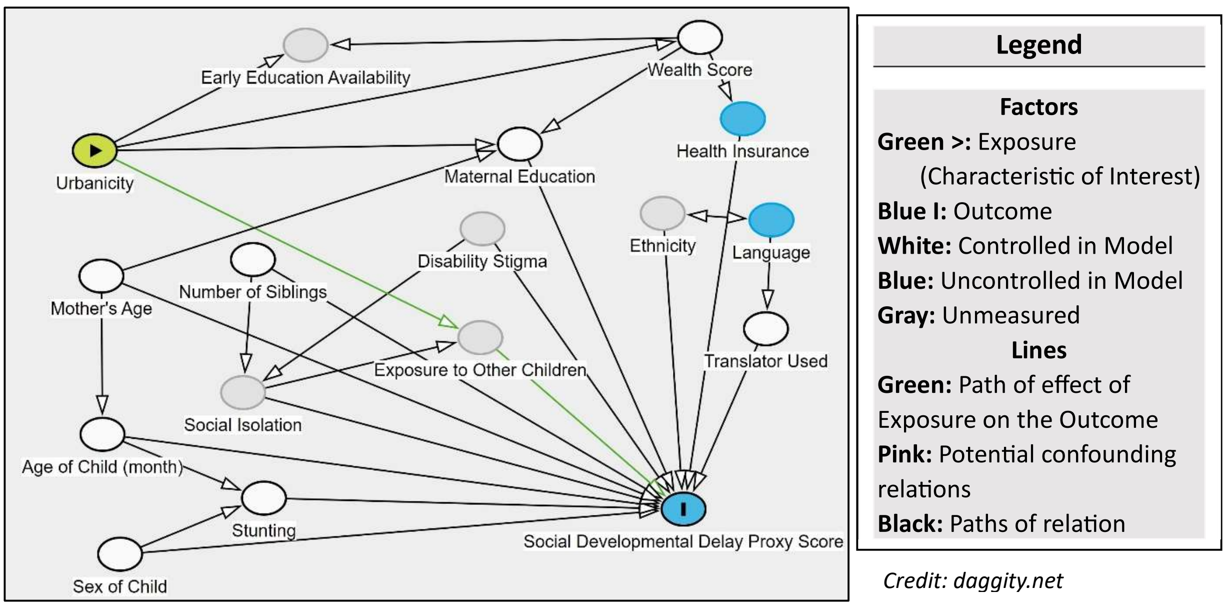
Figure 2. Directed Acyclic Graph of Relationship between Child's Sex and the Social Developmental Delay Proxy Score



Model 3: Urbanicity

Whether the child lives in an urban or rural area of the country may have a great impact on the presence or severity of ASD or social developmental delay, as measured by SDDPS, as well as the ability for any interventions to take place. Urbanicity has been found to influence ASD and similar developmental disorders in similar Central and South American Countries (54,55). Living in a rural area may limit a child's access to and quality of early childhood education due to limited resources, social interaction due to sparse population, health insurance due to lower wealth, on average, and decrease, on average, the level of maternal education reached (56). It is therefore important to measure the direct effect that living in an urban or rural area has on the SDDPS to the exclusion of early childhood education attendance, as well as to consider the influence of other factors on SDDPS. These other factors to be considered are the age of the child, sex of the child, number of siblings, mother/caretaker's age, stunting of the child, maternal education, wealth of the family, and whether a translator was used in the interview. Any social isolation experienced by the child as well as race or ethnicity of the child and the availability of education would also be considered if data were available (Figure 3).

Figure 3. Directed Acyclic Graph of Relationship between Child's Sex and the Social Developmental Delay Proxy Score



Credit: daggity.net

Data

The Multiple Indicator Cluster Survey, Round 6 (MICS6)

The Multiple Indicator Cluster Surveys, first designed in the mid-1990s, are co-created and supported by the United Nations International Children's Emergency Fund (UNICEF) (86). They are a series of surveys that are focused primarily on measuring the welfare of women and children around the world, particularly in LMICs (86). The surveys are delivered in face-to-face interviews by local government actors with support from UNICEF, producing one of the single largest databases of internationally comparable data on women and children (87). These data are vital to many countries, as they help governments in policy planning, program implementation, and public outreach programs (87). The number of countries participating has increased over the 27 years of its existence, currently standing at 119 countries having produced 349 surveys, 67 of which are from the most recent iteration MICS6 (86,88).

As the reach of the surveys has expanded, so, too, has their content and scope. The standard MICS6 contains 5 questionnaires encompassing the following categories: Household (HH), Individual women aged 15–49 (WM), Individual men aged 15–49 (MN), Children aged 5–17 (CH), and Children under age five (U5). These questionnaires are made up of multiple customizable modules and can be split into additional questionnaires as the case requires (86). One notable addition to the U5 questionnaire in the sixth round of MICS was the Early Childhood Development Index (ECDI) in 2016 (87). The design, specific components, and questions are decided upon with country actors during the planning stage before administration (86). For the purposes of this study, the U5 questionnaire and its components are of primary importance and will be expanded upon in the following sections.

Survey Design

The surveys are administered through one-on-one interviews by trained local professionals (87). The language of the survey and the language used by the interviewer is recorded and translators are utilized for either part of or for the entirety of the interview when necessary. In Honduras, 3 translators were used for Miskito-speaking people, while Spanish was spoken as a primary or secondary language for all other respondents. The Spanish MICS6 survey was utilized (59).

The sampling design and size is chosen by each program manager when designing their MICS depending on the country's needs (89). In the 2019 Honduras MICS6, the 18 administrative units of Honduras plus the metropolitan areas surrounding the cities Tegucigalpa (the capital) and San Pedro Sula were identified as the main regions for sampling, with each region divided into urban and rural areas as the primary strata. Within each stratum, 1,226 clusters were systematically demarcated based on census data and 20 households were drawn from each, with an overall sample size of 24,520 households for the entire MICS6 (59). Weighting to account for oversampling of some regions was assigned to each household and to each individual depending on questionnaire.

Honduras MICS6 Under 5 Questionnaire Dataset

The Questionnaire for Children Under 5 (U5) may contain all or some combination of the following 10 modules: the Under Five Child Information Panel, the Under Five Background, Birth Registration, Early Childhood Development, Child Discipline, Child Functioning, Breastfeeding and Dietary Intake, Immunization, Care of Illness, and Anthropometry (86). As the information is available or based on country priorities, pieces of these modules may be excluded from the questionnaire or customized. For instance, immunization information may be collected in different ways depending on if a health record in custody of a health facility is available. In the Information Panel, Background, and Anthropometry, information is collected on multiple common cofactors considered when measuring autism or developmental disabilities. These include maternal education, early childhood education attendance, anthropometric scores (including measures of stunting), wealth information (multiple measures), ethnicity, urbanicity, sex, age, and if an interpreter was utilized during the survey. When attempting to measure potential social developmental delay, the Early Childhood Development and Child Functioning Modules are of particular interest.

The Honduras MICS6 Under 5 Questionnaire (U5) consists of a nationally representative sample of 8713 children. Mothers or caregivers of these children were interviewed, selected from 1221 clusters of up to 24 households, divided into 54 strata. Weighting to account for sample design and oversampling in rural areas was assigned to each child within the U5 questionnaire (variable CHweight). The interviews were one-on-one within the households and were designed to last approximately 30 minutes or less. The parent, or other caretaker when a parent was not living or able to respond, responded on behalf of each child under the age of 5 within the household from around the country with a 97% response rate (N=8461). Of those 8461 children, 3618 responded both to the Early Child Development Survey and Child Functioning Survey (both administered only to those aged 3 and 4). 1723 (weighted 1737) of those children were over 47 months at the time of survey and were considered for the analysis.

Table 1. Survey-Adjusted Nationally Representative Characteristics of the 2019 Honduras MICS6 Under 5 Questionnaire Respondents

		All (N=8461.0)		4-year-olds (N=1737.0)		4yo, Urban (N=702.9, 40.46%)		4yo, Rural (N=1035.0, 59.54%)	
		N	(%)	N	(%)	N	(%)	N	(%)
Age (years)	0	1584.0	18.71	-	-	-	-	-	-
	1	1710.0	20.20	-	-	-	-	-	-
	2	1562.0	18.45	-	-	-	-	-	-
	3	1872.0	22.12	-	-	-	-	-	-
	4	1737.0	20.52	1737.0	100.00	702.9	100.00	1035.0	100.00
	Missing	247.0	2.84	0.0	0.00	0.0	0.00	0.0	0.00
Sex	Male	4358.0	51.47	907.9	52.26	385.1	22.17	522.8	30.09
Urbanicity	Rural	5017.0	59.26	1035.0	59.54	-	-	-	-
Native language	Spanish	8371.0	98.87	1718.0	98.86	699.8	99.56	1018.0	98.39
	English	7.2	0.09	3.1	0.18	0.2	0.03	2.9	0.28
	Misquito	81.6	0.96	14.6	0.84	2.9	0.41	11.8	1.14
	Garifuna	6.5	0.08	2.0	0.12	0.0	0.00	2.0	0.20
Translator used	None	8248.0	97.43	1693.0	97.42	680.0	96.75	1013.0	97.89
	Part Interview	20.0	0.24	4.2	0.24	2.5	0.35	1.7	0.17
	Full Interview	197.6	2.33	40.6	2.33	20.4	2.90	20.1	1.95
Mother's Education Level	None-Primary	5994	70.81	1247	71.79	367.77	52.32	879.52	85.02
	Secondary or greater	2471	29.19	488.5	28.11	335.11	47.68	153.34	14.82
	Missing	1.65	0.02	1.65	0.1	0	0	1.65	0.16
Mother/ Caretaker's Age	Mean (range)	29.2	(13, 98)	32.1	(17, 98)	32.0	(18, 75)	32.1	(17, 98)
Siblings	Mean (range)	1.7	(0, 10)	1.7	(0, 10)	1.6	(0, 7)	1.8	(0, 10)
Wealth Score	Mean (range)	-0.1	(-3.2, 1.9)	-0.1	(-2.9, 1.8)	0.6	(-2.8, 1.7)	-0.6	(-2.9, 1.8)
Stunting	Stunted	294.6	3.48	51.4	2.96	25.6	3.65	25.8	2.49
Insurance	Covered	1162	13.73	251.84	14.50	185.74	26.4250	66.11	6.39
Attending Early Ed	Attending	490.37	5.79	418.54	24.09	160.27	22.80	258.26	24.96
ECDI (Delayed, 36-59 months)	Literacy-Numeracy	3148	87.20	1428	82.17	548.10	77.98	879.50	85.02
	Physical	240.83	6.68	95.71	5.51	31.48	4.48	64.23	6.21
	Social-Emotional	182.47	5.06	64.85	3.73	18.50	2.63	46.35	4.48
	Learning	736.36	20.41	324.38	18.67	129.04	18.36	195.34	18.89
	Missing	4846	57.27	2	0.12	1	0.14	1	0.10
Child functioning (delayed,	Seeing	2.10	0.04	0	0	0	0	0	0
	Hearing	7.04	0.14	1.99	0.11	0	0	1.99	0.19
	Mobility	26.31	0.51	7.48	0.43	0	0	7.48	0.73

24-59 months)	Comm./ Comp.	121.41	2.35	25.82	1.49	6.71	0.95	19.11	1.85
	Cognitive Learning	67.07	1.30	28.58	1.65	13.41	1.91	15.17	1.47
	Fine Motor Skills	24.15	0.47	5.89	0.34	0	0	5.89	0.57
	Behavior	272.81	5.28	72.23	4.15	32.83	4.67	39.41	3.81
	Playing	67.07	1.30	28.58	1.65	13.41	1.91	15.17	1.47
	Missing	3293	38.92	4	0.23	1	0.14	3	0.29

Language/Ethnicity

The surveys were all administered in Spanish. 2.84% of the interviews (N=49) required the use of a translator for at least part of the interview (2.55% (N=44) for the entire interview, 0.29% (N=5 for part of the interview). 96.40% (N=1661) of the households were Spanish speakers, 0.17% (N=3) were English speakers, 3.19% (N=55) were Misquito speakers, and 0.23% (N=4) were Garifuna speakers. This distribution of languages is representative of the country's spoken languages according to the figures reported by WorldData (85). For analysis, usage of a translator was coded as 1/2/3, with 1 indicating a translator being used throughout the interview, 2 indicating the use of a translator for part of the interview, and 3 indicating no translator usage. The ethnicity of the household head was collected in the survey, but 80.15% of respondents chose not to disclose the information, so it was not considered for analysis.

Socio-Demographic

Among the children included in this analysis, 582 (33.78%) live in an urban area and 1141 (66.22%) in a Rural area. This classification was coded as 1/2 for the area, with a score of 1 corresponding to an urban area and 2 corresponding to a rural area. A 2018 UNICEF report found that 77% of Honduran Teens and Children live in poverty (90). In the U5 questionnaire, wealth was recorded in quintiles, deciles, and as a continuous wealth score, both overall and individually for urban and rural populations. For the purpose of the analysis, the overall continuous wealth was utilized. The variable represented the combined wealth score of each child's household, with values ranging from -3.17 to 1.88. The age of the child's mother or caretaker was coded continuously, with a range of 17-98 and average age of 32.1 years for 4-year-olds. The number of siblings was calculated from the total number of children in the household with the same mother/caretaker and was coded continuously, with a range of 0-10 and an average of 1.7 siblings for 4-year-olds.

Physical Characteristics

Of the children considered for analysis, 51.89% were male and 48.11% female. Biological sex was coded binarily as 1/2, with 1=Male and 2=Female for analysis. The U5 questionnaire included children from 0-59 months of age, and recorded the children's ages in years, months, and days. For analysis, the sample was restricted to 4-year-olds, with the children whose age in years was equal to 4 being included. The impact of the age of the child in months was also considered, with values for 4-year-old children ranging from 48-59 (months). While occurrences of stunting were rare among the surveyed children, it was considered as a potential confounding factors. Stunting was coded as 1/0, with 1 indicating presence of stunting and 0 indicating no stunting.

Education

In Honduras, compulsory education begins at age six and extends from grade 1-6 in Basica school, which continues until grade 11 at age 15 (91). The school year runs from February to November. Prébasica (preschool) is available for ages 3-5 but is not available equally around the country. The education system is understaffed and underfunded and still recovering from the devastation of Hurricane Mitch that destroyed an estimated quarter of all schools in 1998 (27). In the dataset, 3583 children had data both on whether they attended school and answered the relevant development survey questions, 1723 of whom were over the age of 47 months. Of those 1723 children, 461 (26.76%) were currently attending early childhood education of any kind and 1262 (73.24%) did not attend. Data were also available for whether the children had ever attended early childhood education or had attended at any point in the current year, rather than simply currently attending, but the more restrictive "currently attending" was chosen for analysis. This variable was coded as 1/0, where 1 means currently attending and 0 meaning not currently attending. The highest level of education reached by the child's mother or caretaker was also considered for analysis. Mother's education level was recorded both in grades and in broader categories of level of education. For analysis, the broader categorical variable was utilized, and recoded binarily 1/0 where 0 refers to no education through primary education only (N=1247, 71.79%) and 1 refers to secondary education or greater (N=489, 28.11%).

Early Childhood Development Index (ECDI)

The Early Childhood Development Index is a population-based measure administered in the MICS to collect data on the quality of a child's early home environment and access to care and education in the first years of life. It was first administered in its current 10-question form in 2009 in the fourth round of MICS, and has since been administered in over 80 surveys, making it the "largest source of internationally comparable data on children's developmental outcomes in low- and middle-income countries" (87). This followed a series of validation and refinement from the original 48-question version introduced during the third round of MICS in 2005-2006. The index was developed in response to an increasing interest in the early years of neurodevelopment and to comprehensively assess a child's holistic development on a population level (87). Having this information is of great importance to a country, as it can inform planning for policies to support and intervene in a child's development during the first vital years. This necessity persists, perhaps to an even greater degree, when considering children with possible autism spectrum disorder.

The ECDI is valid for children ages 3-4 and consists of 10 questions administered to a parent or caregiver within the questionnaire. All questions were coded as 1=Yes, 2=No, 8=Don't Know, and 9=No Response. Some responses were reverse-coded so the "response of interest" is listed below. The questionnaire, translated into Spanish for administration in Honduras, was prefaced with the primer "*I would like to ask you some questions about the health and development of (child's name). Children do not all develop and learn at the same rate. For example, some walk earlier than others. These questions are related to several aspects of (child's name)'s development."* The ECDI is measured in the following four domains:

Table 2. Early Childhood Development Index Questions by Domain

Domain	***Question***	***Response Of Interest***	*Included in Analysis*
Literacy-Numeracy	Can (x) identify or name at least ten letters of the alphabet?	2 (No)	
	Can (x) read at least four simple, popular words?	2 (No)	
	Does (x) know the name and recognize the symbol of all numbers from 1 to 10?	2 (No)	
Physical	Can (x) pick up a small object with 2 fingers, like a stick or a rock from the ground?	2 (No)	
	Is (x) sometimes too sick to play?	1 (Yes)	
Social-Emotional	Does (x) follow simple directions on how to do something correctly?	2 (No)	Yes
	When given something to do, is (x) able to do it independently?	2 (No)	Yes
	Does (x) get along well with other children?	2 (No)	Yes
Learning	Does (x) kick, bite, or hit other children or adults?	1 (Yes)	
	Does (x) get distracted easily?	1 (Yes)	Yes

A child is considered to be developmentally on track in the Literacy-Numeracy and Social-Emotional domains, respectively, if the parent or caregiver answer "yes" to at least two of the three questions. They are considered developmentally on track in the Physical and Learning domains, respectively, if they can do at least one of the two tasks (86). A cumulative Early Childhood Development Index score is calculated from the percentage of children who are developmentally on track in all domains based on these measures. In Honduras, the 2019 MICS6 found that 75% of children ages 3-5 were developmentally on track according to the ECDI (92), although only 4-year-olds were considered for analysis.

Table 3. Weighted Distribution of the Early Childhood Development Index Scores in the Honduras 2019 MICS6

Early Childhood Development Index	36-59 Months (N=3610)		47-59 Months (N=1737)		4yo, Urban (N=702.88)		4yo, Rural (N=1035)	
	N	**(%)**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**
Child identifies at least ten letters of the alphabet (no)	3042	84.28	1384	79.69	524.43	74.61	860.05	83.13
Child reads at least four simple, popular words (no)	3337	92.45	1560	89.79	634.63	90.29	925.37	89.45
Child knows name and recognizes symbol of all numbers from 1-10 (no)	2778	76.95	1216	69.97	442.7	62.98	772.87	74.71

Child able to pick up small object, such as a stick or a stone, with 2 fingers (no)	308.55	8.55	123.62	7.11	40.08	5.7	83.44	8.07
Child sometimes too sick to play (yes)	774.58	21.46	360.16	20.73	132.02	18.78	228.14	22.05
Child follows simple directions (no)	328.6	9.1	145.39	8.37	56.84	8.09	88.55	91.44
Child able to do something independently (no)	351.68	9.74	133.72	7.7	37.95	5.4	95.78	9.26
Child gets along well with other children (no)	242.37	6.71	86.3	4.97	33.75	4.8	52.56	5.08
Child kicks, bites or hits other children or adults (yes)	1004	27.83	438.03	25.21	181.02	25.75	257.01	24.84
Child gets distracted easily (yes)	2264	62.72	1090	62.76	408.86	58.17	681.52	65.88

Child Functioning

The Child Functioning module in the MICS is adapted from the UN Washington Group on Disability Statistics module on functional difficulty (93). The version included in the Honduras 2021 MICS6 is an updated module designed to replace an optional ten-question screening instrument added to the MICS in the fifth round and has been validated across multiple countries (94). The questions are intended to gather population-level data on functioning in the following areas: seeing, hearing, walking, communicating, cognition (learning), upper body functioning, behavior, and playing (93,94). By itself, the child functioning module is not intended as a diagnostic tool or to assess functional impairments in individual children, but rather is intended to gather information on percentages of functional impairments within the population as a whole (95). As with the ECDI, this would help policymakers to plan and so best respond to difficulties present in their countries.

The child functioning module included in the Under 5 questionnaire is applicable to children ages 2-4 and consists of 18 questions answered by a mother or caregiver for every child in the household. It was translated into Spanish, predicated with the phrase "*I would like to ask you some questions about difficulties (child's name) may have*." Coding of variables varied between binary and Likert-scale responses, so coding and "responses of interest" for each variable is listed below. The goal of the module was to measure child functioning in the following areas: seeing, hearing, mobility, communication/comprehension, cognition/learning, fine motor skills, controlling behavior, and playing (93). Excepting questions to guide questionnaire logic, the module as presented in the MICS6 2019 in Honduras consists of the following 12 questions in the 8 domains:

Table 4. Child Functioning Scale Questions and Responses by Domain

Domain	***Question & Responses***	***Response Of Interest***	***Included In Analysis***
Seeing	Does (name) wear glasses? *Yes=1/No=2/Don't Know=8/No Response=9*	1	
	Does (name) have difficulty seeing? *No Difficulty=1/Some Difficulty=2/A Lot of Difficulty=3/Cannot See At All=4/No Response=9*	3 or 4	
Hearing	Does (name) use a hearing aid? *Yes=1/No=2/Don't Know=8/No Response=9*	1	
	Does (name) have difficulty hearing sounds like peoples' voices or music? *No Difficulty=1/Some Difficulty=2/A Lot of Difficulty=3/Cannot Hear At All=4/No Response=9*	3 or 4	Yes
Mobility	Does (name) use any equipment or receive assistance for walking? *Yes=1/No=2/Don't Know=8/No Response=9*	1	
	Compared with children of the same age, does (name) have difficulty walking? *No Difficulty=1/Some Difficulty=2/A Lot of Difficulty=3/Cannot Walk At All=4/No Response=9*	3 or 4	
Comm./ Comp.	Does (name) have difficulty understanding you? *No Difficulty=1/Some Difficulty=2/A Lot of Difficulty=3/Cannot Understand At All=4/No Response=9*	3 or 4	Yes
	When (name) speaks, do you have difficulty understanding (him/her)? *No Difficulty=1/Some Difficulty=2/A Lot of Difficulty=3/Cannot Be Understood At All=4/No Response=9*	3 or 4	Yes
Cognition/ Learning	Compared with children of the same age, does (name) have difficulty learning things? *No Difficulty=1/Some Difficulty=2/A Lot of Difficulty=3/Cannot Learn At All=4/No Response=9*	3 or 4	Yes
Fine Motor Skills	Compared with children of the same age, does (name) have difficulty picking up small objects with (his/her) hand? *No Difficulty=1/Some Difficulty=2/A Lot of Difficulty=3/Cannot Pick Up At All=4/No Response=9*	3 or 4	
Controllin g Behavior	Compared with children of the same age, how much does (name) kick, bite or hit other children or adults? *Not At All=1/Less=2/The Same=3/More=4/A Lot More=5*	4 or 5	Yes
Playing	Compared with children of the same age, does (name) have difficulty playing? *No Difficulty=1/Some Difficulty=2/A Lot of Difficulty=3/Cannot Play At All=4/No Response=9*	3 or 4	Yes

A child was considered to have functioning difficulties in any of the domains if their parent or guardian responded that the child either had a lot of difficulty with a given task or else was unable to complete the task at all. In the case of the Controlling Behavior domain, a child was considered to have functional difficulty in the area is the parent responded that the child kicks, bites, or hits other children or adults "more" or "a lot more" than other children (93). Utilizing these recommended cut-offs, in the Honduras 2019 MICS6, 5.6% of children 2-4 were found to have functioning difficulties (92).

Use of MICS6 in the Detection of Developmental/Intellectual Delay

While the Under 5 questionnaire of Multiple Indicator Cluster Survey's primary utility in the literature appears to be for evaluation of such outcomes as child mortality, nutrition, and vaccination, some studies have focused on early childhood developmental outcomes as well. A recent study utilized the ECDI in all available MICS6 surveys to estimate the global presence of developmental delay in LMICs, finding 25% of children in 63 countries to be suspected of delay in at least one domain (48). A further module of the Under 5 questionnaire focuses on parenting tactics and discipline, which has been utilized in some studies to interesting effect. One study utilized this module to analyze the relationship between screen time and technology and parental interaction in Thailand (96). A further study found a positive relationship between early childhood education attendance and parental interaction (using MICS6 data) and early childhood development (utilizing data from a validation study), regardless of stunting status in four countries (97). Finally, a far-reaching study utilizing MICS6 data from 17 countries analyzed the relationship of children with disabilities to exposure to violent parental discipline, finding children with disabilities to be 17% more likely to be exposed to violent discipline than their peers (98).

Some literature also exists to utilize the MICS datasets to measure generalized developmental or intellectual delay. Two early studies used the third round of the MICS to estimate developmental disabilities prevalent in across all available countries, finding on average 20-23% of children to be identified with some sort of delay (62,99). Interestingly, one study analyzed school general developmental delay and school attendance among children aged 5-9, and found those with disability to be less likely to attend school (99). A more recent study utilized all available MICS4-6 data across 73 countries to estimate the prevalence of cognitive delay among 3- and 4-year old children, finding an overall prevalence of 9.7% (47). This study built on existing literature and utilized data from the ECDI Literacy-Numeracy and Learning domains to estimate significant cognitive delay across multiple countries. The same authors also conducted an additional study utilizing the child functioning module in the MICS6 for 18 LMICs to measure functional disability related to learning as a proxy for intellectual disability (99). They found comparable rates to intellectual disability in HICs (2% compared to 1.8%), but noted reasons to be skeptical of the validity of this measure as the literature suggests that the estimate should be higher in LMICs and because they observed considerable risk of false positive and false negative reports with varying levels of household income and maternal education when compared to other measures of child development in MICS6 (99).

Methods

The complete datasets from the Honduras 2019 MICS6 were downloaded from the MICS.UNICEF.org/surveys with permission from UNICEF. The datasets were converted from SPSS format into excel for visualization before being imported into SAS. The Honduras CH dataset, the U5 questionnaire, was the primary dataset. This dataset was merged to the HH dataset (general household data) and HL (household members) following the UNICEF-provided merging advice for additional household-level data. HH was merged to the U5 dataset on variables “HH1” (cluster number) and “HH2” (household number), while HL was merged to the U5 dataset on variables “HH1,” “HH2,” and “LN” (line number).

To determine whether the data available from the MICS6 can be utilized to gain a better understanding of potential ASD or related social developmental delay, a proxy indicator score for social developmental delay was developed. This indicator, the social developmental delay proxy score (SDDPS), was designed to function like a level-1 ASD screener, and the anticipated percentage of children scoring above the proposed cut-off was selected accordingly. Recent literature has shown that ASD screeners commonly in use are chronically underestimating ASD prevalence in young children, so prioritizing sensitivity over specificity is recommended (100). The M-CHAT, a widely used ASD screener, commonly reports screen-positive rates of between 4 and 8 percent (100–103), although these numbers tend to increase among older children (100), have been demonstrated to be higher among Hispanic children (104), and have demonstrated very high rates in an LMIC context (105). Therefore, an anticipated screen-positive rate was between 4 and 12 percent. This score was used to describe the rates of positively screening children throughout Honduras, according to the nationally-representative sample of the MICS6 U5 questionnaire. Additionally, the relationship between characteristics of interest associated with ASD and the SDDPS was analyzed to determine whether any factors may be considered as predictors of early social developmental delay. All coding and analysis were done in SAS and Excel.

Social Developmental Delay Proxy Score (SDDPS)

From the MICS6 dataset Under 5 (U5) questionnaire, 10 questions were chosen to create the social developmental delay proxy score (SDDPS) which serves as a proxy for potential ASD. Four of these questions were drawn from the Early Childhood Development Index (ECDI) section and six were drawn from the child functioning (CF) section. The questions from the CF section were administered to those children from 24-59 months (2-4 years) and those from the ECDI were administered to children from 36-59 months (3-4 years), with those children to whom all 10 questions were administered being from 36-59 months (3-4 years). The questions were administered to all respondents to the U5 questionnaire. The response rate to the U5 questionnaire among eligible households (households that contained at least one child under the age of five at the time of the survey) was 97%, with only 0.12% (N=2) missing among children 48-59 months responding to the SDDPS questions.

The responses of interest for each variable considered were assigned a value of 1, missing values and "no response" being coded as missing, and all other responses receiving a value of 0. These responses were summed for each child, with possible SDDPS range of 0-10. The variables included in the SDDPS are as follows:

Table 5. Coding of Social Developmental Delay Proxy Score (SDDPS) component variables

	Question	***Response(s) of Interest***	***Coded (0/1)***
1	Child follows simple directions	2 (no)	Reverse coded so “2” =1, “.” and “9” =missing, all others =0
2	Child able to do something independently	2 (no)	Reverse coded so “2” =1, “.” and “9” =missing, all others =0
3	Child gets along well with other children	2 (no)	Reverse coded so “2” =1, “.” and “9” =missing, all others =0
4	Child gets distracted easily	1 (yes)	Coded so “1” =1, “.” and “9” =missing, all others =0
5	Child has difficulty hearing sounds like people’s voices or music	3 (a lot of difficulty), 4 (child is unable to hear)	Coded so “3” or “4” =1, “.” and “9” =missing, all others =0
6	Child has difficulty understanding parent/caretaker	3 (a lot of difficulty), 4 (child is unable to understand)	Coded so “3” or “4” =1, “.” and “9” =missing, all others =0
7	Child has difficulty being understood by parent/caretaker when speaks	3 (a lot of difficulty), 4 (child is impossible to understand)	Coded so “3” or “4” =1, “.” and “9” =missing, all others =0
8	Compared with children of the same age, child has difficulty learning things	3 (a lot of difficulty), 4 (child is unable to learn)	Coded so “3” or “4” =1, “.” and “9” =missing, all others =0
9	Compared with children of the same age, child has difficulty playing	3 (a lot of difficulty), 4 (child is unable to play)	Coded so “3” or “4” =1, “.” and “9” =missing, all others =0
10	Compared with children of the same age, how much does the child kick, bite, or hit other children or adults?	4 (more than other children), 5 (a lot more than other children)	Coded so “4” or “5” =1, “.” and “9” =missing, all others =0

A further question from the ECDI, *Child kicks, bites, or hits other children or adults,* was also considered to be part of the SDDPS. However, 25.16% of parents responded “yes” to this question, and it was determined to be too broadly inclusive of typical behavior. Additionally, this question was similar to the Child Functioning question, so it was excluded. Question 5, concerned with the child’s difficulty hearing. While this question is intended to identify significant hearing loss, many children with ASD exhibit limited responsiveness to others’ voices and hearing loss is initially suspected. However, only 2 children aged 4 had a response of interest and no parents or caretakers responded that their child could not hear at all (response=4), so the variable was retained as being potentially indicative of ASD-like social developmental delay when observed in combination with other factors.

Missing values

Missing values within the dataset account for 2.84% of all children, but 0 children aged 4 had missing data for any of the variables analyzed. Due to the small number of missing values, all observations with missing or “no response” answers were set to missing and treated as a list wise deletion. There were 2 missing values among 3-year-olds and 2 "no response" values among 4-year-olds, for a total of 4 children with 1 or more missing value within the proxy indicator components, accounting for 0.12% of total respondents within each age category and 0.12% of eligible respondents (3-4 year-olds) overall.

Coding of the outcome response variable "Social10", the SDDPS

To create the outcome variable ("Social10") that serves as the SDDPS, 10 questions were chosen from the Early Childhood Development Index and Child Functioning modules of the U5 questionnaire of the MICS6 survey. Utilizing the recommended scoring for each scale, responses of interest were chosen for each question potentially indicating that the child may not have reached the relevant developmental milestone. Responses of interest were assigned a value of 1, missing values and "no response" were assigned to missing, and all other responses were assigned a value of 0. The following subdomains were created according to the necessary coding (see Table 4) for responses of interest:

- Subdomain 1: cumulative score for Questions 1-3
- Subdomain 2: score for Question 4
- Subdomain 3: cumulative score for Questions 5-8
- Subdomain 4: score for Question 9
- Subdomain 5: score for Question 10

The values of each subdomain were summed in the variable "Social10", resulting in a possible SDDPS range of 0-10. For analysis, a cut-off score to indicate potential social developmental delay was calculated based on the cut-off score from the Social Responsiveness Scale 2 Preschool (SRS-2P). Each SRS-2P question is particular to 1 of 5 subscales attributable to ASD. The subscales consist of 1) Restricted Interests and Repetitive Behaviors (RRB), focused on the restricted repetitive behaviors observed among children with ASD, while the remaining four subscales measure the social responsiveness of the child: 2) Social Awareness (AWR), 3) Social Cognition (COG), 4) Social Communication (COM), and 5) Social Motivation (MOT).

When scoring an SRS-2P, a total score is calculated in addition to each subscale. Cut-offs vary between each subscale for what response indicates a mild, moderate, or severe score. To calculate the cut-off score for the social developmental delay proxy score (SDDPS), each MICS6 question was matched with 1 or more questions from the SRS-2P Questionnaire based on similarity of content (Table 5). To achieve the desired sensitivity of a level-1 screener, the cut-off for a "mild" score was then calculated based on the scoring of each subscale corresponding to the amount they contribute to the SDDPS. The SDDPS scoring scale was weighted by each subscale with the following weights: AWR 0, COG 2.67, COM 4.33, MOT 2, and RRB 1. From this, the cut-off for children with social development of concern for the SDDPS was set to a score of 3 or more.

Table 6. Matching of MICS6 Questions to SRS-2P Domains

MICS6 SDDPS Question	SRS-2 Preschool Question(s)	SRS-2 Preschool Domain
1	44	COG
2	9	MOT
3	22, 37, 57	COM
4	65	MOT
5	35	COM
6	10, 15, 36	COG/COG/COM
7	12, 35, 37	COM
8	44	COG
9	22, 20	COM/RRB
10	22, 8	COM/RRB

The SDDPS outcome variable was additionally coded binarily to reflect this outcome, named "SocialCat." Within this binary variable, all values of "Social10" from 0-2 were assigned a value of 0, values of "Social10" from 3-10 were assigned a values of 1, and all missing values were assigned to be missing.

Descriptive methods

To account for the complex survey design, survey-specific procedures were utilized. The primary sampling unit was the cluster, coded as "psu", the stratum was the survey strata, coded as "stratum" and the individual weight assigned to each child utilized for the "weight" statement was "chweight." The procedures surveyfreq and surveymeans were utilized to produce descriptive statistics of the distribution of the outcome variable, Social10, by itself and by characteristics of interest and socio-demographic variables. Differences of mean values for the SDDPS score was analyzed via a survey-adjusted t-test using the t-test option in suveymeans.

Analytic methods

To account for the complex survey design, survey-specific procedures were utilized. The primary sampling unit was the cluster, the stratum was the survey strata (divisions of the population along the 18 administrative units & major metropolitan areas), and the weighting assigned to each under-5 child in the U5 questionnaire was used for the "weight" statement. More complex analytic methods were utilized to assess whether any relevant, measured factors may be acting as significant predictors of increasing SDDPS. Linear regression, both simple and accounting for potential confounding variables, was done using proc surveyreg. The SDDPS outcome, survey10, was modeled continuously and, with the intention to detect any overall changes in score. Regression diagnostics were run for the linear regression utilizing the partial, pcorr2, and vif options in proc reg (non-suvey-specific). Full models, considering all potential confounders from the conceptual model, as well as gold models following backwards elimination, were completed (Table 7).

Table 7. Linear Regression Models Conducted for Analysis of Each Characteristic of Interest

Model	*Characteristic*	
Simple	Early Education	$Social10 = \alpha + \beta_1 EarlyEd$
	Sex	$Social10 = \alpha + \beta_1 Sex$
	Urban	$Social10 = \alpha + \beta_1 Urban$
Full	Early Education	$Social10 = \alpha + \beta_1 EarlyEd + \gamma_1 Urban + \gamma_2 Sex + \gamma_3 Translator + \gamma_4 MothersEd + \gamma_5 Stunting + \gamma_6 AgeInMonths + \gamma_7 MothersAge + \gamma_8 Siblings + \gamma_9 Wealth$
	Sex, Urban	$Social10 = \alpha + \beta_1 Sex + \beta_2 Urban + \gamma_1 Translator + \gamma_2 MothersEd + \gamma_3 Stunting + \gamma_4 AgeInMonths + \gamma_5 MothersAge + \gamma_6 Siblings + \gamma_7 Wealth$

Poisson regression, both simple and full models, were conducted using proc genmod, with an adaptation of the surveygenmod macro (106) (Table 8). The SDDPS outcome was modeled binarily ("SocialCat") as above or below the cut-off (social10 >2) to detect changes among those who scored positively compared to those who scored within the normal range. Poisson regression was chosen to model the binary outcome as occurrences of the outcome (scoring above the cut-off) were very rare. The Poisson regression was restricted to children aged 4 using a where statement, which may have skewed the confidence intervals, as no domain statement was possible with the procedure. Acceptable model fit was determined using the overall F-test and p-value for model fit, although an under-dispersion due to low data was detected so the dscale option was applied. Logistic regression was also considered for modeling the binary outcome, but the limited number of individuals with scores above the cut-off depowered the analysis and extremely poor model fit was observed.

Table 8. Poisson Regression Models Conducted for Analysis of Each Characteristic of Interest

Model	*Characteristic*	
Simple	Early Education	$\ln(SocialCat) = \alpha + \beta_1 EarlyEd$
	Sex	$\ln(SocialCat) = \alpha + \beta_1 Sex$
	Urban	$\ln(SocialCat) = \alpha + \beta_1 Urban$
	Complete	$\ln(SocialCat) = \alpha + \beta_1 EarlyEd + \beta_2 Sex + \beta_3 Urban$
Full	Early Education	$\ln(SocialCat) = \alpha + \beta_1 EarlyEd + \gamma_1 Urban + \gamma_2 Sex + \gamma_3 Translator + \gamma_4 MothersEd + \gamma_5 AgeInMonths + \gamma_6 MothersAge + \gamma_7 Siblings + \gamma_8 Wealth$
	Sex, Urban	$\ln(SocialCat) = \alpha + \beta_1 Sex + \beta_2 Urban + \gamma_1 Translator + \gamma_2 MothersEd + \gamma_3 AgeInMonths + \gamma_4 MothersAge + \gamma_5 Siblings + \gamma_6 Wealth$

Results

Descriptive

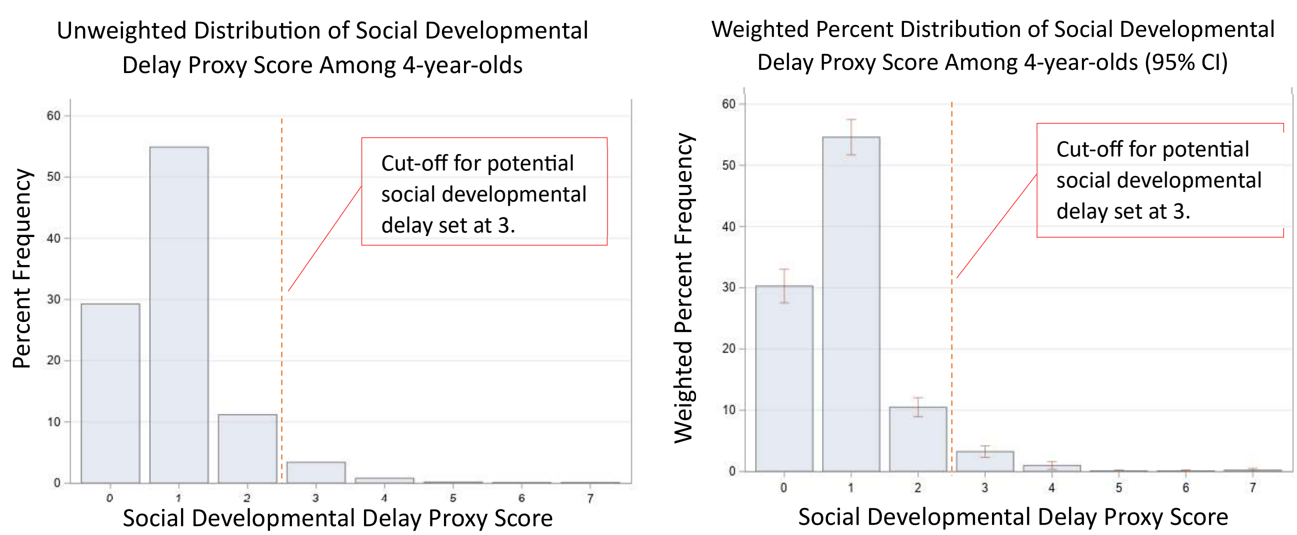
The Social Developmental Delay Proxy Score (SDDPS) is comprised of components from the Early Childhood Development Index (ECDI) and the Child Functioning (CF) section. Each component is intended to assess a child's development and have been combined and coded within the SDDPS so that each point (range 0-10) indicates an incidence of a child not meeting developmental milestones. A score of 0 means all responses were as expected for the child's development and increasing scores indicate greater potential developmental delay. A total score within the combined SDDPS of 3 or more is considered to be above the cut-off and potentially indicative of social developmental delay similar to that observe in autism spectrum disorder (ASD). The majority of the scores were contributed by the ECDI (Table 7). The most common score for the ECDI was 1 (56.2%) and 0 for the Child Functioning section (93.3%).

Table 9. Weighted Early Childhood Development Index and Child Functioning Components of the ASD Proxy Indicator Scores

Score	ECDI Component						Child Functioning					
	All (N=1726)		Urban (N=582)		Rural (N=1144)		All (N=1726)		Urban (N=581)		Rural (N=1144)	
	n	%	n	%	n	%	n	%	n	%	n	%
0	548	31.52	256	14.74	291	16.78	1619	93.32	651	37.52	968	55.80
1	976	56.20	374	21.52	602	34.68	101	5.83	47	2.68	55	3.14
2	165	9.48	57	3.26	108	6.22	7	0.38	0	0.00	7	0.38
3	44	2.52	15	0.86	29	1.67	5	0.32	3	0.18	2	0.13
4	5	0.27	1	0.08	3	0.19	3	0.16	0	0.00	3	0.16

The highest possible score from the ECDI component was 4, and 6 from Child Functioning, while the highest score contributed by either component was 4. For the overall SDDPS, the most common score was 1, (N=947, weighted 54.58%), followed by 0 (N=505, weighted 30.28%) and 2 (N=193, weighted 10.5%). Of the 1735 4-year-olds measured, a weighted 4.64% (N=80) had a score of 3 and over, measuring above the cut-off (Fig 4). This is largely similar to what has been described in other populations of preschool-aged children in Peru, Colombia, and low-income populations within Germany, China, and New York (ranging from 4-20%) (51,107–110).

Figure 4. Unweighted frequency and percent frequency distribution of 4-year-old children within the Honduras MICS6 survey by proxy social developmental delay score.



The distribution of the SDDPS varied based on urbanicity, whether the child was attending early education attendance, and, to a lesser degree, the sex of the child (Table 10). The variance between whether the child lived in an urban or rural area was the most distinct of the key characteristics analyzed.

Table 10. Weighted Distribution of Social Developmental Delay Proxy Score by Characteristic of Interest

	All (n=1725, Missing=2)		Attending Early Ed (n=419)		Not Attending Early Ed (n=1316)		Male (n=908)		Female (n=828)		Urban (n=701)		Rural (n=1034)	
Score	n	%	n	%	n	%	n	%	n	%	n	%	n	%
0	525	30.3	124	7.2	401	23.1	269	15.5	257	14.8	244	14.0	282	16.2
1	947	54.6	245	14.1	702	40.4	500	28.8	447	25.8	367	21.2	580	33.4
2	182	10.5	36	2.1	146	8.4	97	5.6	85	4.9	62	3.5	121	7.0
3	56	3.2	10	0.6	46	2.7	30	1.7	26	1.5	20	1.1	37	2.1
4	17	1.0	2	0.1	15	0.8	9	0.5	8	0.5	8	0.4	9	0.5
5	2	0.1	0	0.0	2	0.1	2	0.1	0	0.0	0	0.0	2	0.1
6	2	0.1	0	0.0	1	0.1	1	0.1	0	0.0	0	0.0	2	0.1
7	4	0.2	0	0.0	4	0.2	0	0.0	4	0.2	1	0.1	2	0.1
Total	1735	100	419	100	1316	100	908	100	828	100	701	100	1034	100
Mean Score	0.97 (0.93, 1.01)		0.86 (0.78, 0.94)		0.94 (0.88, 1.00)		0.92 (0.86, 0.99)		0.92 (0.84, 0.99)		0.84 (0.75, 0.93)		0.97 (0.91, 1.03)	

Differences of mean values for the SDDPS by differing levels of the 3 characteristics were considered (Table 11). There was a slight, if not statistically significant lowering by 0.08 points on average in SDDPS score observed among 4-year-olds attending early childhood education compared to 4-year-olds who were not attending early childhood education (p=0.132). On average, a slight increase of 0.01 SDDPS score among 4-year-olds males was observed compared to 4-year-old females, although this was not statistically significant (p=0.91). On average, 4-year-old children in urban areas had an SDDPS score 0.13 points higher than those living in a rural area, which was statistically significantly different (p=0.017).

Table 11. Differences in distribution of continuous SDDPS score from survey-adjusted T-Test

Characteristic (Difference)	Estimate	p	95% CI
Early Education (Yes-No)	-0.08	0.132	-0.18, 0.02
Sex (Male-Female)	-0.01	0.913	-0.10, 0.09
Urbanicity (Urban-Rural)	0.13	0.017	-0.24, -0.02

Analytic

The relationship between 3 characteristics of interest (early childhood education attendance, sex, and urbanicity) and the SDDPS score was also analyzed in order to identify any potential predictive factors (See Conceptual Model). Simple and full models utilizing linear regression (Table 8) and simple and full models utilizing Poisson Regression (Table 9).

Linear Regression

Linear Regression was used to consider the relationship between the characteristics of interest and any additional relevant, socio-demographic exposures and point differences in the outcome (SDDPS) indicative of potential social developmental delay (Table 12).

Table 12. Outcomes of Linear Modeling of Simple and Full Models of 3 Characteristics of Interest on SDDPS

		Early Education Model			*Sex/Urbanicity Model*		
Model	*Variable*	*Estimate*	*P*	*95% CL*	*Estimate*	*P*	*95% CL*
Simple	Early Education (Yes/No)	-0.08	0.132	(-0.18, 0.02)			
	Sex (Female/Male)				-0.01	0.913	(-0.1, 0.09)
	Urbanicity (Urban/Rural)				-0.13	0.017	(-0.24, -0.02)
Full	Early Education (Yes/No)	-0.06	0.271	(-0.16, 0.04)			
	Urbanicity (Urban/Rural)	-0.04	0.619	(-0.18, 0.11)	-0.01	0.766	(-0.11, 0.08)
	Sex (Female/Male)	-0.01	0.753	(-0.11, 0.08)	-0.03	0.647	(-0.18, 0.11)
	Mother's Ed (Secondary or greater/ Primary or less)	-0.13	0.064	(-0.28, 0.01)	-0.14	0.049	(-0.28, 0)
	Translator (Complete Interview/ None)	0.06	0.781	(-0.37, 0.05)	0.05	0.818	(-0.38, 0.48)
	Translator (Partial Interview/None)	0.02	0.951	(-0.63, 0.67)	0.02	0.954	(-0.64, 0.68)
	Stunting (Yes/No)	0.11	0.716	(-0.48, 0.7)	0.11	0.721	(-0.48, 0.69)
	Age in months	0	0.554	(-0.02, 0.01)	-0.01	0.448	(-0.02, 0.01)
	Mother's Age	0	0.893	(0, 0)	0	0.915	(0, 0)
	Number of Siblings	0.02	0.337	(-0.02, 0.05)	0.02	0.305	(-0.02, 0.05)
	Wealth	-0.04	0.291	(-0.11, 0.03)	-0.04	0.311	(-0.11, 0.04)

Characteristics of Interest

On average, 4-year-old Honduran children who currently attending early childhood education had an SDDPS 0.08 (95% CI: -0.18, 0.02) points lower than children who were not currently attending early childhood education in 2019, although it was not statistically significant. This difference decreased when accounting for the full model, and though neither model were significant, they were in line with expectations. On average, among 4-year-old Honduran children surveyed in 2019, females had an SDDPS 0.01 (95% CI: -0.10, 0.09) points lower than males. This difference remained the same when accounting for the full mode, and while not significant, the slight difference observed was in the expected direction.

On average, 4-year-old Honduran children surveyed in 2019 who lived in an urban area had an SDDPS 0.13 (95% CI: -0.24, -0.02) points lower than children living in a rural area. This difference was statistically significant (p=0.017). The difference decreased to 0.03 (95% CI: -0.17, 0.11) points lower when controlling for age of the child in months, sex, mother's education level, translator usage, stunting, mother's age, number of siblings, and wealth, losing statistical significance (p=0.647).

Socio-Demographic Variables

In addition to the 3 characteristics of interest, mothers' education level, translator use, stunting, child's age in month, the number of siblings, mother's age, and wealth were also considered as part of the conceptual model in linear regression. For the full model including the child's early education attendance, none of these variables had a statistically significant association, but when early education was removed in the full model for sex and urbanicity, the level of education reached by the child's mother reached statistical significance. On average, 4-year-old Honduran children surveyed in 2019 whose mother or caretaker reached secondary school or beyond had an SDDPS 0.14 (95% CI: -0.28, 0.00) points lower than children whose mother or caretaker only had a primary education level or below (p=0.049).

Poisson Regression

Poisson regression was used to consider the relationship between the characteristics of interest and any relevant socio-demographic exposures and whether a child scored above or below the cut-off (score ≥ 3) for the outcome (SDDPS), indicative of potential social developmental delay (Table 13).

Table 13. Outcomes of Poisson Modeling of Simple and Full Models of 3 Characteristics of Interest on the Binary Outcome

(Simple) Variable	*IRR*	*Estimate*	*P*	*95% CI*				
Early Ed. (Yes/No)	0.6	-0.52	0.172	(-1.26, 0.22)				
Sex (Female/Male)	0.99	-0.01	0.974	(-0.49, 0.48)				
Urbanicity (Urban/Rural)	0.81	-0.21	0.472	(-0.77, 0.36)				
	Early Education Model				Urbanicity/Sex Model			
Full) Variable	*IRR*	*Estimate*	*P*	*95% CL*	*IRR*	*Estimate*	*P*	*95% CL*
Early Ed. (Yes/No)	0.61	-0.49	0.203	(-1.25, 0.27)				
Urbanicity (Urban/Rural)	0.98	-0.02	0.96	(-0.83, 0.78)	1	0	0.999	(-0.81, 0.81)
Sex (Female/Male)	0.97	-0.03	0.912	(-0.52, 0.46)	0.99	-0.01	0.965	(-0.5, 0.48)
Mother's Ed (Secondary or greater/ Primary or less)	0.91	-0.1	0.824	(-0.93, 0.74)	0.87	-0.14	0.735	(-0.97, 0.68)
Translator (Complete Interview/None)	3.16	1.15	0.091	(-0.19, 2.49)	2.9	1.06	0.115	(-0.26, 2.38)
Translator (Partial Interview/None)	0	-19.7	0	(-20.23, -19.16)	0	-19.68	0	(-20.14, -19.23)
Age in months	0.97	-0.03	0.469	(-0.1, 0.05)	0.96	-0.04	0.322	(-0.11, 0.04)
Mother's Age	0.99	-0.01	0.362	(-0.04, 0.01)	0.99	-0.01	0.333	(-0.04, 0.01)
Number of Siblings	1.16	0.15	0.027	(0.02, 0.29)	1.17	0.16	0.022	(0.02, 0.29)
Wealth	0.91	-0.1	0.604	(-0.47, 0.27)	0.92	-0.08	0.665	(-0.46, 0.29)

Characteristics of Interest

For 4-year-old Honduran children, those currently attending early childhood education were 40% less likely to score above the cut-off compared to children who were not currently attending early childhood education, although this relationship was not statistically significant (p=0.172), a relationship unchanged in the full model. There was no relationship observed between whether a child would score above the SDDPS cut-off and sex. For 4-year-old Honduran children, although not statistically significant (p=0.472), those living in a rural area were 19% less likely to score above the cut-off compared to those living in an urban area, a difference that lowered to null with the full model.

Socio-Demographic Variables

In addition to the 3 characteristics of interest, mothers' education level, translator use, child's age in month, the number of siblings, mother's age, and wealth were also considered as part of the conceptual model in Poisson regression. For both the full model including the child's early education attendance and the full model for sex/urbanicity, only child's number of siblings reached statistical significance. In the early education full model, for 4-year-old Honduran children, those with one more siblings were 16% (Est. 0.15; 95% CI: 0.02, 0.29) more likely to score above the SDDPS cut-off compared to children with one fewer sibling (p=0.027). In the full model for sex/urbanicity (with early education removed), this difference raised to children with one more sibling being 17% (Est. 0.16; 95% CI: 0.02, 0.29) more likely to score above the SDDPS cut-off compared to children with one fewer siblings (p=0.022).

Discussion

The primary aim of this study was to determine whether the MICS6, in particular 10 questions from the Under 5 questionnaire, may be repurposed to function as a population-based, level-one screener for early social developmental delay to indicate potential autism spectrum disorder (ASD) in the LMIC of Honduras. To this end, the screen-positive rate of the Social Developmental Delay Proxy Score (SDDPS), indicative of prevalence of potential social developmental delay, was described based on caregiver responses to the 2019 Honduras MICS6 for children under the age of 5 years and compared to expected screen positive rates from similar populations. Additionally, this study sought to identify what variables may be acting as potential predictors of social developmental delay. To this end, three characteristics of interest associated with ASD and social developmental delay that may be informative for policymakers were identified. These were modeled both linearly and binarily to clearly define their relationship with the SDDPS. Finally, additional socio-demographic variables were considered. They were included in both predictive model types to account for potential confounding, but also identified potential new avenues of investigation.

The SDDPS was intended to measure social developmental delay as a proxy for potential ASD, consisting of a cumulative score ranging from 0-10 constructed from two scales within the U5 questionnaire. Responses indicating atypical social development increased a child's score, and a score above the calculated cut-off (SDDPS≥3) was considered to be indicative of potential social developmental delay. To describe prevalence of potential social developmental delay, this study found a survey-adjusted 80 out of 1725 4-year-old children surveyed to be above the cut-off, representing 4.64% of the 4-year-old population of Honduras. Promisingly, this screen-positive rate was within the anticipated range of 4-12%. As the MICS is a representative survey, if validated, this would allow Honduran policymakers, and potentially those in other countries where the MICS has been administered, interested in building infrastructure for early detection and assistance to plan more accurately for screening and diagnostics. The SDDPS was deliberately constructed to be inclusive of more generic symptoms than those specific to ASD, and the ultimate prevalence of ASD is anticipated to be lower, perhaps in the range of 2% most recently reported in the US (3). The distribution of SDDPS was also slightly, but significantly, higher among the urban population compared to the rural, which could be useful for distribution of resources. Environmental exposures like particulate matter (PM) that have been positively associated with ASD are generally more present in urban areas (111), potentially accounting for this difference.

To meet the second aim of identifying any potential predictive factors, three characteristics of interest were chosen and modeled with the SDDPS. Whether a child was currently attending education attendance was chosen because preschool is a key location for identification and intervention for ASD or social developmental delay. The sex of the child was chosen as ASD is strongly associated with sex, being consistently identified more commonly among males than females. Finally, urbanicity was chosen as a characteristic of interest as several socio-economic and cultural factors as well as access to interventions or facilities vary between urban and rural regions. Only urbanicity showed a statistically significant association with the outcome. Namely, those children residing in a rural area had a significantly higher SDDPS score on average than those residing in an urban area. This association may be due to cultural or social factors impacting the perception of development and disabilities, as one study in a rural environment in Honduras noted a high level of stigma (112). Alternately, families living in urban areas may be exposed to other children or be influenced by knowledge or values present in a more urban environment, potentially impacting how they responded to the SDDPS components of the MICS6. Interestingly, this relationship was not maintained when considering the SDDPS binarily, which may require further investigation. The lack of difference based on sex was surprising. While further investigation would be required to elucidate this relationship, it may be explained in part as infant and early child mortality in Honduras has been noted to be differential based on sex, with 19.36/1000 live birth male deaths to 15.76/1000 live birth female deaths in 2019 (113). No difference based on early education attendance was less surprising. Being around other children and in an education environment can have a positive effect on social development (5,6,75), but the Impact of this can vary (71,75). So too, can the qualities and resources available for early education in Honduras, limiting the size of impact that may have been detectable in this study's sample size (45,56).

Finally, several additional socio-demographic exposures were considered, but only mother's education level and the number of siblings were significantly associated with the outcome. Mother's education level had a statistically significant association with a lower SDDPS score, although not with whether a child scored above the cut-off. Children of mothers or caretakers who had more education (secondary level or higher) scored slightly lower than those whose mothers or caretakers had less education (primary level or none at all). This suggests that children of more highly educated parents may be more likely to recognize or willing to report developmental concerns, as has been observed among families with higher SES status (46). This association did not persist when controlling for whether the child was currently attending early childhood education. The direction of the effect was surprising since higher parental education is most commonly identified as a protective factor, although not always (47,48,50,51). As expected, children with more highly educated caretakers were less likely to score above the cut-off, on the other hand, although the association was not significant. These results suggest that more highly educated mothers or caretakers may be more likely to recognize developmental concerns but, on average, having a mother or caretaker with a higher level of education does not make a child more likely to show signs of developmental delay.

When the SDDPS was considered binarily, only having a higher number of siblings was significantly associated with a child scoring above the cut-off. While not a factor typically considered in surveys of early child development or social or developmental delay, resource depletion due to a larger number of siblings has been associated with poorer general development (65,66). If a family has more dependents, mothers and caretakers may be busier, leaving less time for social interaction with the children, or may have demands with higher priorities, like ensuring basic necessities for the children, beyond seeing to social development. Interestingly, the number of siblings was not associated with a higher point score on average, only with scoring above the cut-off. This association may be useful for focusing future screening efforts, but as this is an association not commonly identified with ASD or social developmental delay, further research would be required to elucidate this relationship.

While not all anticipated associations were observed and the screen-positive rate was on the lower end of what was anticipated, the findings were still broadly in line with what was anticipated and what has been presented in the literature. As a level-1, population-based screener, the SDDPS is not meant to be diagnostic nor to identify any specific children for further evaluation or diagnosis. Rather, the SDDPS is intended to be informative for countries that may currently have no formal measure of ASD within their population but have completed a Multiple Indicator Cluster Survey as recently as the 6th series. The SDDPS may be able to provide policymakers and other interested parties with vital information to guide future actions.

Strengths and Limitations

Strengths

The MICS is an established population-based survey with highly validated measures conducted by well-trained local staff. It has been administered in dozens of LMICs, most of which have no formal estimates of ASD in their population. The data produced is highly reliable and representative of the general population of the surveyed country, and easily accessible to policymakers and interested parties. The SDDPS is a relatively simple measure that could easily be reproduced by many countries that have conducted a MICS that contains the Early Childhood Development Index section of the Under 5 Questionnaire.

Additionally, the MICS is a very broad, comprehensive survey with a wealth of data. While this study restricted analysis to a few characteristics and socio-demographic exposures, there is potential for the investigation of additional relationships with further exposures. The MICS, as a publicly available, established source of data for many countries has great potential as a vital source of information for many countries in burgeoning fields like ASD.

Limitations

This study deliberately chose the MICS as a widely utilized and established survey and source of data for its utility for future policymakers and countries. However, the MICS6 was not designed to function as a screener and the method in which questions about a child's development are asked can play a role in how a parent or caregiver responds. This is secondary, cross-sectional data accessed after the fact, so it is not possible to influence how questions were asked and how the interviewers interacted with parents during this particular section of the questionnaire. This manner of questioning may introduce information bias into the data collection process. If questions are not asked properly with the explicit intention of gaining a clear understanding of a child's development, the SDDPS may be less likely to detect social developmental delay and results may be bias towards the null.

The Early Childhood Development Index and Child Functioning sections were not designed with screening for social developmental delay or ASD in mind, but rather to gather a general sense of if children are developmentally on track. Many of the questions asked, while similar to those used in ASD and social developmental delay screeners, are not identical and have not been validated for this purpose. This may have influenced responses. The calculated SDDPS was designed to be as sensitive as possible, given these limitations. The questions chosen for the screening tool, while modeled after the symptoms typically displayed in the social development domain by children with ASD, are not specific to ASD and could be typical of more generalized social developmental delays or similarly presenting developmental disorders, like ADHD. This could be another source of information bias, although, depending on the skew of answers, it could conceivably bias responses either toward or away from the null.

Stunting was noted in the literature as being an important indicator of early childhood social developmental delay and was measured in the study. However, only 50 instances of stunting were observed in the considered set of children so it was not analytically viable and was cut from the Poisson model. Stunting may have been a source of confounding, but the small numbers indicate its exclusion likely had little impact on the results. Ethnicity was also considered for analysis as it has been noted, along with race, as an important indicator of early childhood development. These factors were measured exclusively by asking after the ethnicity of the head of the household. Only 23.3% of those surveyed responded to this question, however, so this variable was not considered in the analysis. Ethnicity may have been a significant source of confounding in this analysis, as it has been in other studies to be intertwined with resources, health disparities, and cultural factors (43,53). While the impact of ethnicity may not carry over across multi-cultural settings, the presence of significant confounding in either direction is possible.

Conclusions

Implications

Early detection is vital to maximize the impact of early intervention, but for early detection and intervention to occur, a significant amount of infrastructure and resources need to be in place. Establishing effective surveillance and intervention systems can be costly and time-consuming, and laying out a plan and garnering political will with little country-specific evidence may be very difficult. This study was founded on the premise that such endeavors would be aided by having a better estimate of how many children need to be served and where they are located within the country. Once validated, the SDDPS may be able to serve as a key source of information for resource allocation. While the SDDPS was confined to 4-year-olds for consistency, ASD is prevalent in all age groups. The estimated screen-positive rate of 4.64% may be applied beyond the narrow age-group when considering policy actions. While anticipated actual rates of ASD are expected to be lower, Honduras has a population of over 10 million, about 30% of whom are under the age of 15 (85,114). The SDDPS, combined with the geodata available to the countries themselves, may potentially allow policymakers to narrow their focus from children in the country down to a more manageable 4-5% of school-aged children.

In Honduras, providing early intervention to children with ASD or other developmental disabilities can be a challenge. Education availability can vary widely and school attendance, especially among young children, is low, with pre-primary education reaching 41.1% in 2018 but declining steadily to 33.8% in 2021 (27,115). Special education and care centers are mandated to provide support to schools by providing teachers or teaching teams as needed, but resources do not always allow full utility of this system (56). Many schools currently lack specialized training for teachers, have a high student-to-teacher ratio, and experience stigma and superstition surrounding a child with disabilities, handicapping services despite best intentions (29,112). Despite this, early education attendance remains a key part of the Honduran system to support children with ASD or other developmental disabilities, as this is where a child is most likely to be identified and intervention is intended to take place. Having more specific, actionable information about where resources need to be devoted within these schools, as well as any other areas of the country's infrastructure, is of vital importance. The SDDPS would allow Honduras, and countries like it, to act with more direction and information to fortify and expand the resources available for their children with ASD.

Future Research Needs

Further research into the SDDPS, specifically a validation of the SDDPS as an instrument for measuring social developmental delay indicative of ASD, is necessary before it may be applied and made actionable by policymakers. As this is secondary data collected for a different purpose, it is not certain whether the SDDPS is acting as intended. While the screen-positive rate and detected associations are promising, validation, both with other ASD screeners (SRS-P or the MCHAT) as well as with actual ASD diagnoses is necessary. Furthermore, while sensitivity or specificity is key in a level-1 screener, there was no association observed between sex and SDDPS, despite ASD being consistently expressed in males at a 4:1 ratio to females (2,3,7), which would require investigation during validation.

Additionally, the application of the SDDPS, either in its current or any future iterations, would require validation in the context of multiple countries. While the MICS is designed to be validly applied in multiple cultural contexts, future research would be required to ensure that the SDDPS is transferrable in this way as well. A key feature of the SDDPS is that it can be adapted for any country that has completed a Multiple Indicator Cluster Survey that contains the relevant sections. This assertion would need to be validated, both in current MICS, as well as any future iterations. While much work yet remains, promising and interesting results were still found. The screen-positive rate detected by the SDDPS was representative of 4.6% of the 4-year-old population of Honduras, within the anticipated range. 4-year-old children living in an urban area on average scored 0.13 points lower on the SDDPS than those living in an rural area, and among the additional socio-economic factors considered, on average those children with higher parental education scored 0.14 points lower and those with one more sibling were 16% more likely to score above the cut-off compared to those with one fewer sibling. These results are broadly in line with expectations and provide groundwork for future research into the SDDPS as a tool for screening for potential social developmental delay indicative of ASD in LMICs.

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Annex

Annex Table 1. Unweighted Characteristics of the 2019 Honduras MICS6 Under 5 Questionnaire Respondents

		All (N=8461)		**47-59 Months (N=1722)**		**4yo, Urban (N=582, 33.80%)**		**4yo Rural (N=1140, 66.20%)**	
		N	(%)	N	(%)	N	(%)	N	(%)
Age (years)	0	1575	18.61	-	-	-	-	-	-
	1	1711	20.22	-	-	-	-	-	-
	2	1556	18.39	-	-	-	-	-	-
	3	1897	22.42	-	-	-	-	-	-
	4	1722	20.35	1722	100	582	100	1140	100
	Missing	247	2.84	0	0.00	0	0.00	0	0.00
Sex	Male	4437	50.95	894	51.92	315	54.12	579	50.79
Urbanicity	Rural	5613	64.46	1140	66.20	-	-	-	-
Native language	Spanish	8130	93.36	1660	96.40	567	97.42	1093	95.88
	English	8	0.09	3	0.17	1	0.17	2	0.18
	Misquito	311	3.57	55	3.19	14	2.41	41	3.60
	Garifuna	12	0.14	4	0.23	0	0.00	4	0.35
Translator used	None	8217	94.36	1673	97.15	566	97.25	1107	97.11
	Part Interview	24	0.28	5	0.29	2	0.34	3	0.26
	Full Interview	220	2.53	44	2.56	14	2.41	30	2.63
Mother's Education Level	None	383	4.40	99	5.75	18	3.09	81	7.11
	Primary 1-3	1226	14.08	274	15.91	39	6.70	235	20.61
	Primary 4-6	3377	38.78	692	40.19	166	28.52	526	46.14
	Primary 7-9	1404	16.12	238	13.82	92	15.81	146	12.81
	Secondary 1-3	1709	19.63	308	17.89	185	31.79	123	10.79
	Post-Secondary	603	6.92	109	6.33	82	14.09	27	2.37
	No response	6	0.07	2	0.12	0	0.00	2	0.18
Average wealth decile (mean, Q1, Q3)	Overall	4.33	(2, 7)	4.43	(2, 7)	6.17	(5, 8)	3.26	(1, 5)
	Urban	4.20	(2, 6)	4.65	(2, 7)	4.65	(2, 7)	-	-
	Rural	4.55	(2, 7)	4.69	(2, 7)	-	-	4.69	(2, 7)
Stunting	Stunted	278	3.19	50	2.90	22	3.78	28	2.46
Insurance	Covered	824	9.46	176	10.22	128	21.99	48	4.21
Taken outside	No	5835	67.01	823	47.79	231	39.69	592	51.93
Attending Early Ed	Attending	550	6.32	461	26.77	136	23.37	325	28.51

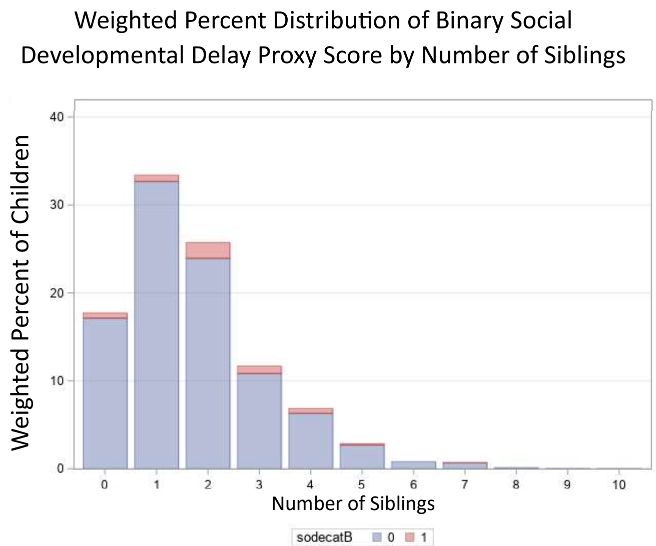
ECDI (Delayed, 36-59 months)	Literacy-Numeracy	3156	87.50	1416	82.23	458	78.69	958	84.04
	Physical	258	7.15	100	5.81	29	4.98	71	6.23
	Social-Emotional	197	5.46	70	4.07	17	2.92	53	4.65
	Learning	746	20.68	324	18.82	108	18.56	216	18.95
Child functioning (delayed, 24-59 months)	Seeing	2	0.04	0	0.00	0	0.00	0	0.00
	Hearing	7	0.14	2	0.12	0	0.00	2	0.18
	Mobility	26	0.50	7	0.41	0	0.00	7	0.61
	Comm./ Comp.	122	2.36	22	1.28	5	0.86	17	1.49
	Cognitive Learning	65	1.26	27	1.57	10	1.72	17	1.49
	Fine Motor Skills	21	0.41	4	0.23	0	0.00	4	0.35
	Behavior	269	5.21	64	3.72	24	4.12	40	3.51
	Playing	65	1.26	27	1.57	10	1.72	17	1.49

Table 14. Unweighted Distribution of the Early Childhood Development Index Scores in the Honduras 2019 MICS6

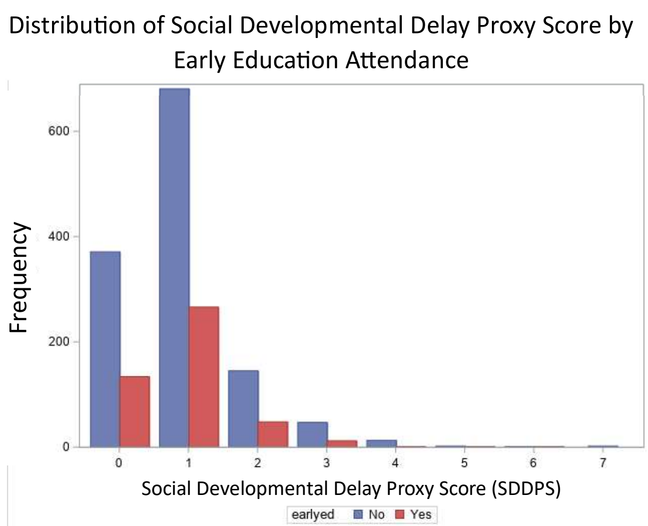
Early Childhood Development Index	36-59 Months (N=3607)		47-59 Months (N=1722)		4yo, Urban (N=582 33.80%)		4yo, Rural (N=1140 66.20%)	
	N	**(%)**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**
Child identifies at least ten letters of the alphabet (no)	3060	84.84	1376	79.91	436	74.91	940	82.46
Child reads at least four simple, popular words (no)	3314	91.88	1536	89.2	521	89.52	1015	89.04
Child knows name and recognizes symbol of all numbers from 1-10 (no)	2826	78.35	1218	70.73	372	63.92	846	74.21
Child able to pick up small object, such as a stick or a stone, with 2 fingers (no)	331	9.18	128	7.43	35	6.01	93	8.16
Child sometimes too sick to play (yes)	831	23.04	388	22.53	118	20.27	270	23.68
Child follows simple directions (no)	345	9.56	148	8.59	44	7.56	104	9.12
Child able to do something independently (no)	386	10.7	149	8.65	34	5.84	115	10.09

Child gets along well with other children (no)	253	7.01	93	5.4	39	6.7	54	4.74
Child kicks, bites or hits other children or adults (yes)	1000	27.72	430	24.97	151	25.95	279	24.47
Child gets distracted easily (yes)	2310	64.04	1090	63.3	344	59.11	746	65.44

Annex Figure 1. Distribution of Binary SDDPS Score by Number of Siblings Among Surveyed 4-year-olds



Annex Figure 2. Distribution of Social Developmental Delay Proxy Score by Early Childhood Education Attendance Among Surveyed 4-year-olds



Annex Figure 3. Distribution of Social Developmental Delay Proxy Score by Sex Attendance Among Surveyed 4-year-olds

Distribution of Social Developmental Delay Proxy Score by Sex