A Review of Data Analysis for Early-Childhood Period: Taxonomy, Motivations, Challenges, Recommendation, and Methodological Aspects

A. H. ALAMOODI[1], B. B. ZAIDAN[1], A. A. ZAIDAN[1], SUZANI MOHAMAD SAMURI[1], AMELIA RITAHANI ISMAIL[2], OMAR ZUGHOUL[1], MOMANI FAIEZ[1], GHAILAN A. ALSHAFEAY[1], AND M. A. CHYAD[1]

[1]Department of Computing, University Pendidikan Sultan Idris, Tanjong Malim 35900, Malaysia
[2]Department of Computer Science, International Islamic University Malaysia, Kuala Lumpur 53100, Malaysia

Corresponding author: A. A. Zaidan (aws.alaa@gmail.com)

ABSTRACT Early childhood is a significant period when transitions take place in children. This period is a hot topic among researchers who pursue this domain across different scientific disciplines. Many studies addressed social, scientific, medical, and technical topics during early childhood. Researchers also utilized different analysis measures to conduct experiments on the different types of data related to the early childhood to produce research articles. This paper aims to review and analyze the literature related to early childhood in addition to the data analyses and the types of data used. The factors that were considered to boost the understanding of contextual aspects in the published studies related to early childhood were considered as open challenges, motivations, and recommendations of researchers who aimed to advance the study in this area of science. We systematically searched articles on topics related to early childhood, the data analysis approaches used, and the types of data applied. The search was conducted on five major databases, namely, ScienceDirect, Scopus, Web of Science, IEEE Xplore, and PubMed from 2013 to September 2017. These indices were considered sufficiently extensive and reliable to cover our field of the literature. Articles were selected on the basis of our inclusion and exclusion criteria ($n = 233$). The first portion of studies ($n = 103/233$) focused on the different aspects related to the development of children in early age. They discussed different topics, such as the body growth development of children, psychology, skills, and other related topics that overlap between two or more of the previous topics or do not fall into any of the categories but are still under development. The second portion of studies ($n = 107/233$) focused on different aspects associated with health in early childhood. A number of topics were discussed in this regard, such as those related to family health, medical procedures, interventions, and risk that address the health-related aspects, in addition to other related topics that overlap between two or more of the previous topics or do not fall into any of the categories but are still under health. The remaining studies ($n = 23/233$) were categorized to the other main category because they overlap between the previous two major categories, namely, development and health, or they do not fall into any of the previous main categories. Early childhood is a sensitive period in every child's life. This period was studied using different means of data analysis and with the aid of different data types to produce different findings from the previous studies. Research areas on early childhood vary, but they are equally significant. This paper emphasizes the current standpoint and opportunities for research in this area and boosts additional efforts toward the understanding of this research field.

INDEX TERMS Early-childhood, panel data, longitudinal data, cross-sectional time series data.

I. INTRODUCTION

Early childhood is the period when most of transitions in children take place; this period is a significant influencer of child development as children progress into adolescence [1] and adulthood [2]. Early childhood is an intriguing research in the academic world that warrants

considerable attention [3]. Early childhood was investigated in many domains, such as social and medical domains; researchers emphasized the importance of this period in shaping many aspects of children's lives, especially brain development as discussed in [4] and [5]. This period plays a significant role in shaping other aspects of childhood development, such as growth [6], [7], emotions [2], [4], [5], [8], socialization, behavior [3], [6], [8]–[10] and health [6]. Most of children's skills are shaped during this period; these skills include cognitive [2], [8], [9], perception [11], inhibitory control [12], executive function [13], language [3] and education [14], [15]. Early childhood also represents great risk, wherein many neurodevelopmental disorders emerge [8] in addition to the internalization and externalization of problems in children [16]. Family bonds between parents and children are formed during this time [17]. Literature shows that early childhood research is gaining significant interest, which is recognized as a hot topic. Several researchers conducted data analysis on this domain and obtained good results. Therefore, data analysis is essential in the study of early childhood.

Data analysis plays a significant role in science research. Researchers worldwide utilized different data analysis measures in their respected fields for different reasons. Researchers tend to work with different analysis methods for various scientific purposes, such as evaluation [18], classification [19], investigations [11], [20], data modeling [21] and prediction [22]. Others highlighted the role of data analysis for its contribution to research [13], answering research questions [23] and the relationship of findings [24]. Some referred to social purposes, which include understanding children's related norms, such as health [25], tracking and describing changes [26], [27]; reducing biases [28]–[30] and their contribution to lack of consensus [31]. However, the nature and type of data used for the analysis play a major role in any data analysis approach.

Data type is also a significant part of any study, which is equally important as data analysis because they complete each other. Data type alone does not provide sufficient information without proper analysis. The same goes for data analysis, which will not provide information without proper data. We notice that data types in early childhood studies represent an occurrence or a situation for children at that time period. Data type may not be a significant indicator of how this period is observed given the fact that data related to children are not recorded by them, but they are recorded by parents or other caregivers [32]–[34]. A longitudinal type of data emerged in literature, which enables researchers to observe children for many years. This type of data aids researchers across the majority of early childhood studies for various purposes, such as evaluation [18], improvement of study models [35], provision of consistent estimates [6], maximization of statistical power [36], [37] and maintenance of data records [8]. Longitudinal data also vary in terms of usage; some researchers used these data for answering research questions [31], conducting investigations [38], [39], performing comparisons [40], testing models [41], [42],

providing clarifications [43], examining effects [44]–[47] and determining findings [48].

Since 2013, researchers studied different areas of early childhood by utilizing different measures and approaches. Despite the main categories, current studies focused on challenges that hinder previous researchers from exploring this area. Moreover, these studies provided suitable recommendations, which act as a guide in dealing with these types of studies in the future. Research on the area of early childhood is vast and diverse. The present study aims to provide valuable insights for future researchers in the early childhood domain by understanding the nature of the current gaps in this domain of science. The present study is meant to shed light on previous research efforts in response to early childhood studies by mapping the research landscape into a coherent taxonomy and determining the proper features and settings that characterize this line of research. This study is organized as follows. Section 1 discusses early childhood, followed by the nature of data analysis used and the types of data used for the analysis. Section 2 describes the research method, scope, literature sources and steps in research filtering. Section 3 reviews the results and statistical information of the final set of articles in this study. Section 4 shows the research landscape based on literature, which is mapped into a coherent taxonomy. Section 5 discusses and classifies the challenges, motivations and recommendations encountered by previous researchers, which were extracted from different articles on early childhood period from 2013 to September 2017. Section 6 presents the methodological aspects of previous researchers and their research settings. Section 7 presents the conclusions.

II. SYSTEMATIC REVIEW PROTOCOL
This section is based on systematic review approach or systematic literature review (SLR). This type of review promotes a comprehensive understanding of a certain topic of interest or phenomenon, which provides details and important insights for policies and future studies. This study is a good approach to identify, interpret and evaluate existing literature related to the subject [49]. This approach is widely recognized for its significant importance and its ability to accommodate various types of research methods. Such an evidence-based approach is a desirable way of boosting quality and identifying the current position of the topic and gaps in literature. This study determines topics that should be thoroughly investigated and summarizes details for future research [50]. The individual studies used in the systematic review are called primary studies. The systematic review is often referred to as secondary study.

A. INFORMATION SOURCE
The search strategy was based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement [50], which is summarized as shown in Figure 3. Five digital databases were selected for articles on search and selection. (1) ScienceDirect offers varied access to journals from different domains, such as medical, scientific and
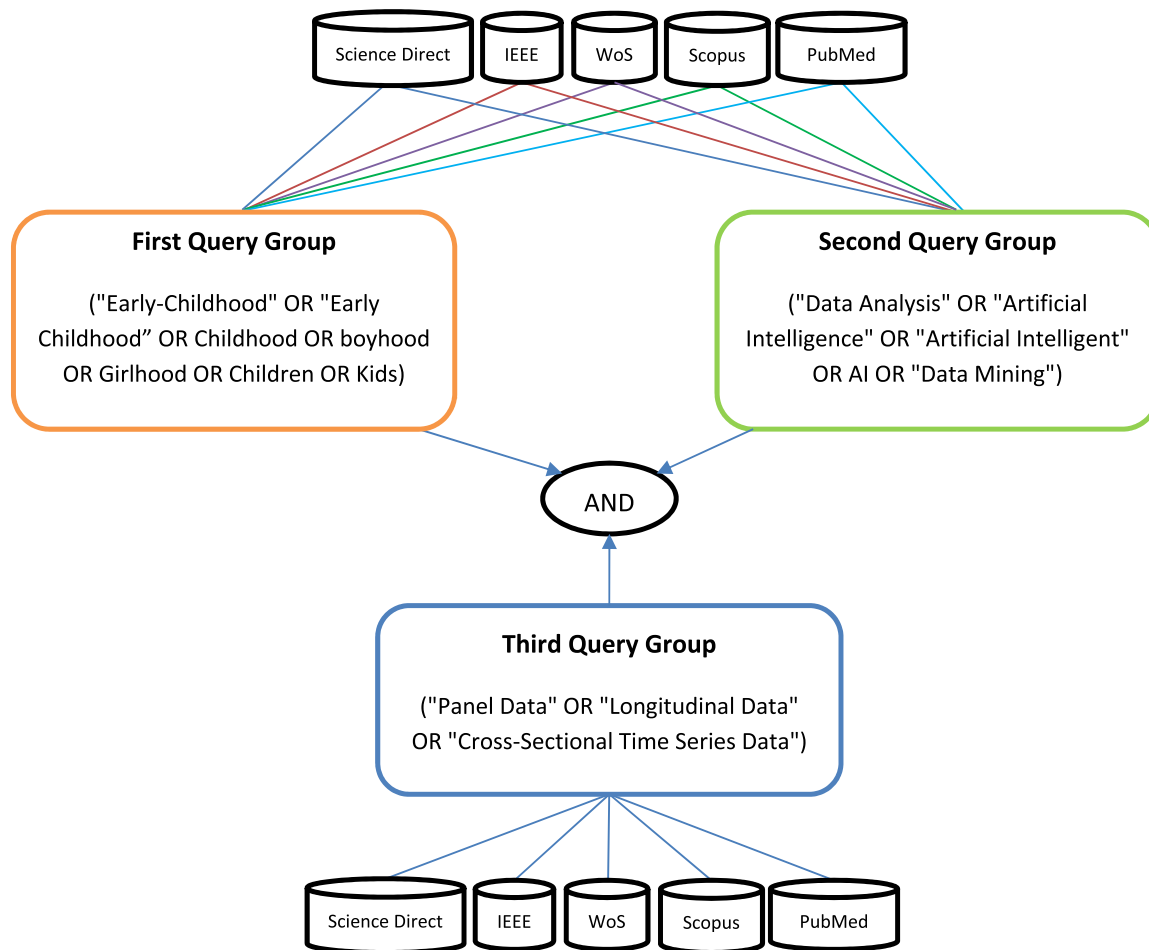
FIGURE 1. Mapping search queries.

technical journal articles. (2) IEEEXplore library offers various technology and engineering related journal articles. (3) Scopus database features various life sciences, social sciences, physical sciences and health sciences journal articles. (4) Web of Science (WoS) includes journal articles from various domains, such as social sciences, arts and the humanities. (5) PubMed database that features large number of medical and biology research papers. These five databases were selected because of their academic reliability and various presentations for journal articles from technical, social and medical disciplines.

B. SEARCH STRATEGY

The search was conducted at the middle of September 2017 in the search boxes of all five previously mentioned databases: ScienceDirect, IEEEXplore, Scopus, Web of Science and PubMed. Various word combinations and different terms were used to describe the three focus areas: ''AND'' operator was used between focus areas, and ''OR'' operators were used inside each focus area to gather phrases and words with similar meaning. Our first area of interest was related to early childhood followed by the second area, which sought to

identify different terms of data analysis approaches, such as data mining and machine learning, to determine their availability and usage in literature. The last area of the search focused on the types of data we sought to find, such as longitudinal and panel data. The exact query is presented at the top of Figure 3. We applied few extra options during the search to exclude materials, such as books, chapters and other types of reports, which do not fall under journal and conference articles. We recognize those two options as the most suitable for inclusion of the latest proper scientific papers relevant to our main area of interest.

C. SEARCH QUERIES

The search queries were created by specifying the main terms and close meaning of each section. The first section focused on synonyms and terms related to early childhood. The second section aimed to hunt for different types of data analysis. The last section was concerned with the type of data used for the analysis, as shown in Figure 1. A good number of search attempts resulted in the following search queries. The queries were expressed as three parts, which were used during the phases of title and abstract scanning and full text reading.

	Article Title	Reference 1	Reference 2	Reference 3
1	Article Title			
2	Type Of Study			
3	Age Group :(Range)			
4	Number Of Participants (Population)			
5	Type Of Analysis			
6	Technique Used			
7	Analysis Software			
8	Case Study			
9	Country			
10	Source Of Data			
11	Motivations			
12	Challenges			
13	Recommendations			
14	Limitations			
15	Year Of Publication			
16	Journal Name			
17	Database Used: (IEEE, WOS, Scopus, ScienceDirect and PubMed)			
18	Notes			

FIGURE 2. Scanned attributes of full text reading.

("Early-Childhood" OR "Early Childhood" OR Childhood OR Boyhood OR Girlhood OR Children OR Kids)

AND

("Data Analysis" OR "Artificial intelligence" OR "Artificial intelligent" OR AI OR "Data mining")

AND

("Panel data" OR "Longitudinal data" OR "Cross-sectional time series data")

D. STUDY SELECTION

The study selection phase started with the initial search, which generated 2436 articles. This phase was followed by three phases, which include screening, filtering and initiating of category to determine whether the generated articles will be included in the review or not. Duplicated articles were identified and excluded from the various databases. Title and abstract scanning were utilized to determine the relevance of each article, which were categorized later in different folders based on their attributes and similarities. The second filtering phase was commenced by conducting a thorough full-text reading of screened articles from phase one. The last phase involved a deep examination of articles to determine suitable main and sub-categories. Several notes and comments were taken during that process. Each article was analyzed separately for many attributes, which were later recorded into an Excel sheet, as shown in Figure 2. All selected articles went underwent the same process and every reference of each article was added to a separate column in a Microsoft Excel sheet.

E. INCLUSION AND EXCLUSION CRITERIA

A set of criteria were enforced for the selection of studies during the initial screening process. Studies were included if they were published between 2013 and September 2017. An additional criterion limited papers from all databases to English language. ScienceDirect papers must include articles, review articles or short surveys. IEEEXplore provides access to conferences papers, journals and magazines or early-access articles. Only article journals were used from Web of Science and Scopus. As for PubMed, it is either reviews or clinical trials. Other aspects of the inclusion criteria were mainly concerned with the topic. The first aspect was age. Given that the focus is early childhood, children 5 years or below are included. The ages of children are between 0 and 5. Thus, our search relied on this scope. Articles about children older than 5 years of age were discarded. Another type of age discusses children age's as a longitudinal process. For example, some articles examined child development over many years. Some of them are from ages 3 to age 12. This age range was included because it represents one of our main target ages (between 0 and 5) and an older age. Another type studied children at different time points. For example, some studied the effect of mother parenting over the social development of their children at age 4. At age 10, they studied children again to determine whether correlation exists between mother parenting and the development of the social behavior aspect of children when they grow up. This type was also selected. Another type of study was mainly concerned with the population of the children given that some articles do not specifically differentiate between the number of children and other individuals who participated in the studies, such as family members. For example, a type of articles states the population number of the children participated in the study. The other type mentions them with their family members, such as family dyads or mothers with their children, without differentiating their exact number. Any study that does not
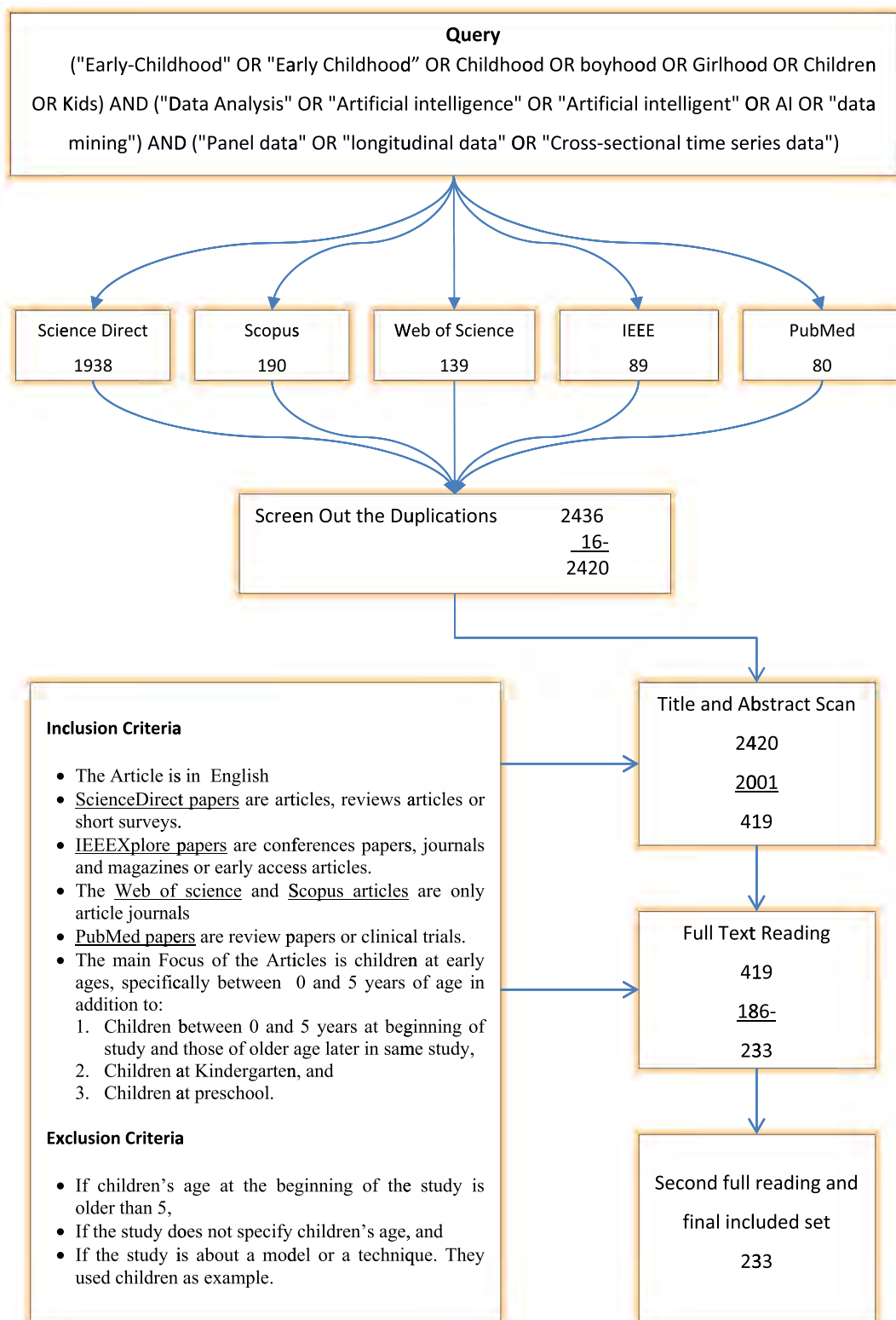
FIGURE 3. Flowchart of study selection, query and inclusion criteria.

clarify the age of the children was excluded. Any study that discusses a certain model or analysis technique, which has only been performed on the children as study case, was also excluded. For example, some articles test a new statistical model or algorithm. The aim of the article is this model, but the article included children as case study to test the validity of the model. The inclusion and exclusion criteria and the queries and search results are presented in Figure 3.
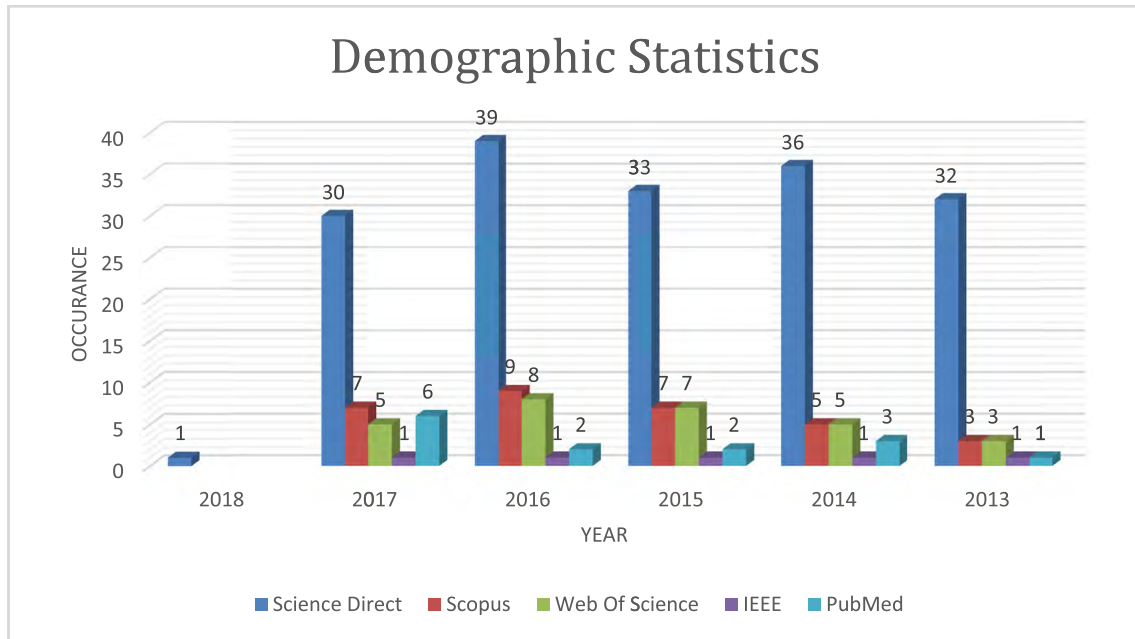
FIGURE 4. Demographic statistics.

TABLE 1. Article duplication.

Year	Database	Duplications Occurrences
2017	Science Direct, Scopus, WOS and PubMed	1
	Scopus and WOS	1
	WOS and PubMed	1
	Scopus, WOS and PubMed	1
2016	Scopus and WOS	1
	Scopus, WOS and PubMed	3
2015	Scopus and WOS	3
2014	Science Direct and Scopus	1
	WOS and PubMed	1
	Scopus, WOS and PubMed	1
	Science Direct, Scopus and PubMed	1
2013	Scopus , WOS and PubMed	1

III. DEMOGRAPHIC STATISTICS
This section presents the demographic statistics of the query search in the databases and shows the relevance rates of articles from the five databases along with years of publications (Figure 4).

Figure 4 shows that the demography of selected articles across the five different databases. Science Direct is wider in scope than any of the databases, followed by Scopus, Web of Science and PubMed. The IEEE database had the lowest number of articles. Duplication is observed between the chosen articles after the full-text reading phase within the five search databases. The results are shown in Table 1.

IV. DISTRIBUTION OF PUBLICATION BASED ON JOURNAL, AND IMPACT FACTOR
This section presents the classification of related studies with respect to Journal, and Impact Factor. This type of classification aid the researchers to target journal related to the early childhood area. (Table 2).

V. TAXONOMY
This section presents our taxonomy, which summarizes the result of our search process. The process began by searching, scanning, filtering and full-text reading of all selected articles. Upon the completion of the previous phases, all articles were classified into three major categories and

TABLE 2. Distribution of publications.

Journal / Conference Name	Impact Factor	Reference	Journal / Conference Name	Impact Factor	Reference	Journal / Conference Name	Impact Factor	Reference
Early Childhood Research Quarterly	2.364	[117] [107] [105] [225] [90] [116] [92] [91] [230] [152] [21] [44]	International Journal of Educational Development	1.403	[110] [26]	EBioMedicine	6.183	[180] [31]
Children and Youth Services Review	1.383	[17] [4] [155] [222] [130] [16] [128] [150] [154] [151] [149]	Journal of Experimental Child Psychology	2.424	[113] [102]	Educational Researcher	4	[114] [233]
Social Science & Medicine	3.007	[214] [156] [159] [210] [166] [7] [212] [169]	Journal of Pediatric Health Care	1.450	[76] [43]	IEEE Transactions on Neural Systems and Rehabilitation Engineering	3.972	[88] [39]
Infant Behavior and Development	1.669	[86] [83] [104] [72] [82] [81] [29]	Journal of Pragmatics	1.039	[79] [98]	British Journal of Nutrition	3.657	[221]
Journal of Applied Developmental Psychology	2.310	[13] [68] [24] [41] [47] [127] [48]	Lancet Global Health	18.705	[185] [168]	Canadian Journal of Cardiology	4.524	[178]
Child Abuse & Neglect	2.899	[195] [194] [193] [223] [196]	Malaria Journal	2.845	[190] [192]	Cancer Epidemiology	2.888	[183]
NeuroImage	5.426	[8] [120] [36] [35] [18]	Nutrition Research	2.707	[6] [226]	Child and adolescent psychiatric clinic	1.798	[45]
The Journal of Pediatrics	3.667	[176] [144] [161] [77] [100]	PLoS One	2.766	[174] [191]	Clinical Psychology Review	9.577	[25]
Early Human Development	2.025	[84] [87] [63] [61]	Preventive Medicine Reports		[211] [179]	Cognitive Development	1.440	[118]
Journal of Communication Disorders	1.696	[97] [101] [119] [236]	Research in Developmental Disabilities	1.820	[160] [138]	Cognitive Psychology	3.104	[122]
Journal of School Psychology	2.299	[111] [109] [1] [40]	The Journal of Allergy and Clinical Immunology	13.258	[162] [228]	Computers in Human Behavior	3.536	[123]
Journal Of The American Academy Of Child & Adolescent Psychiatry	6.250	[65] [66] [42] [60]	World Development	3.166	[27] [215]	Developmental Medicine & Child Neurology	3.289	[137]
Appetite	3.174	[23] [219] [220]	Environmental Pollution	4.358	[200]	Developmental Psychology	2.934	[12]
Contemporary Educational Psychology	3.356	[89] [115] [14]	Journal of Memory and Language	2.829	[46]	Economics Bulletin	1.02	[172]

TABLE 2. *(Continued.)* Distribution of publications.

Journal	IF	References	Journal	IF	References	Journal	IF	References
Economics and Human Biology	2.675	[170] [58] [140]	PLOS Neglected Tropical Diseases	4.45	[188]	Economics of Education Review	1.293	[78]
International Journal of Pediatric Otorhinolaryngology	1.305	[148] [143] [227]	Acta Tropica	2.509	[167]	Emotion	3.039	[5]
Journal of Fluency Disorders	1.727	[235] [234] [103]	Addictive Behaviors	2.686	[22]	Epilepsia	5.067	[145]
The Lancet Respiratory Medicine	21.466	[197] [182] [165]	American Journal of Hypertension	3.046	[207]	European Journal of Developmental Psychology	1.208	[3]
LINGUA	0.864	[95] [93] [94]	American Journal of Kidney Diseases	7.129	[187]	Food Policy	3.111	[157]
Academic Pediatrics	2.806	[9] [153]	American Journal of Medical Genetics Part A	2.264	[62]	Frontiers in Psychology	2.089	[74]
Annals of Allergy Asthma and Immunology	3.263	[164] [217]	Asian Nursing Research	0.918	[2]	Health & Place	3.000	[57]
BMC Pediatrics	2.042	[11] [133]	Augmentative and Alternative Communication	2.137	[112]	Infancy	1.873	[64]
CHEST Journal	7.652	[201] [141]	Bioinformatics and Biomedicine (bibm)		[232]	Intelligence	2.785	[135]
Clinical Neurophysiology	3.614	[146] [142]	Biological Psychiatry	11.412	[10]	International Journal of Epidemiology	8.36	[38]
Developmental Cognitive Neuroscience	4.815	[52] [129]	Biological Psychology	2.891	[54]	International Journal of Infectious Diseases	3.202	[231]
International Journal of Public Health	2.617	[177]	BMC Health Services Research	1.843	[132]	Reproductive Toxicology	2.580	[198]
JAMA Internal Medicine	19.989	[158]	BMC Medicine	9.088	[203]	Schizophrenia Research	3.958	[59]
Jama Pediatrics Journal	10.769	[224]	BMJ Open	2.413	[173]	Science of the Total Environment	4.610	[163]
Journal of Anxiety Disorders	3.481	[69]	Journal of Infectious Diseases	5.186	[181]	Sleep Medicine	3.395	[34]
Journal of Cognitive Neuroscience	3.468	[96]	Journal of Pain and Symptom Management	3.249	[184]	Vaccine	3.285	[30]

TABLE 2. *(Continued.)* Distribution of publications.

Journal	IF	Ref	Journal	IF	Ref	Journal	IF	Ref
Journal of Community Health	1.530	[139]	Journal of Physiological Anthropology	1.487	[208]	Vision Research	2.069	[80]
Journal of Cystic Fibrosis	3.858	[205]	Journal of Proteomics	3.722	[28]	ZDM Mathematics Education	2.72	[108]
Journal of Dermatological Science	3.675	[216]	Journal of Psychiatric Research	4.000	[73]	Environmental Research	4.732	[136]
Journal of Divorce & Remarriage	N/A	[229]	Journal of Safety Research	2.394	[204]	International Journal of Behavioral Nutrition and Physical Activity	5.548	[124]
Journal of Environmental Psychology	3.553	[67]	Journal of Social Service Research	0.510	[71]	Journal of occupational and environmental medicine	1.355	[199]
Social Psychiatry and Psychiatric Epidemiology	2.918	[125]	Journal of the Academy of Nutrition and Dietetics	4.021	[218]	Obesity	4.042	[175]
Teachers College Record	N/A	[70]	Labour Economics	1.066	[15]	Procedia-Social and Behavioral Sciences	N/A	[20]
The Academy of Nutrition and Dietetics	4.021	[209]	The Lancet Infectious Diseases	25.148	[189]	Paediatric Respiratory Reviews	2.354	[75]
The American Journal of Clinical Nutrition	6.549	[171]	Learning and Individual Differences	1.420	[106]	Pediatric Neurology	2.398	[147]
The American Journal Of Tropical Medicine and Hygiene	2.564	[206]	Public Health	1.441	[56]	Personality and Individual Differences	1.967	[131]
The Annals of Thoracic Surgery	3.779	[85]	Maternal and Adolescent Mental Health	0.52	[33]	Psychological Medicine	5.475	[126]
The Journal of Perinatal Medicine (JPM)	1.558	[37]	Medicine	2.028	[53]	Nutrients	4.196	[202]
The Pediatric Infectious Disease Journal	2.305	[186]	NeuroImage: Clinical	3.869	[55]	Oriental COCOSDA	N/A	[99]
Nursing Outlook	2.425	[32]	Neuromuscular Disorders	2.487	[213]	Paediatric and Perinatal Epidemiology	2.508	[134]
Neuropsychologia	3.325	[51]	Psychoneuroendocrinology	4.731	[121]			

various sub-categories. The first category, development, is related to various domains of early childhood development across many aspects. The development category has four sub-categories. The second category; Health, is related to different health aspects of children. This category has five sub-categories. The last category; ''Others'', is related to studies that do not fall in any of the previous categories. This section also presents articles that overlap between the major main categories. The main categories with their sub-categories are described in the next sections (Figure 5).

A. DEVELOPMENT

The first major category of the taxonomy is related to the early childhood development period and it contains (n= 103/233) articles. This section explains in depth all development related aspects of children by separating them into 4 sub categories.

1) BODY/GROWTH RELATED

The first sub category, namely, body/growth-development, is related to children development processes and periods related to body growth when children proceed with normal human activities, such as eating, drinking and other normal habits a person is expected to develop. Articles in this category fall into three topics namely, brain development, physical body development and general growth.

Brain development related articles ($n = 11/103$) described related studies regarding brain evolvement and growth. Studies [31], [51] focused on the electroencephalography (EEG) to scan children between 4 months and 6 years of age. Two studies examined the cortical activity of infants' brain in response to visual motion similar to [51] or explored the functional connectivity differences of 137 young children similar to [31]. Following [52], the second technique was focused on the Functional Near-Infrared Spectroscopy. This screening technique was used on Gambian infants to assess their cortical activation period from an early age until the second year of life. The third screening technique is magnetic resonance cisternography (MRC). The MRC technique was used to assess the dynamic characteristics of symptomatic arachnoid cyst (ACs) and to classify these ACs into groups [53]. The last screening technique of the brain development is Magnetic resonance imaging (MRI). The MRI technique was used mostly in the brain development with a majority of studies [8], [10], [18], [35], [36], [54], [55] and across different areas. Two studies were involved with the growth trajectories of different areas of the brain similar to [18] and [36]. Two more studies were related to age changes in children and examined whether these changes were functional [8] or related to limbic structures and symptomatology [54]. The last few articles discussed various topics, such as brain left hemisphere [55], white matter maturation [35] and neural connectivity patterns [10]. These studies were categorized on the basis of the screening technique.

Physical Development related articles ($n = 4/92$) aimed to describe articles associated with children's physical development. Four different perspectives are found in the area of physical development. External factors and their impact on children physical development include social side [56] and left-behind children of parents migration to another country to seek employment [57]; the third article was concerned with epigenetic age and physical development similar to [38]. The last one was concerned with protein and energy intakes effects on children's height and weight growth [58]. All those articles were mainly focused on the physical development of children from different angles.

General Growth related articles ($n = 7/88$) aimed to identify and offer a brief description of the head growth and growth period of children. Various topics were reported. The first one focused on children's head growth issues, such as head circumference and its relationship with autism spectrum disorder (ASD) [59] or growth trajectory during infancy [60]. Another topic focused on head growth from deformities and possible risk factors [61]. The second topic featured in the growth sub category is the period of growth which has been discussed in relation to physical growth patterns [11], height-for-age growth reference for children with achondroplasia [62] the growth period patterns between birth and five years of age [6] or characterize the child growth at three different time points [7].

2) PSYCHOLOGICAL/MENTAL

Psychological/mental category is meant to describe domains associated with the mental and psychological abilities of the children during early development. This category presents two important domains, namely, behavior and sleep. The category offers ($n = 20/81$) articles that are based on one of the two previously mentioned domains.

Behavior *related articles* ($n = 15/81$) aimed to highlight behavior related articles that cover different areas of interest related to abilities, problems and effectors. These abilities presented in literature have emotion-regulating aspect [63], imitation [64] and inhibitory control [12]. The next set of articles address the effectors of children's behavior, which have a significant impact on children's behavior competence according to the literature. Few related issues were discussed in literature, such as housing and school mobility, which are respectively presented in [65] and [66]. Other effectors were related to the environmental factors that surround children, such as genetic and environmental influences [5] and green space urban neighborhood [67]. Other articles were identified in relation to different domains, such as pre-adoption [68], trauma [69], school life with tardy classmates [70], Early parenting [71] and maternal support for children negative emotion [72]. The last set of article addresses the behavior problem encountered in the literature, which focused on different topics, namely, antisocial behavior [73] and prosocial behavior [74]. The last one was a review related to mental health problems [25].

Sleeping *related articles* ($n = 5/66$) aimed to explore the part of the literature which focuses on sleeping role in children lives and how different authors across the literature have addressed this domain from different angles. Some addressed children's rhythm of sleep patterns [34] or sleep and breathing developmental changes [75]. Others focused on sleeping problem, such as insufficient sleep [9] and other sleep problems and interventions [29]. The last one highlighted the association between children's daily routines and sleep duration [76].

3) SKILLS
Skills related fourth category is a large category that represents various aspects of the literature. This category aimed to describe all related skills found within the literature and assigning them in different domains, such as cognitive, motor, communication, academic and external factors, associated with skills. The category represents ($n = 49/61$) articles categorized based on five previous mentioned domains.

Cognitive- *related articles* ($n = 7/61$) aimed to identify literature that focuses on children's perception and cognitive development and many factors associated with growth. The family's role in the literature is significant for child perception and development; several authors explored the relations from various points, such as mother's parenting and breastfeeding [77], mother's parenting and father-figure support [13], father and mother's sensitive parenting [24], parent-child interactions [48] and reading to children [78]. Others discussed different points, such as children's ability to quote variety of linguistic inputs [79] or related to more medical and vision research [80].

Motor- *related articles* ($n = 9/54$) aimed to explore and present the articles related to the children's early motor development. Motor development in the early years of life refers to physical skills that require children to use their entire body movements. Motor development plays a significant role in shaping children's dynamic interactions with their surrounding environment [81]. Motor development is a more important effector than other domains of development, which include cognitive, social and language domains [81]. The motor development domain was and still is an interesting area of research for many. We came across set of articles which address this domain of child development from different settings and views. The first group was focused on an infant's reaching behavior [82] or reaching kinematics [83]. Others were interested in investigating parenting influence over the motor development of their infants [84] or investigating the parent assessment report validity over their children's motor development compared with two examiner-administered assessments [81]. Among other interesting investigations were the characterization of infants motor development status after cardiac operations [85] or assessment of infant hand-use preferences to identify stable preferences [86]. The last three articles focused on studying postural adjustments in infants with high

risk of cerebral palsy [87], oral-motor Behavior [39] and trunk support system to Identify Posture control [88].

Communication- *related articles* ($n = 19/45$) aimed to describe the articles which address topics related to communication skills in children. The topics found are either linguistic-based, such as vocabulary, language- or social-based. The first group was concerned with vocabulary development [89], [90]. Various topics were presented, such as language maintenance and loss [91] and speech and language competence for indigenous children [92]. Other interesting studies went deep into grammar, which includes the complement control acquisition of Mandarin Chinese language [93] and ditransitive verb structure acquisition for Russian and Ukrainian languages [94]. Others discussed language acquisition from different perspectives aside from grammar, such as bilingual first language acquisition [95], discriminate of vowel length for deaf infants [96] and comprehension of 'who' questions among children with hearing loss [97]. The rest of the studies focused on other areas, such as expressive communication skills [21], single-word to multiword speech [98], phonological network influences in children's speech [46], normative database of word production [99], mother sensitivity, cognitive and linguistic stimulation's effect over deaf children language growth [100], phonemic accuracy development in children with cochlear implants [101], children's syllabic words spelling [102], expressive and receptive language role in the recovery or persistence of stuttering [103]. The second group, which was concerned with the social aspect of the communication, presented two articles. The first one was a hybrid between expressive language abilities and prosocial behavior [3], and the last one was concerned with the social interactions of twin infants with their caregivers and same-age siblings [104].

Academic- *related articles* ($n = 9/26$) aimed to identify skills-related literature, which focuses on the academic achievement of young children. Two major groups of literature were identified in this area; the first group addresses mathematics and reading skills from different views [40], [47], [105]–[109]. The second group is considered the least academic skills that address grade retention [110], [111]. The first group dealt with various topics in relation to mathematics and reading skills; the topics include how changes in instructional practice are associated with the mathematical achievement of children [47], spatial ability and mathematics competence [11], and mathematics development of students with and without learning disabilities [109]. Other authors focused on mathematics and reading achievement by considering external human effectors, such as mother–child attachment styles [105], teacher–child relationships [40] and socio-economic status differences [108]. The last two articles in this group discuss topics, such as the importance of reading and mathematics for science achievement [106], and preschool mathematics competencies predict later mathematics achievement in later grades [107]. The second group associated with grade retention in early childhood

highlighted issues, such as the effects of early grade retention on mathematics development [110] and risk factors for grade repetition [111].

The External Factors related articles (*n* = 5/17) aimed to describe related literature of the skills but it does not fall under any of the previous four sub categories. Few articles were identified in this group and they represent different topics such as Mastery motivation [112], spacing effect [113], Science Achievement Gaps [114], peer interactions and scientific reasoning [26] and visual spatial skill [115].

4) OTHER/DEVELOPMENT

Other development category aimed to identify the remaining articles in the development of the main category that do not fall into the previous main sub-categories, namely, body growth, psychological/mental, skills and external factors sub-categories. This category also represents the articles that intersect between the major categories within the development. A relationship is found between two or more of the four major main categories. The total number of articles that falls into this category is (*n* = 12/12). The first group of articles with notable intersections begins with an intersection among behavior abilities, visuomotor skills and academic skills [116] or between behavioral abilities and academic skills [117], [118]. Another intersection took place between four different categories, which include motor, cognitive and language skills in association with growth trajectories [119] or between MRI brain scanning technique and language development [120]. An intersection exists between the social skills of the communication category and academic skills [1], followed by intersections between skills external factor and language [14] and between emotion knowledge behavioral effector and academic skills [41]. The next group represents articles that do not fall into previous categories and has no intersection, but they represent an aspect of development and have been labeled as others due to their paucity. The articles discuss various subjects, such as blood plasma proteome [28], hypothalamic-pituitary-adrenal [121], basal ganglia [42] and theory of mind [122].

B. HEALTH

The second major category of the taxonomy is related to the early childhood health domain, which contains (*n* = 107/130) of the remaining articles, this section explains the different aspects presented in literature that are connected with children's health in the early period of life. This section is divided into five sub-categories that explain various related issues, and each of those are separately detailed.

1) FAMILY RELATED

Family-related health category aimed to discuss the parental effectors that may influence or affect their children's health. Many studies (*n* = 25/107) in the health category contributed to this area. Various topics were identified, and each of them affects children differently from one another. The topics related are based on a family or a parent's behavior, mental health, parenting style, mother's pregnancy period and racial disparities.

Parent behavior-related articles (*n* = 3/107) aimed to describe literature where parents' behavior and practices pose a significant influence over their children's health; parental behavior is an important aspect of their children [123]. Three topics were identified with regard to behavior, such as a mother's role in children's outdoor play and screen-time [124], parents mobile device use and parent-child interaction [123] and parental and offspring conduct problems [125].

Parent mental health-related articles (*n* = 6/104) aimed to identify and discuss the articles related with the mental health of the parents and their children. Different studies have focused on the mental health of parents and children [17]. Various points and views are presented, such as parents' thoughts of death [17], and caregivers' depressive symptoms, which include maternal [33] and paternal symptoms [126]. Two more articles discussed maternal mental health and child behavior [127], maternal psychological functioning and school readiness [44] and the deployment impact of military families with young children [32].

Parenting style-related articles (*n* = 4/98) found that literature focused on this area, which is considered one of the most significant effectors over children's development delays [128]. Many interesting topics were addressed, such as harsh parenting [129], parental spanking [130], parenting styles and practices in either children with risk for developmental delay [128] or with children personality [131].

Pregnancy period-related articles (*n* = 8/94) focused on associated health issues with regards to the mother's pregnancy. Some of the articles describe premature labor and other actions of the mother during pregnancy. Among the ones aimed to describe the pregnancy comes three articles that discuss premature babies, each of the articles represent different views and interests, such as care patterns [132], risk factors [133], and mortality risks [134]. The second type of articles describe actions taken by the mother that may have affected the pregnancy, which includes parental smoking [135], [136]. Other authors argued the different effectors in the literature, such as prenatal exposure to food scarcity [27], parents blood pressure [37] and hypertension [137].

Racial disparity-related articles (*n* = 2/86) address the ethnic differences of mother practices in relation to their children across two different settings. These articles show that the racial differences of mothers influence children's health; the first article discusses hospital use and cost for mothers from different ethnic groups [138], and the last article discusses the social disparities in relation to children's health [139].

Other factor-related articles (*n* = 2/84) focus on articles that falls on the family side but have different topics from the ones mentioned above. Two articles identified and discussed parental education in relation to children's body

weight [140] or parental sense of coherence against an obesogenic environment [23].

2) MEDICAL PROCEDURE

Medical procedure health category present articles that spoke about a medical procedure performed on children. This category represents a few articles ($n = 4/82$), as per our search in the literature that considers the age scope of children. The articles discussed were deep into the medical domain, and they pointed out several techniques, such as spinal muscular atrophy [141]. The article was considered despite that the age of the participant is less than 10 years, and we assumed its acceptability because the range is not specific. Other techniques were electrical impedance myography [142], the Furlow technique for late cleft palate [143] and echocardiographic screening for patients with heart disease between the ages of 5 and 17 [144].

3) INTERVENTIONS

Health intervention category pointed out efforts that have been implemented to protect children or asses their health. Authors have taken different approaches in this domain. Some relied on techniques, which are the first subcategory. Others focused on services and center-based programs, and the rest addresses the matter in a general practice perspective. The intervention category represents ($n = 17/78$) journal articles that were categorized into three subcategories.

Technique-*related articles* ($n = 4/78$) showed the approaches used with regard to children's health and intervention. The authors took different approaches and techniques in analyzing and proposing ideal solutions. The first example represented by [145] is a prediction technique that aims to predict seizure count for paediatric epilepsy. The model relies on big data approach, and it is one of the views that relied on a non-statistical prediction approach. The next study relied on a prediction technique to classify infants at risk of a language-based learning disorder and a support vector machine (SVM) for classification [146]. The last two articles relied on different techniques, such as biomarkers for assessing Duchenne muscular dystrophy [147] and Paediatric diagnostic audiology testing [148].

Services-*related articles* ($n = 11/74$) identified intervention services across literature that have been investigated for the benefit of children and how they were implemented. Few researchers addressed this topic with respect to families, such as parenting and children behavior changes after a support program [149], early program impacts on parenting [150] and improving of practices [151]. Others discussed intervention approaches [152], [153] and intervention outcomes [45], [154]. The last few articles discussed different topics, such as crisis nursery [155], health insurance impacts [156], interventions effectiveness [157] and their relationship to population health improvements [158].

Practices-*related articles* ($n = 2/63$) described general practices that contribute to an early intervention for children health. Only two articles are described. The first one focuses on changing the handwashing behavior [159], and the last one focuses on an intervention strategy for destructive behavior in children with severe intellectual disability [160].

4) RISKS

Health's risks category shed light on literature associated with health risks that affect children based on age. Health risks are serious and significantly contribute to the downfall of children's health. This category presents ($n = 46/61$), which is considered the majority of the entire health category. The category is divided into three main subcategories. The first one discusses health risks related to diseases that affect children at a young age. The second one investigates health risks with regard to adverse childhood experiences. The last one discusses other factors. Articles were placed in this category given their small numbers.

Disease-*related articles* ($n = 35/61$) represented the most popular diseases found in literature with regard to early childhood. Some of these diseases are life-threatening, such as asthma [161]–[165] which seems to be associated to children's behavior and skills [166] and caregivers quality of life [43]. The second most fatal disease related to this issue is child mortality, which has been covered by a great amount of literature from different sides, which include patterns [167], trends [168] and its impact by democracy and media freedom [169]. Moreover, child mortality seems to play a major role in the country's economy [20], [170]. Other authors addressed child mortality with respect to human deficits, such as stunting, wasting and being underweight [171] and with respect to vaccination effect [30]. The rest of the articles that tackle child mortality focused on different areas, such as relation with fertility decline [172], comorbidity [173] and household demography [174]. The third disease is associated with obesity children, which is a major concern that needs to be taken seriously during the early ages because being overweight may have a lasting effect on children's health. Obesity has been linked to many external effectors before and during the children lives; some cases of obesity occur even before the child comes to life, which is related to maternal gestational weight gain [175] and the timing of delivery [176]. Moreover, obesity was investigated to determine if it is a risk factor of stunting growth in children [177] or evaluate its prevalence in children with congenital heart disease [178]. The last study aimed to investigate the relationship of between obesogenic environment and children adiposity [179]. The last few remaining articles focused on other remaining diseases, such as anaemia [180], dengue [181], chronic obstructive pulmonary [182], cancer [183], [184], sickle cell trait [185], HIV [186], kidney disease [187] and malaria [188]–[192].

Adverse childhood experience-*related articles* ($n = 5/26$) presented studies related to abuse and maltreatment in the early days of life and the negative experiences they may leave on children given their fragile nature at these ages. They may carry these experiences for the rest of their lives. Among the issues discussed in literature is sexual abuse [193], repeated maltreatment [16], characteristics [194], patterns

of exposure [195] and the relation of these factors with unemployment [196].

Other common related articles *(n = 6/21)* presented other risks associated with childhood period that are not a disease but may cause the deterioration of children's health and lead to a disease. Other interesting areas covered in literature that are related to these causes are germs and bacteria [197], contaminated drinking water [198], [199], childhood cigarette and alcohol use [22], smoke exposure [200], and risk of hospitalization [201].

5) OTHER/HEALTH

Other health category identified the remaining articles in the health main category that do not fall into the previous main subcategories (family, medical procedure, intervention and risks). This category also represents articles that intersect between the major categories within health, and they have a relationship between two or more of the four major main categories. The total number of articles that fall into this category is (*n* = 15/15). The articles with intersections begin with an intersection between a mother's dietary patterns during pregnancy period and childhood obesity [202], in addition to mother's depression and its relationship with infant health problems and abuse [2]. Other researchers covered different issues, such as vaccination strategies [203], traffic fatality [204], Oropharyngeal swab in children with cystic fibrosis (CF) [205], predictors of inflammation in infants [206], the association between serum levels of uric acid and blood pressure tracking in childhood [207], kindergarten barefoot policy's effect on preschool children's toes [208], added sugar consumption [209], socioeconomic status (SES) and child injuries [210] and prescriptions for outdoor physical activity among children [211]. The last few articles covered children's health effect on education [212], myotonic dystrophy [213], how household social capital and socioeconomic inequalities can result in child undernutrition [214] and how mother's empowerment relates to children's nutritional status [215].

C. OTHER

The third and last major categories of the taxonomy are related to the remaining articles of our literature review. The section presents (*n* = 23/23) articles, which are placed in this side of the taxonomy and overlap between development and health. If any article is associated with two or more of the main two categories (development or health) or does not fall in any of the previous categories, it is represented in this category. First set of articles aimed to define and differentiate between different aspects related to food in early childhood period, which includes allergy, preferences and body mass index (BMI). Food allergy is a serious health and developmental concern that ultimately affects children's quality of life [216]. Among other topics that discussed children's food allergy is the timing of allergenic food introduction by parents similar to [217] or another side related to dermatology with the timing of eczema onset and its relation to food allergy

similar to [216]. As for the food preferences. Early childhood is a sensitive period and a critical development phase that also plays a major role in shaping children's dietary patterns [218]. Among the points discussed in the literature are parental strategies used to influence children's food preferences [219], the article shows an overlap between development category and intervention practices from the health category the relation of noncore foods, such as vegetables and fruits, with children's later food preferences as in [218], which shows an overlap between health category and the psychological from the development category. As for body mass index (BMI) related studies. BMI is the most appropriate quantitative measure of overweight in children. BMI is defined in two ways. The first one is the association between the BMI of packaged and fast food brands and children's knowledge, as in [220]. The second one pertains to how protein intake from early childhood to puberty is associated with adult BMI, as in [221]. The first one is the association between the BMI of packaged and fast food brands and children's knowledge, as in [220]. The second one pertains to how protein intake from early childhood to puberty is associated with adult BMI, as in [221]. Both articles of BMI show an overlap between health category and the development category. Second group of articles in this category shows different topics that overlaps between the categories. The first article by [222] drew a relation between behavioral effectors under the psychology, academic skills and racial disparities. The second one falls among intervention services, adverse childhood experience and language development [223]. The next one by [224] belongs to intervention services, mental health problems and academic skills or with only academic skills and intervention services [225]. An overlap between growth and family health, as shown in [226], includes mental health and parenting style, cognitive skills and children's behavioral problems [4]. Overlap was also observed between language development and the EEG technique of the brain [227] and between asthma and BMI [228]. The last three articles in this respect described divorce psychological effectors in relation to a practice framework under intervention services [229], child care subsidies and children's cognitive development [230], effect of helicobacter pylori infection on growth impairment [231] and growth patterns in children at high risk of obesity [232].

The last set of articles covered different points, which we believe do not fall in the previous areas of the taxonomy; these articles include how minority children are disproportionately represented in special education schools [233] and professional development of preschool teachers with respect to child education [15]. Two articles addressed children with stuttering sub types [234] and their relation with sympathetic arousal [235]. The last article described school and home language environments of preschool-aged children with Autism spectrum disorder ASD [236].

VI. DISCUSSIONS

This section describes three major points in this study. After the full reading phase and the taxonomy, this phase aims

to summarize some interesting points included in existing literature. The points discussed in this section are summarized into three major points, which includes challenges, motivations and recommendations associated with early childhood studies. The significance behind this is to show future researchers in early childhood the challenges and issues they may face and enable them to take early actions in addressing these challenges. For example, among the common issues faced in the literature is the issue of biased reporting by family members or others during the data collection stage [33], [34], [217]. Therefore, as future researchers proceed in this domain of science, they consider this issue before its occurrence. The same concept is applied for other challenges. The motivations which also inform future researchers how their previous peers were drawn into this domain of science and things that inspired them to pursue their respected studies in the early childhood area. The last discussion includes the recommendations, which represent the link between previous researchers and the new ones. As previous researchers acknowledge their limitations, they transform their knowledge in the form of recommendations for their future peers who pursue a similar type of studies. Therefore, new researchers expand previous research to improve work in this domain.

A. CHALLENGES

This section describes the common challenges found in early childhood studies across different domains, as presented in the previous taxonomy in Figure 5. The challenges discussed in this section are elaborated because they come from different domains and separating them for the sake of this paper is a highly complex process. They are only shared based on their general importance. (Figure 6).

1) CHALLENGES RELATED TO DATA NATURE AND AVAILABILITY

Data is the most important aspect in any study and it is the most significant effector that controls the analysis, findings and all the study's elements. However, when dealing with early childhood studies, some notable data issues occur in many areas of literature, such as missing data [21], [66], [138], [152], [176], [199], [212], reliance on administrative data [114], [137], [138] and the huge lack of longitudinal data and studies [1], [3], [17], [28], [31], [37], [41], [48], [55], [71], [102], [109], [114], [123], [124], [160], [162], [177], [178], [184], [192]–[194], [206], [212], [213], [222], [228], [231], [233]. Other studies shed light on other issues related to data, which include structure [1], accuracy [110], incompletion [100] and scarcity [65], [116].

2) CHALLENGES RELATED TO STUDY POPULATION

This challenge discusses major issues related to the samples and population of previous studies; several issues were identified with respect to early childhood studies, which include a small sample size, as pointed out in references [5], [10]–[12], [14], [23], [40], [53], [55], [61], [66], [81], [87], [90], [97], [111], [112], [116], [119], [129], [135], [138], [141]–[143], [146], [149], [152], [159], [164], [173], [176], [179], [181], [187], [198], [199], [206], [207], [211], [212], [219], [224]–[226], [233], [236].

3) CHALLENGES RELATED TO DATA ACQUISITION

This challenge is meant to investigate the common issues faced during the data collection process from various studies across the literature. Parent involvement in data collection with respect to their children is common. Moreover, researchers across many studies consider it a major limitation that introduces undeniable biases. Family biases while reporting children's information can include many daily scenarios, such as sleeping [9], [34], [76], physical activities [211], food allergy [216], [217] and outdoor playing time [124]. Others biases can be found during interactions with children [33], [150], and when measuring their behavior [3], [16], [23], [74], [149], [193], [194], [222], development [81] or health-related issues [166]. Aside from the parenting report for their children, the next issue resides in reporting parental information by themselves, which also introduces self-reported biases, as seen in their psychological and mental health [4], [17], [44], [63], [126], [212], and practices [13], [77], [128], [131], [159], [195], [197]. Other reporting biased can be introduced through teachers [1], [47], [224] and other self-reporting methods [110], [145], [209], [210]. The second major issue in the data acquisition phase is the incomplete survey [176], [177], [199].

4) CHALLENGES RELATED TO FINDINGS

This challenge points out two common issues related to the findings of previous early childhood studies based on the literature point of view. The two most significant issues are the inability to generalize the findings and inability to draw a casual conclusion. The inability to generalize could be due to various reasons, namely, missing information [223], limited samples [11], [61], [123], [146], single population [2], [11], [26], [33], [41], [64], [87], [117], [130], [150], [153], [178], [179], [194], [218], [236], different ethnicities [40], [69], [127], [138], different geographical locations [14], [43], [56], [130], [137], [144], and different socio-economic level [9], [43], [124], [137]. The second issue is the inability to draw a casual conclusion; it is also affected by several causes, such as data limitation [47], [93], insufficient sample [205], observational study nature [221] and cross-sectional study nature [23], [155], [226].

5) CHALLENGES RELATED TO LACK OF STUDIES

This challenge focuses on the lack of study on early childhood across many domains. This lack of studies is distributed based on the general area. First, studies that examine relations between parents and their children to determine what type of effects they pose on each other are lacking [4], [13], [23], [24], [33], [44], [100], [127], [129]–[131], [152], [155], [217]. Second, the skill-related studies to measure various topics and issues from language, mathematics, reading
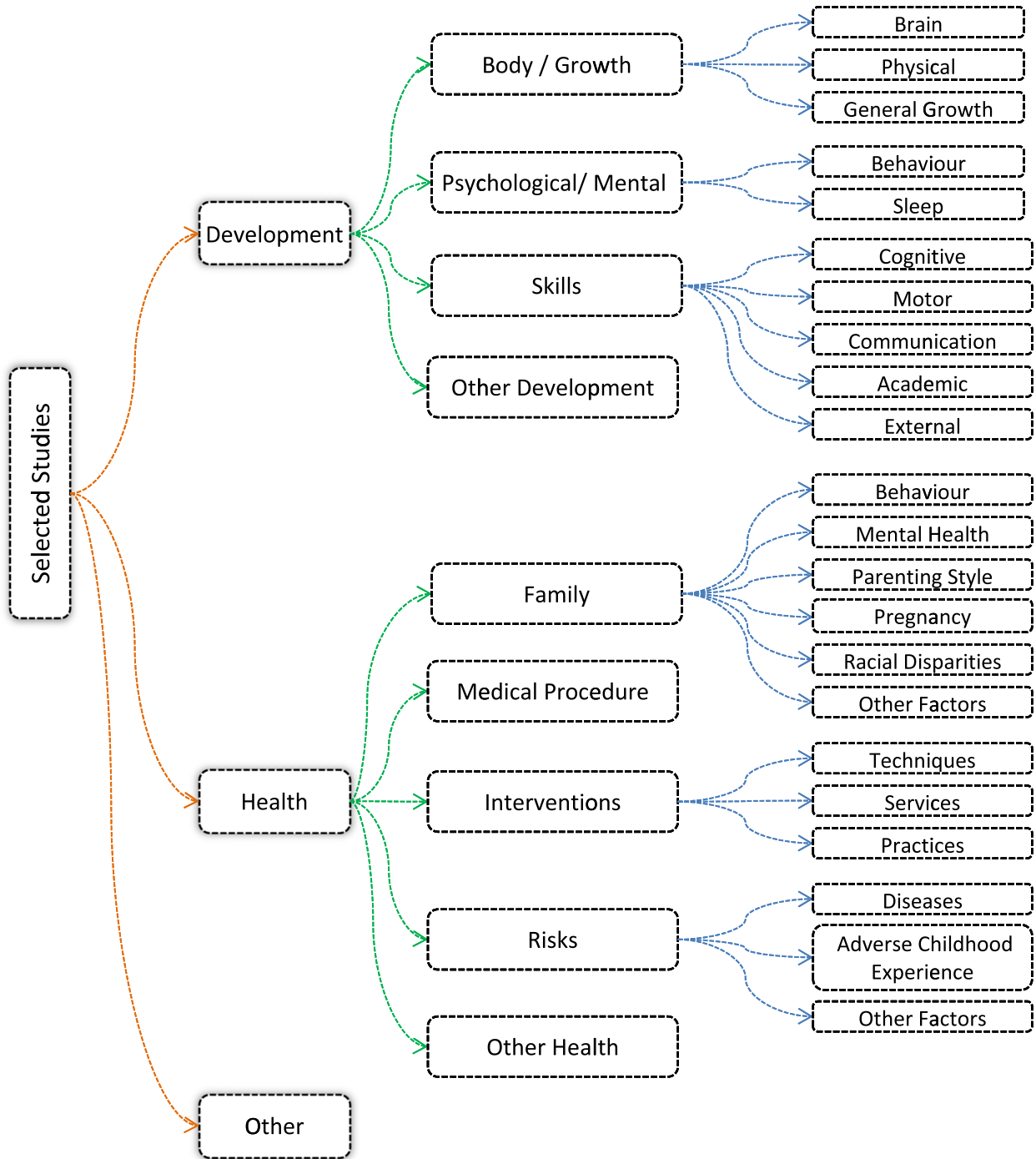
FIGURE 5. A Taxonomy of research literature on early childhood.

and social are lacking [11], [12], [41], [80], [89]–[91], [94], [105], [107], [115], [116], [223], [230]. The last two portions lack studies related to health [6], [23], [43], [156], [161], [209], [221] and development [63], [77], [84], [223].

6) OTHER CHALLENGES
This challenge is meant to address many challenges that do not fall into any of the above ones. In early childhood studies,

researchers across discussed complex and different areas of interest due to the vast size of this study domain. Most of the issues discussed in this challenge have a slight occurrence in the literature and are not sufficient to form their own section. However, the remaining challenges are discussed and brought close to each other (Figure 7).

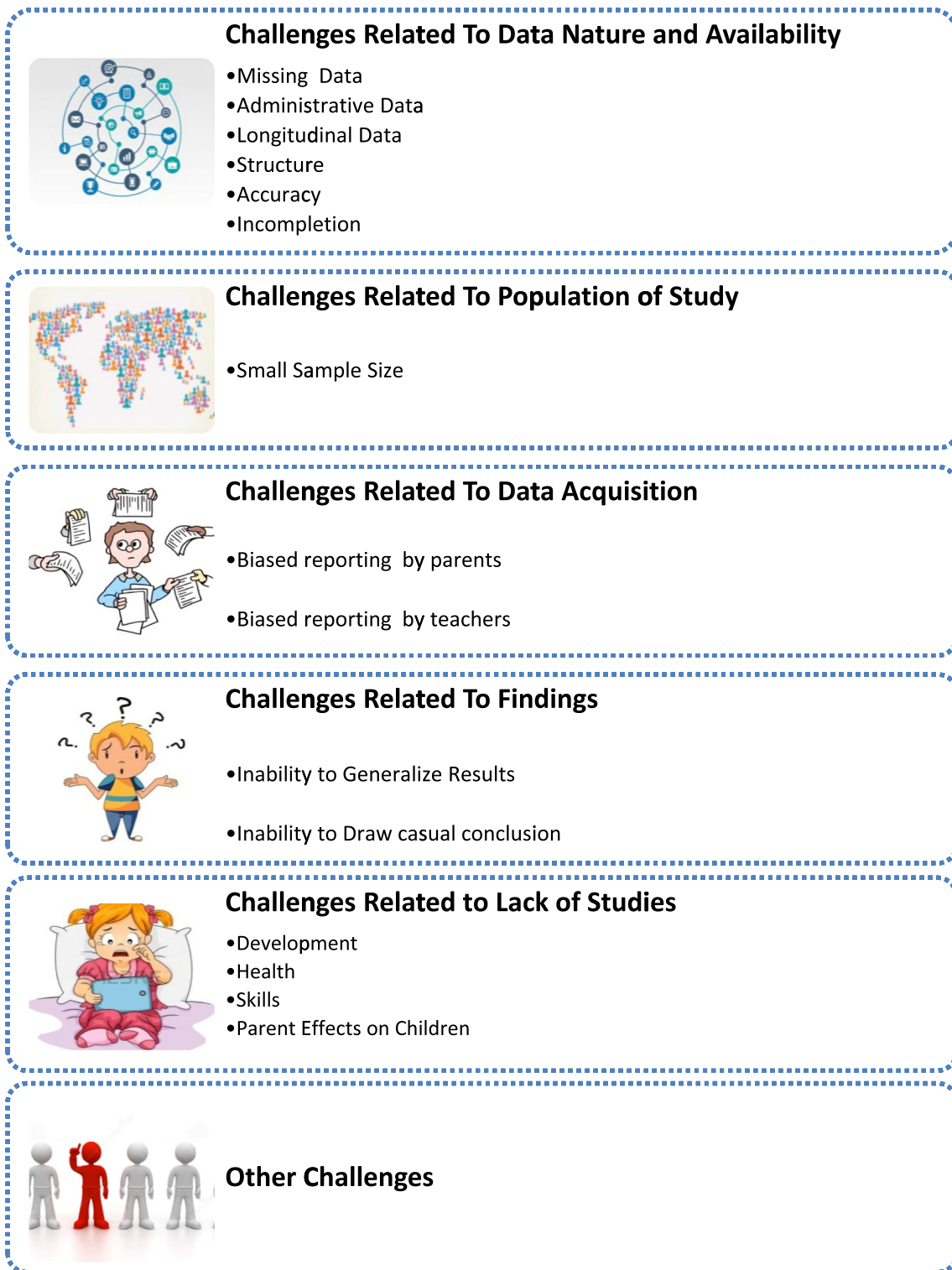The first issue in the other challenges is method, which speaks about the previous method and its inability to

Challenges Related To Data Nature and Availability
- Missing Data
- Administrative Data
- Longitudinal Data
- Structure
- Accuracy
- Incompletion

Challenges Related To Population of Study
- Small Sample Size

Challenges Related To Data Acquisition
- Biased reporting by parents
- Biased reporting by teachers

Challenges Related To Findings
- Inability to Generalize Results
- Inability to Draw casual conclusion

Challenges Related to Lack of Studies
- Development
- Health
- Skills
- Parent Effects on Children

Other Challenges

FIGURE 6. Issues and challenges overview.

measure issues, such as the density of the household that emitted coal smoke in a neighborhood [200]. The second issue is the mechanism used in some previous studies and how they failed to inform researchers about many phenomena and problems, such as the inability to explain increases in malaria risk through iron supplementation [180], mechanisms to explain the relationship between insufficient sleep and adverse health outcomes [9], mechanisms to show how
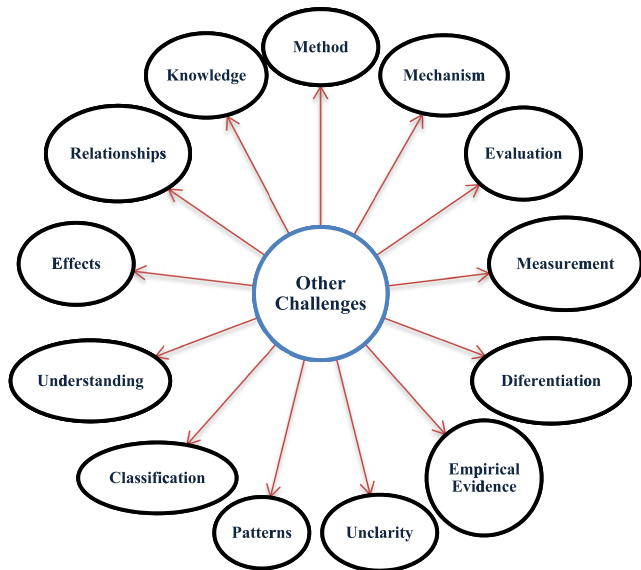
FIGURE 7. Other challenges overview.

protein intake in early life is positively associated with the risk of obesity [221], imitation mechanism in the social development aspect [64] a and mechanisms to explain depressive symptoms in fathers with behavioral and emotional problems in children [126].T The next issue is evaluation. Reference [85] indicated the lack of a validated metric for objective evaluation of early motor impairments in the intensive care unit for children. The next issue is measurement. Children who experienced hospitalization [85] and preadoption [68] have no short-term consequence measurements. Differentiation is another issue. Two studies pointed out that previous literature did not differentiate between the types of hearing devices and children with different degrees of hearing loss [97] and between the head circumference growth in preschizophrenia cases [59]. Next issue is lack of empirical evidence, which was pointed out in two studies that discuss topics, such as children's outdoor prescription for their physical activity [211], science achievement gaps in children in the United States [114], and Quality of Life in Children with HIV [186]. The next issue is lack of clarity, which has been experienced in some previous early childhood studies that cover topics, such as the spacing effect [113], anxiety effect on limbic regions development [54], mycoplasma pneumoniae effect on Asthma control [164] and nature of brain structural change [8]. Another issue is patterns; few studies report the lack of and need for pattern identifications in cases such as seasonal patterns of mortality rates [167], maltreatment patterns on non-sexually abused children [193] and patterns of mastery motivation in children with complex communication needs [112]. Other studies focused on the classification issue, as shown in previous classification subtypes of children stuttering [234] and classification agreement on infant hand use preferences [86]. Many researchers are challenged by the previous understanding of certain issues, which seems to raise their awareness and encourage them to dig deeper in these areas; some were motivated by issues, such as

the association between emotion and stuttering [235], food preferences development within families [219], visuomotor skills link to academic success [116], healthy brain development trajectories during preschool [8], cortical mapping of cognitive function in infant [52], and reading achievement and mathematics achievement in the prediction of science achievements [106]. The next challenge concerns the effects of some variables over others many points from different academic domains, such as teacher–child relationships [40], genetic differences in emotion [5]; housing mobility on mental health [65]; parenting on children's outcomes [24]; allergic food introduction [217], echocardiography effect on screened children [144]; psychological, health and schooling effects of divorce on children in UAE [229]; the psychological effect of school mobility on early adolescence [66]; parent's food deprivation effect on children [27] and child mortality impact on GDP per capita [170]. Some researchers were challenged by the ambiguous relationships of some variables, which include socio-economic status (SES) and child body weight changes [140], why a mother's attachment with her child is stronger than a father's attachment [84], and unemployment and child maltreatment [196]. Researchers were also challenged by the lack of knowledge of certain topics in many cases, such as effective intervention knowledge for children at risk of abuse and maltreatment [155], sources that contribute to early arithmetic learning in children [14], language acquisition for children in multilingual and multicultural environments [92], factors that help predict recovery of stuttering [103], characteristics of school language environments for children with ASD [236] and children's ability to quote a variety of linguistic inputs [79].

B. MOTIVATION
This section describes the parts of the literature that encouraged researchers in early childhood studies across many domains. These motivations were categorized based on their general purpose and similarities (Figure 8).

1) RELATED TO EDUCATIONS
Education is an important aspect of children's early lives. Education is the foundation that guarantees children's skills development. Researchers were motivated to pursue this kind of studies for many reasons, which include differences in learning and whether the differences were driven by socioeconomic status [108] or children's race [225]. Others looked into education from different points and were highly motivated by the desire to understand issues during the learning process, such as behavior problems' relationship with academic problems [222], childhood health effect on schooling [212] and early care education role in helping children who have been through adverse experiences [223]. Some scholars were driven by academic transitions in children skills in cases such as mathematics [47] and language [91]. Other topics, such as later education achievements in children, attracted the attention of researchers for its long-term and positive effects [15], predicting positive transitions and later

Motivations Related to Education
- Differences in learning
- Learning issues
- Academic Transitions
- Education Achievement

Motivations Related to Family
- Positive Effects
- Negative Effects

Motivations Related to Interventions
- Clinical decisions
- Supporting strategies
- Education settings
- Early control
- Maintaining future health
- Risk prevention and control

Motivations Related to Data Source
- Limited data
- Single or incomplete time points
- Lack of data resources
- Poor testing

Motivations Related to Children
- Changes
- Abilities
- Skills
- Emotions
- Developmental issues
- Child Care Services

Other Motivations

FIGURE 8. Motivations overview.

school outcomes [225], early competencies [107], acquisition of further and advanced academic skills [14], [41], [91], [118] and its role for later school grade achievement [44]. The last group was motivated by understanding the role of teachers in promoting the academic resilience of racial/ethnic minority children at-risk for poor achievement [40] and the importance of understanding academic outcomes for children with disabilities [109].

2) RELATED TO FAMILY
This motivation is driven by the interest of researchers across the world to understand family effects on their children and how these effects, whether negative or positive, can contribute to one's early childhood. The first group focused on understanding the importance of positive family presence in various cases, such as the benefits of family interactions for children with positive experience [13] and emotion [48] and in the learning context [44], [100], as well as the family sense of coherence [23], parent-children relationship [128], understanding children differences [131], nutrition relationship [215], [224], skills [13], [44], [72], [78], development [24], [71], [78], [84], [105], [167] and health [139], [166], [226], [229]. Other researchers were more driven by the importance of understanding of

negative effects associated with parents and their effects on children in many cases, such as parents' depression [2], [126], [127], stress [44], unemployment [196], smoking [135], divorce [229], spanking [130], poor nutrition [27], poor behavior [131] and migration [57].

3) RELATED TO INTERVENTIONS

This motivation discusses parts of literature that were inspired by the possibility of an intervention that may help maintain risks or control them. Many interventions across the literature were meant for various reasons. The most important ones are meant for medical related means, such as clinical decisions [213], supporting strategies [105], [229], early control of children behavior [160], emotions [5], early diagnosis [28], education settings [21], [109], [111], [153], [212], promoting positive practices [159] and maintaining future health [25], [156]. Others were highly encouraged by the possibility of early intervention for risk prevention and control in disease-related [43], [124], [144], [161], [162], [185], [188], [189] and non-disease-related cases that also covers child-related cases, such as disorders [8], [12], [103], injuries [210], maltreatment [194], [196], hearing loss [148] and development delays [128] or parent related such as preterm birth [133] and pregnancy risks [137].

4) RELATED TO DATA RESOURCES

Researchers across literature were handicapped by data resources, whereas others considered a challenge. Others were motivated to pursue looking by existence. Some of these motivations that encouraged many were data-related, such as data limitations, due to geographical location setting [6], [34], collecting previous data at single or incomplete time points [11], lack of data resources [168], acquisition [93] and considering findings based on one time point [16].

5) RELATED CHILDREN

This motivation summed up all the remaining previous efforts of researchers across the early childhood domain to understand the different aspects related to children. Researchers from various academic background and research domains were inspired by changes in children and led them to pour their interest in such studies. Some were motivated by body related changes in children [2], [8], [18], [36], and others were more encouraged by abilities [11], [97], skills [81] and emotions [4], [128]. Another group was encouraged by the importance of various developmental issues in children's lives, which include changes [28] effects [190], [231], relationships [54], [172], [188], [202], [218], [235] and differences [119]. Remaining motivations were concerned with other children related issues but had few occurrences, which include the importance of understanding the impact of some child care services, such as subsidies [230] and crisis nursery [155], immune response to dengue virus [181], in addition to understanding reaching development via kinematics [82], syllabic stage in the development of literacy, speech

development after cleft repair [143], and language development through neighborhood density [46].

6) OTHER MOTIVATIONS

This part aims to address the remaining motivations that did not fit into the above categories and had few individual occurrences in literature. Some of the researchers were motivated by the importance of this kind of studies for medical reasons, such as clinical trial design and analysis [145], conducting and understanding epidemiological studies [166], [199] and future research directions [35], [183].

C. RECOMMENDATIONS

This section discusses the portion of the literature that summarizes previous researchers' recommendations for future directions. These recommendations were categorized based on their relevance, as shown in Figure 9.

1) RELATED TO RESEARCH

This recommendation discusses the previous researchers' hopes and recommendations for future studies. Most researchers across early childhood domains agreed on some recommendations despite differences in their field of interest among early childhood studies; they agreed on certain recommendations such as the need of early studies to conduct a more comparative research [18], [219], [236], genetics research [5], [64], [74] and evaluations studies [11], [31], [63], [65], [85], [146], [162], and the large sum of recommendations for a more longitudinal research [1], [5], [10], [12], [38], [43], [45], [47], [48], [54], [61], [63], [69], [75], [91], [93], [103], [117]–[119], [121], [136], [146], [162], [193], [209], [210], [212], [219] and exploratory research [5], [33], [37], [41], [72], [84], [109], [111], [123], [124], [203]. Among the hot topics that were highly recommended is research for parents and their children Some researchers recommended that other aspects related to children's skills must be studied more, which includes visual spatial aspects [14], [115], reading and mathematics [105], [106], arithmetic [11], scientific reasoning [26], academic [118], cognitive [112], and language and vocabulary [14], [89], [90], [97]. The next group of researchers recommended future studies for the health domain to address issues, such as diseases [163], [171], [177], [183], [216], and children's health changes [8], [9], [75], [211].

2) RELATED TO DATA ANALYSIS

Data analysis is one of the most important components of most early childhood studies; researchers across many domains in the literature viewed recommendations for future studies that utilize data analysis technique; some encouraged the utilization of more data analysis objective measures [43], [76], [141], [211] and replicated studies while utilizing different measures [194]. Others focused on using different techniques, such as machine learning [146], [147], time-to-event analysis [162], cross-lagged analysis [5],
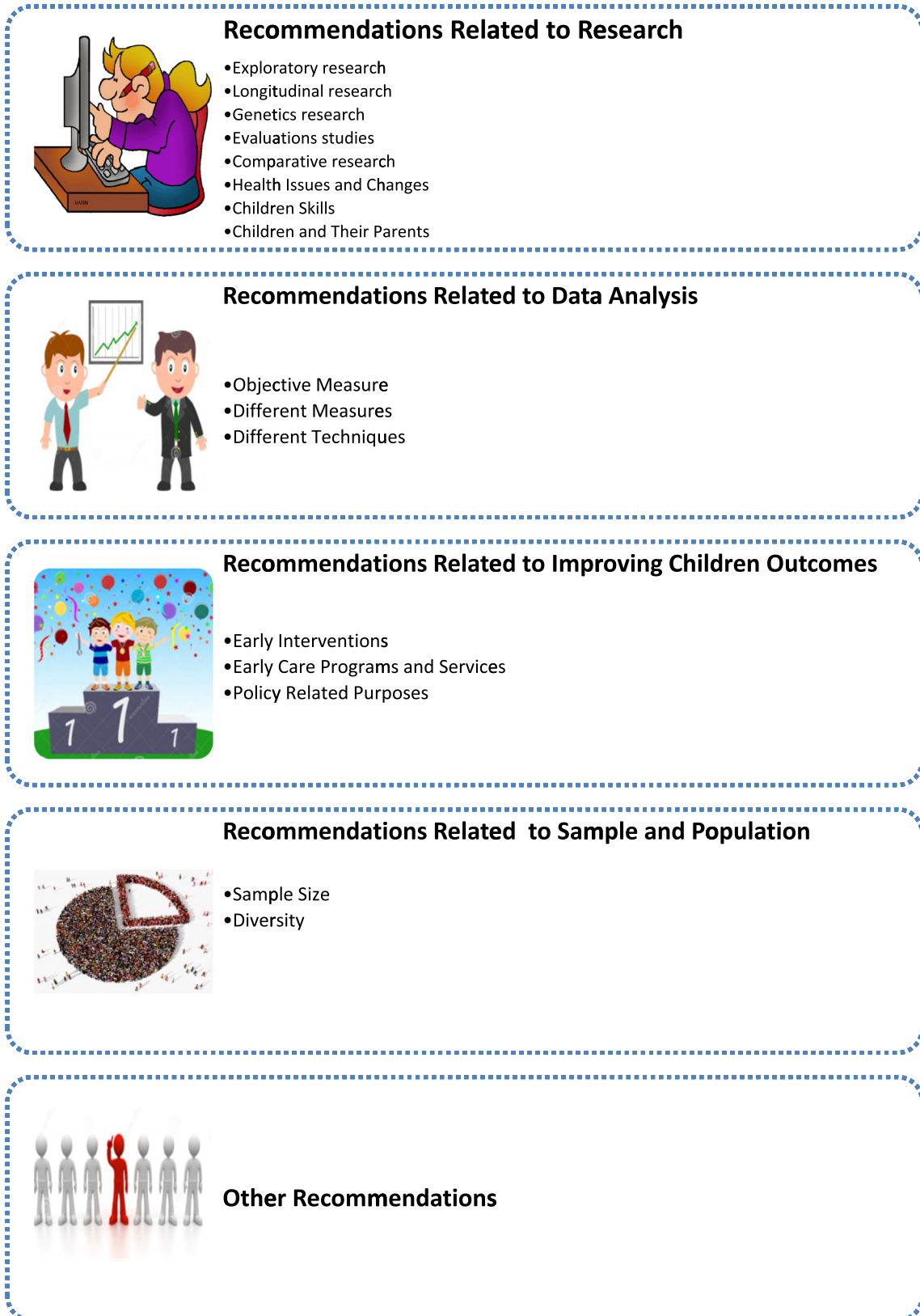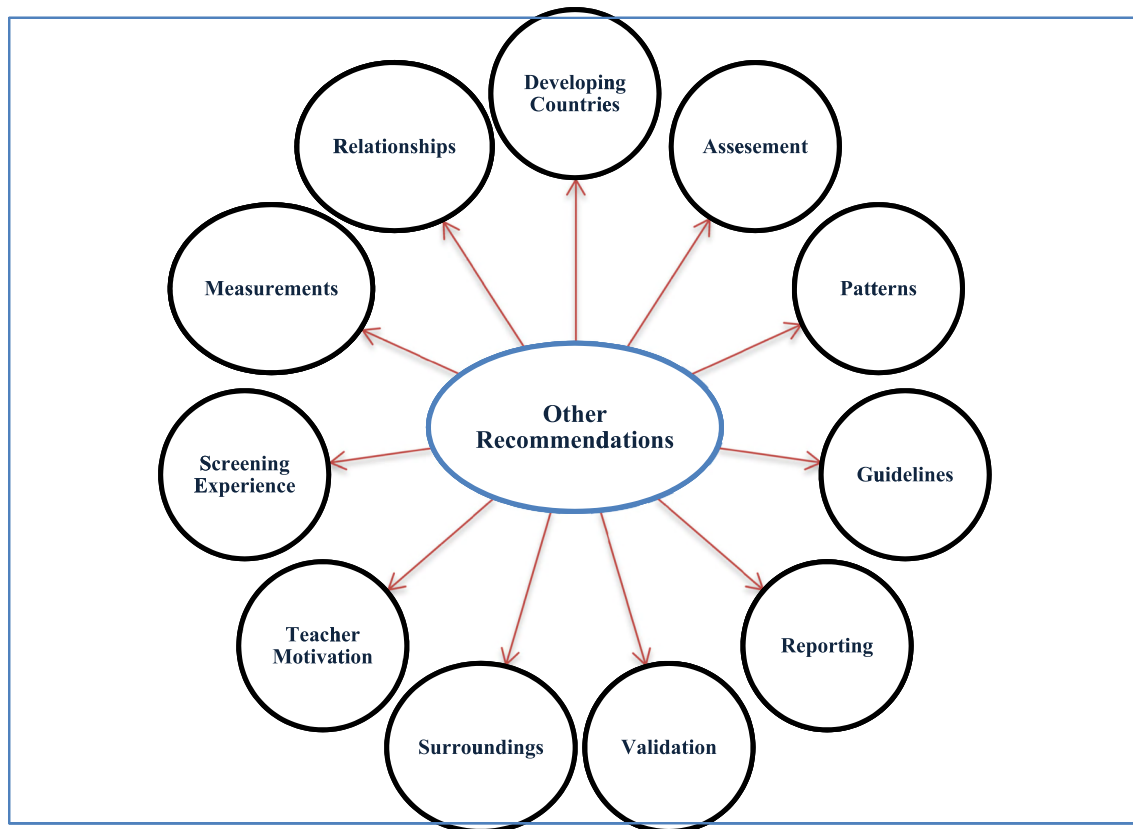
Recommendations Related to Research

- Exploratory research
- Longitudinal research
- Genetics research
- Evaluations studies
- Comparative research
- Health Issues and Changes
- Children Skills
- Children and Their Parents

Recommendations Related to Data Analysis

- Objective Measure
- Different Measures
- Different Techniques

Recommendations Related to Improving Children Outcomes

- Early Interventions
- Early Care Programs and Services
- Policy Related Purposes

Recommendations Related to Sample and Population

- Sample Size
- Diversity

Other Recommendations

FIGURE 9. Recommendations overview.

FIGURE 10. Other recommendations.

mixed methods statistical analysis [111] and biomarker analysis [226].

3) RELATED TO IMPROVING CHILDREN OUTCOME

Children's later outcomes have been a significant topic for many researchers to pursue and recommend future directions. This recommendation aims to highlight the parts of literature where they recommend aspects associated with improving children's outcomes to cover areas associated with the impact of early interventions [153], such as improving and evaluating nutrition [58], [215], [218], [226], addressing science achievement gaps [114], behavior [222], hygiene [159], academic assistance For children with behavior problems [222] and disease management [43]. The other group was highly keen on early care programs and services, such as the effectiveness of special education [109], child care subsidies [230], home visiting programs [150], community level care [132], configurations of care [152], research-supported practices for educators [107], rehabilitation programs [178], preventive strategies with assessment skills [2], guidance and preparation for health care professionals [91], [217], delivering paediatrician prescriptions [211] and skills and knowledge advancement for social worker [229]. Few recommendations were meant for policy-related purposes, which include policies for children's screen time [201] and how different policies may play a role in fostering children's skills [230].

The last group was meant for different recommendations to cover the vast aspect of improving children's outcomes, such as expansion of rotavirus vaccine programs [30], and provision of early childhood education and health services [91].

4) RELATED TO SAMPLE OR POPULATION

Researchers recognized the significance of the study sample in most types of studies and provided their views and suggestions for future studies. In early childhood studies, many researchers agreed on few recommendations associated with populations and sample. They believe they play a major role in producing highly accurate and solid findings; various recommendations were proposed by previous researchers, such as a large sample size [12], [17], [32], [40], [53], [103], [105], [129], [149], [207], [208], [211] and diversity, which includes gender differences [12], [59], [213], population [32], [44], [51], [211], race [16], [32], [138], culture [44], [71] and socioeconomic level [32], [71], [140], [157], [166], [210].

5) OTHER RECOMMENDATIONS

The last recommendation group is meant to highlight the remaining recommendations by previous researchers that do not fall into previous recommendation categories. The recommendations are presented in Figure 10.

Early childhood studies are important and should target more developing countries [6]. Some researchers
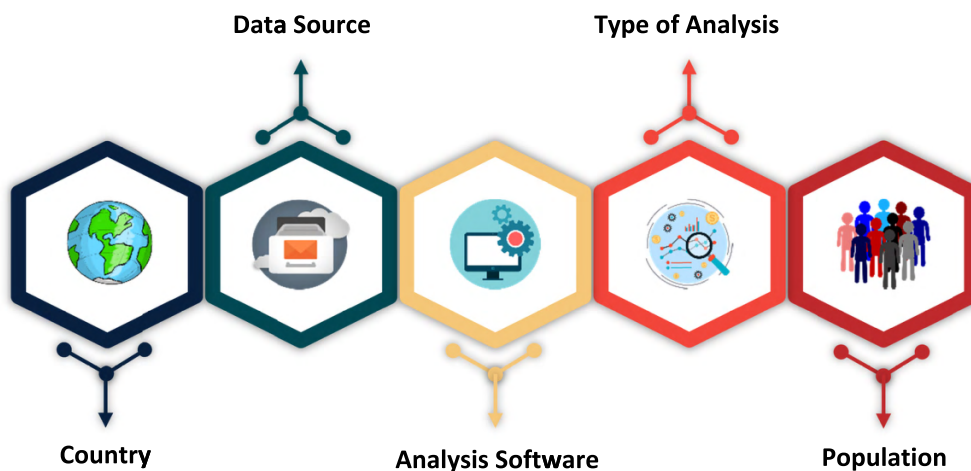
FIGURE 11. Methodological aspects overview.

encouraged assessment in case language abilities and proso-cial behavior [3] and the monitoring of behavioral develop-ment for children to investigate maltreatment [194]. Youth adjustments should be studied in relation to early substance use patterns [22]. Health characterization pattern should be investigated in relation to different races [139]. Future research should be directed towards useful and realistic guidelines, such as parents' mobile device use during the presence of their children [123]. Other researchers were more concerned with the issue of biased reporting and encouraged future studies to utilize multiple informants aside from caregiver reports [186], [194]. Future studies should improve the validation process [198], especially in medical records for disease outcomes. The surroundings of children involve many researcher perceptions and advice to pursue research in areas, such as green surroundings [67], and home and school learning [11], [236]. Teacher motivation [110] for students should be investigated to determine whether it affects the risk of repetition in children. Practitioners should aim to improve the diagnosis and screening experience of children [144] to avoid harmful effects. More studies on measurements [235] are needed for areas, such as childhood stuttering. Other researchers recommended more investiga-tion into relationships between variables, such as early head and brain growth and ASD [60], lexical development and multiword speech [98], post-adoption crying behaviors and attachment measures [68].

VII. METHODOLOGICAL ASPECTS OF PREVIOUS RESEARCH

This section discusses the methodological aspects of previous studies. Many attributes are covered in this section and all of them are discussed (Figure 11).

The significance of conducting methodological aspects of previous research is to inform future researchers in this area, whose settings and approaches have been utilized before. For example, future researchers who aim to work on early childhood will gain a brief sense of the proper settings

for the designated area, which include sufficient sample size, the type of analysis used and how it was utilized, by examining previous methodological aspect. Moreover, future researchers also know which countries have con-ducted more studies than others, the analysis software and data sources used and the available methods for external researchers.

A. COUNTRY

Early childhood studies were conducted in other coun-tries around the world. Therefore, this area of research has gained significant interest from researchers and agencies and bodies who may be using these studies for research, medical, social and other purposes. We found that most studies on early childhood came from 37 countries, as seen in Figure 12, ($n = 127/233$) studies, and more than half were conducted in the Unites States alone [1], [4,] [5], [7], [9], [10], [12], [13], [16]–[18], [21]–[25], [27]–[29], [31]–[33], [35], [40]–[48], [54], [55], [57], [59], [60], [62], [64], [65], [68]–[71], [73], [74], [77], [81], [85], [86], [88], [90], [100], [102]–[109], [112]–[114], [116], [117], [119], [122], [123], [129], [130], [132]–[134], [136]–[139], [142]–[145], [147], [150], [152]–[155], [157], [158], [161], [164], [166], [171]–[174], [179], [180], [182], [184], [186], [187], [193]–[196], [198], [199], [201], [204], [209], [211], [212], [220]–[225], [230]–[236]. The United Kingdom comes second with ($n = 13/233$) [34], [38], [52], [66], [67], [76], [110], [126], [151], [160], [163], [165], [215]; ($n = 24/233$) studies were conducted in Germany [61], [80], [95]–[97], [120], [162], [227], [228], Australia [78], [91], [92], [124], [141], [156], [177], [218], [219] and China [53], [93], [99], [175], [210], [226]. Canada has ($n = 8/233$) studies from [3], [8,] [36], [75], [118], [121], [127], and [178], Netherlands with ($n = 5/233$) studies from [87], [125], [149], [176], and [217]. Hong Kong has ($n = 4/233$) studies [11], [14], [89], [115], New Zealand has ($n = 3/233$) studies [63], [135], [200]; Taiwan has ($n = 3/233$) studies [72], [84], [183], Brazil has ($n = 3/233$) Studies [6], [82], [83],
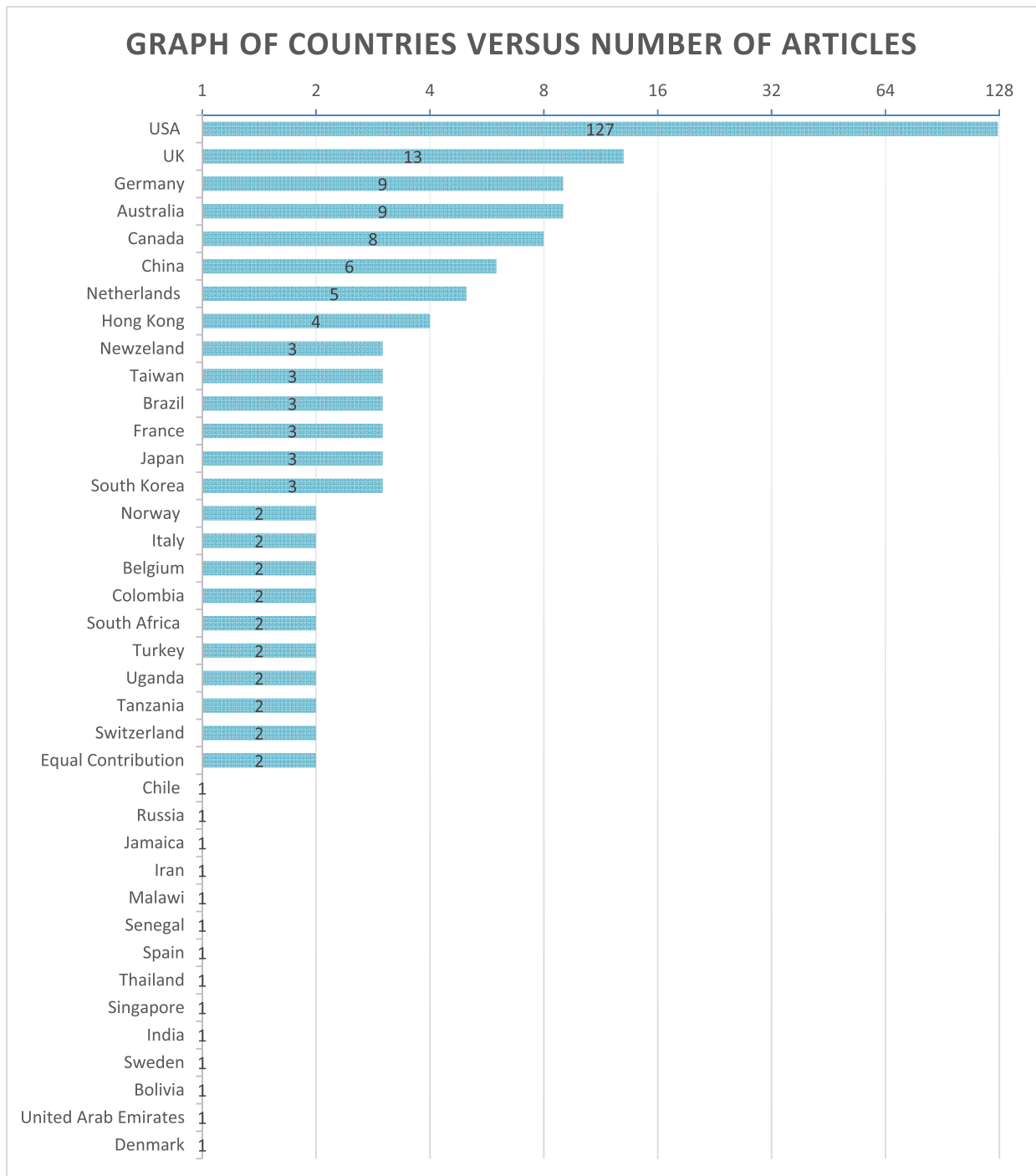
FIGURE 12. Countries with number of articles.

France has (n = 3/233) studies [56], [98], [140], Japan has (n = 3/233) studies [79], [208], [216], and South Korea has (n = 3/233) studies [2], [128], [207]. The next group includes countries with two studies each; we start with Norway [51], [94], Italy [39], [203], Belgium [101], [111], Colombia [26], [30], South Africa [148], [205], Turkey [20], [169], Uganda [185], [190],

Tanzania [191], [192] and Switzerland [159], [167]. The countries of the authors of two articles were unknown, but they were tagged with equal contribution [168], [197]. The last group contains countries with only one study; these countries include Chile [58], Russia [131], Jamaica [37], Iran [146], Malawi [188], Senegal [189], Spain [170], Thailand [181], Singapore [202], India [214], Sweden [213],
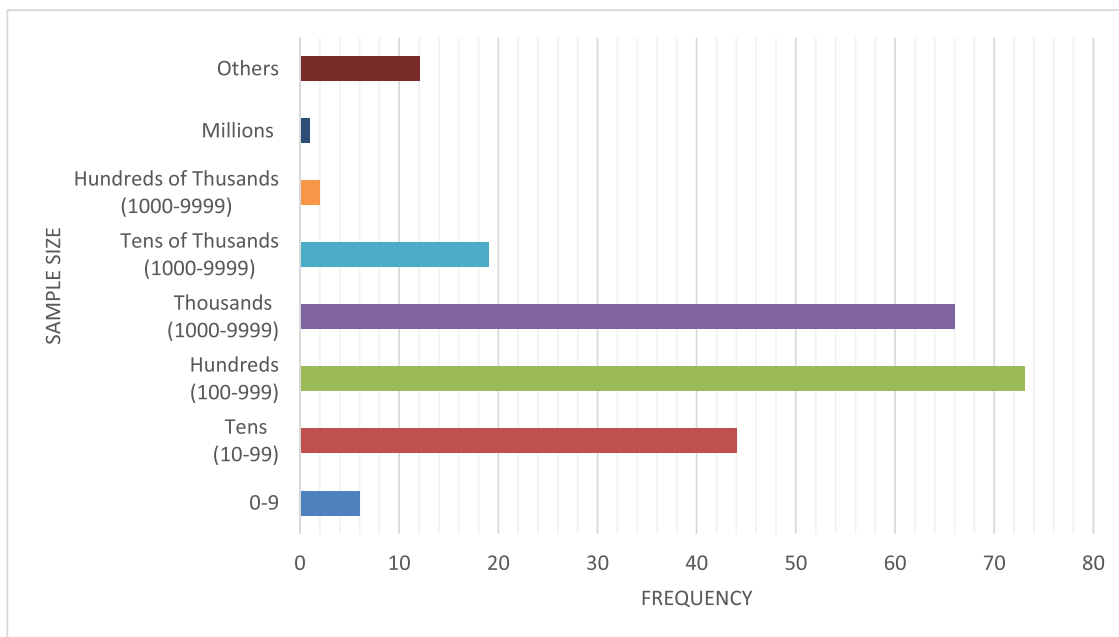
FIGURE 13. Sample size overview.

Bolivia [206], United Arab Emirates [229] and Denmark [15].

B. SAMPLE SIZE

This section highlights the sample size and methodological aspects of previous studies in the screened literature for early childhood studies. Many researchers utilized children's data for analytical purposes. The sum of the participants varies from one study another. This section presents all the previous sample sizes used by previous researchers, which we categories them into seven groups. The first group utilized between 1 and 9 participants, as in [26], [39], [79], [88], [93], and [98]. The second group is called Tens and uses between 10 and 99 participants as presented by [8], [10], [14], [28], [35], [46], [51]–[53], [55], [80]–[83], [87], [90], [94]–[97], [101], [103], [104], [112], [113], [119], [120], [122], [141]–[143], [146], [147], [164], [179], [197], [199], [205], [211], [213], [219], [227], and [234]–[236]. The third group is Hundreds, which uses samples between 100 and 999 participants from [5], [11]–[13], [16], [18], [23], [24], [31], [36], [37], [40]–[43], [45], [48], [54], [59]–[64], [72], [74], [76], [85], [86], [89], [92], [100], [102], [107], [115], [116], [118], [121], [124], [125], [127]–[129], [131], [135], [136], [144], [145], [148]–[151], [155], [157]–[160], [165], [167], [174], [178], [180], [181], [184], [186], [187], [189], [190], [192]–[194], [203], [206]–[208], [217], [218], [220], [225], and [231]. The fourth group is Thousands. Studies with 1000 and 9999 participants include [2], [9], [15], [27], [38], [68], [69], [84], [105], [108], [117], [130], [153], [162], [182], [198], [202], [216], [221], [223], and [224], 2001 and 3000 participants include [6], [21], [44], [65], [71], [73], [109], [163], [173], [176], [195], [196], [212], [222], and [226],

3001 and 4000 participants include [34], [58], [126], [161], [177], and [229], 4001 and 5000 participants include [4], [17], [33], [91], [99], [139], [200], and [232], 5001 and 6000 participants include [111], [166], and [191], 6001 and 7000 participants include [66] and [67], 7001 and 8000 participants include [1], [7], [47], [70], [77], [114], and [152], 8001 and 9000 participants include [57], [110], and [183] and 9001 and 10000 participants include [185] and [214]. The next group is tens of thousands, which is meant for studies with participants between 10001 and 99999 [3], [22], [56], [106], [132]–[134], [137], [140], [154], [156], [171], [175], [188], [209], [210], [228], [230], and [233]. The next group is hundreds of thousands which range between 100000 and 999999; only two studies were identified in this group [138], [204]. The last group utilizes big samples obtained for a long time. This group is regarded as millions of participants and includes Reference [201], where children at risk of hospitalization utilized 1,564,596 hospital encounters. All the previous samples were utilized across many studies. Some of these studies were used more than one group of participants. We reported a total number of all used samples especially in studies, where more than one group of participants are studied. Studies that do not indicate a sample size or those reviews for other studies have been labeled under 'Others'. Figure 13 shows sample size charts across previous studies for illustration purposes.

C. TYPE OF ANALYSIS

Most previous studies within literature utilized a form of analysis for various research purposes. However, despite the vast amount of data analysis approaches in literature, not all of them used similar analysis types for their desired purposes. Various approaches in data analysis are utilized for a big

pool of early childhood studies, where the area of interest is based on the early age of children without specifying a certain domain. We found analysis types across the screened articles with a typical data analysis as reported in [1], [2], [4], [7], [11], [17], [22], [23], [26], [39], [42], [43], [51], [52], [54], [57], [60], [65]–[68], [77], [81], [90], [92], [96], [98], [103], [105], [107], [109], [111], [112], [117], [121], [127], [128], [131], [134], [135], [138], [139], [141], [142], [147]–[152], [154], [156], [159], [160], [167], [178], [190], [192], [194], [201], [209], [210], [212], [215]–[218], [222], [229], [233], [234], and [236], followed by *statistical analysis* as reported in [3], [5], [6], [9], [11], [12], [16], [21], [25], [31], [33]–[38], [53], [55], [56], [59], [61], [63], [72], [73], [76], [82]–[85], [87], [89], [94], [97], [100], [101], [106], [110], [113], [120], [124]–[126], [132], [133], [136], [143], [144], [153], [155], [157], [161]–[165], [168], [171], [173]–[177], [179], [182]–[189], [191], [197]–[200], [202], [206]–[208], [213], [216], [217], [220], [221], [224], [226], [228], [231], and [235], *descriptive Statistics* [4], [7], [11], [12], [14], [20], [27], [47], [48], [58], [64], [68], [69], [74], [92], [105], [107], [108], [116], [129], [131], [140], [148], [164], [166], [167], [184], [192], [205], [207], [210], [214], [222], [226], [228], [230], *bivariate analyses* [4], [59], [133], [134], [180], [222], [223], *sensitivity analysis* [15], [56], [78], [137], [158], [162], [170], [176], [182], [200], [203], [212], [226], [228], [230] and *confirmatory factor analyses (CFAs)* [24], [41], [47], [48], [118], [125]. Many types of analysis have been reported, such as regression related analysis types, which include typical regression analysis [20], [104], [125], [197], [220], *multivariate linear regression analysis* [223], *multiple regression analysis* [133], *growth curve analysis* [222] and *path analysis* [13], [44], [71]. Other types were mentioned but not as frequent as previous ones; these types include post hoc analyses [13], [36], [116], [129], *machine learning* [136], [146], [232], *univariate analysis* [179], [182], [187], [207] and *multivariate analysis* [180], [182]. The last group is associated with other types of analysis, which has few occurrences in the literature and includes Bayesian related analysis [122], [203], *benchmarking analysis* [204], *bootstrapping analysis* [8], *brain electrical source analysis (BESA)* [51], *comparative index analysis* [204], *component analysis* [120], *conjunction analysis* [8], *DNA-related analysis* [5], [64], [74], *EEG analysis* [31], *generalized estimating equation (GEE) analysis* [59], [198], [199], *human subject analyses* [88], *fMRI analysis* [10], *kinematic analysis* [83], *video analysis* [82], *functional data analysis (FDA)* [11], *electromyography (EMG) analysis* [87], *group analysis* [17], [52], [146], *head motion regression analysis* [8], *growth curve analysis* [119], *graph theoretical analysis* [55], *laboratory analyses* [206], [231], *population analysis* [35], *longitudinal analysis* [30], [143], *mediation analyses* [44], *resting-state functional brain connectivity analysis* [120], *trunk support dynamics analyses* [88]. Other additional types of analysis were reported, such as panel data analysis [158], [169], [172], *principal component analysis* [11], [133], [191], *quantitative analysis* [219], [227], *power analysis* [25],

predictive analyses [107], *preliminary analyses* [44], *meta related analysis* [25], [32], [123], *correlational analysis* [74], [233], cross-sectional *analysis* [2], [18], *exploratory and factor related analysis* [2], [13], [43], [214], [223], *stratified analyses* [193], *structural analyses* [79], *structural connectivity analysis* [55], structural *image analysis.* [36], *structural volume analysis* [18], *subsequent analysis* [110], *supplementary analyses* [11], *latent profile analysis (LPA)* [225], *multilevel model analysis* [4], *time-frequency analysis* [51], *time-series analysis* [26], *time-to-event analysis* [162], *trajectory analysis* [86], *trend analysis* [28], [80], *trunk support dynamics Analyses* [88], *two confirmatory factor analyses* [23], [116], *two-step analysis* [109], *unadjusted analyses* [179], *VEP peak analysis* [51], *missing data analyses* [40], *mixed-model analyses* [102], *model-fitting analysis* [74], *multi-group and interaction analysis* [126], *multilevel survival analysis* [46] *multilevel analysis* [163], *rigorous multivariate analysis* [114], *robustness analyses* [27], *score analysis* [40] and *secondary data analysis* [155].

D. ANALYSIS SOFTWARE

Researchers utilized data and analyzed them using analytical tools for different research purposes during the full text reading of the chosen articles on early childhood. One of the attributes we scanned for is associated with the analytical software that the researchers used in their studies as mentioned in Figure 2. The most used software in the screened studies on early childhood is STATA data analysis and statistical software, which has been used for different data analysis purposes in various studies and includes [4], [6], [7], [22], [25], [30], [34], [40], [56], [67], [77], [78], [90], [105], [107], [116], [124]–[126], [132]–[134], [139]–[141], [143], [152], [157], [177], [182], [192], [202], [205], [209], [210], [214], [222], [223], [226], and [233]. The next most used software is a statistical analysis system (SAS), which was also used for different data analysis purposes [5], [9], [16], [21], [23], [31], [44], [59], [64], [74], [84], [85], [100], [114], [137], [138], [153], [155], [162], [164], [165], [171], [175], [176], [178], [179], [184], [187], [200], [201], [206], [212], [213], [224], [228], [233], [235]; this software is followed by SPSS [1], [2], [36], [41], [43], [44], [54], [66], [67], [69], [76], [87], [90]–[92], [103], [118], [121], [131], [135], [163], [181], [182], [188], [211], [213], [216], [220], [229], [231], [234], [235], *Mplus* [1], [3], [11], [13], [14], [17], [21], [24], [44], [65], [66], [89], [106], [115], [117], [125], [130], [194], [195], [225], [228], *R* software [6], [18], [28], [31], [35], [46], [59], [82], [96], [102], [109], [136], [142], [165], [173], [180], [181], [187], [189], [191], [206], [217], *MATLAB* [8], [36], [39], [83], [122], [142], [145]–[147], [203] and *AMOS* [2], [41], [48], [71], [72], [118], [131], [188]. Other software was used in different areas of literature, but with fewer occurrences than the previous ones; these software include brain imaging software CIVET pipeline [36], *AMIRA* 3D and 4D data visualization software [42], *Data processing assistant for resting-state fMRI (DPARSF)* [120], *BESA*
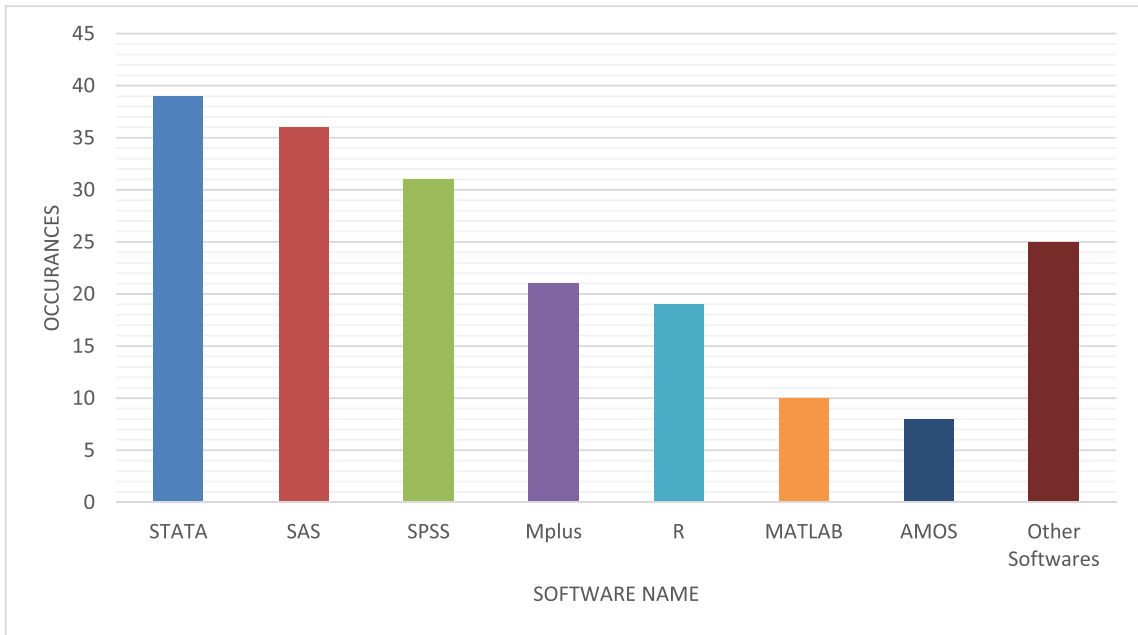
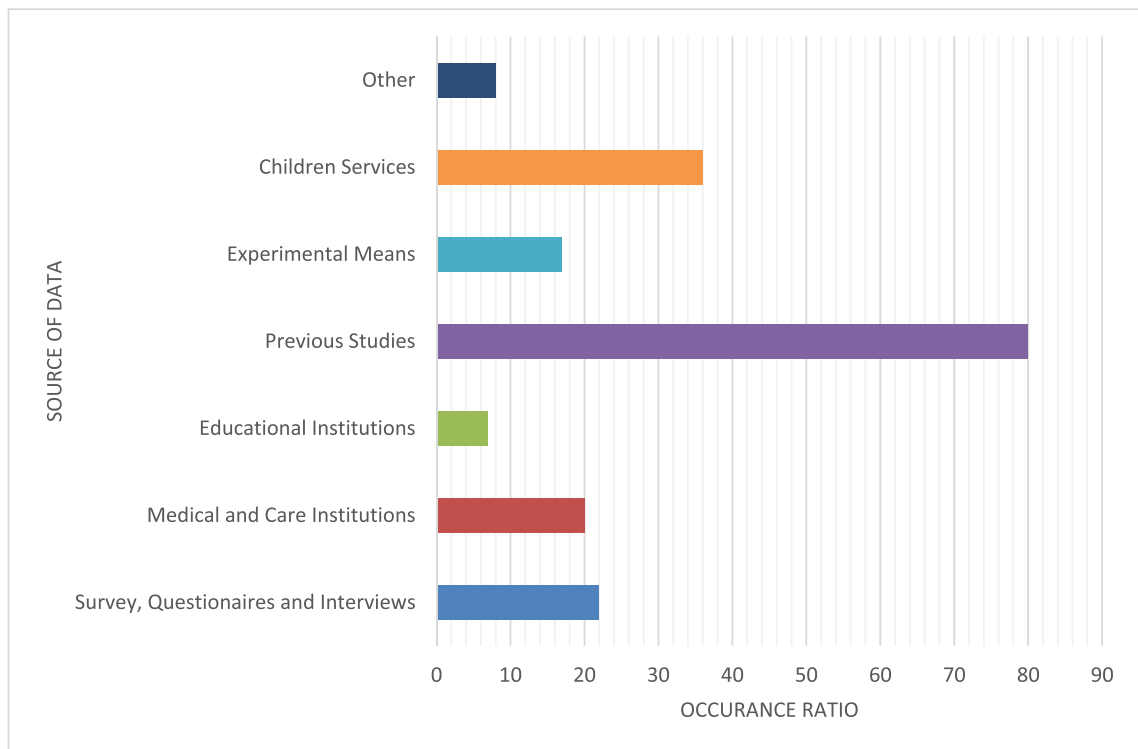**FIGURE 14.** Overview of the softwares used.

FIGURE 15. Data resources overview.

statistics [51], *Bioconductor* for genomic data [136], *Brain vision analyzer* [129], *E views* for statistics [20], *Microsoft Excel* [30], [61], *REDCap* for data collection [217], *AFNI* software for functional imaging data analysis [10], *G Power 3* statistical power analysis software [25], *GraphPad Prism* graphing and statistics software [61], [180], [190], *HLM* scientific software [47], [119], [121], *JMP* statistical discovery software [101], *Joinpoint* trend analysis software [183], *MaxQuant* software for large-scale mass-spectrometric data sets [28], Python [46], *MedCalc* statistical software [144], *Net*

Station software for signal recording [51], *Noldus* Observer for video coding [86], *OpenBUGS* for Bayesian analysis of complex statistical models [167], *PedEMG* software for Electromyography analysis [87], *REST* software and tool box [8], [120], *TANAGRA* data mining software [26], *TIBCO Spotfire* data visualization and analytics software for validation analysis [187] and *Neuroguide* software [31]. Figure 14 shows a chart of previous software usages.

E. DATA SOURCE

Data are a vital element to any study on early childhood data and are the most important aspect because they are the liaison between the analysis and the findings. In early childhood studies, the source of data is equally important and some consider it challenging. The data source was reported in many studies from various sources by utilizing previous literature in early childhood studies. The first source is *survey*, followed by *questionnaire and interviews*, which were stated in literature [57], [58], [65], [85], [117], [131], [140], [150], [156], [157], [159], [161], [177], [194], [203], [209], [210], [214], [215], [219], [221], [223]. Others acquired data from *medical and care institutions*, such as hospitals [6], [8], [53], [63], [143], [181], [188], [205], medical system and records [43], [62], centers [11], [36], [97], [118], [148], [184], [191], [197], [217], clinics [13], nurseries [155] and birth records [64], [74], [86]. Some researchers obtained their data from *educational institutions*, which include kindergartens [14], [89], [97], [115] and schools [11], [102], [108]. Many researchers outsourced their data from *previous studies*, which include longitudinal ones [1], [4], [7], [12], [35], [38], [44], [47], [66], [69], [77], [78], [81], [91], [92], [98], [103], [106], [109], [112], [114], [126], [152], [166], [189], [193], [225], [230], [233], birth and cohort studies [3], [9], [22], [28], [34], [37], [56], [59], [67], [84], [100], [163], [176], [200], [202], [207], [212], [231], [232], ongoing studies [104], [147] and other studies from various areas, including family [17], [127], [130], [139], development [2], [54], [105], [136], [216] and health [76], [162], [187], [206]. Other researchers relied on data, which were introduced through *experimental means*, such as trials [40], [58], [122], [124], [132]–[134], [165], [186], [218] and recruitment [41], [51], [68], [83], [116], [142], [146], [180], [234]. The data of other researchers were drawn from *children related services*, which include agencies [169], [170], [229], offices [82], [149], [196], daycare and data systems [72], [138], databases [18], [20], [30], [79], [99], [141], [167], [168], [183], [201], [209], surveillance systems [52], [110], [175], projects [5], [24], [48], [55], [71], [73], [87], [107], [111], [195], [235] and programs [137], [179], [185], [236]. The last group of researchers relied on data outsourced from *other* different places, which include online resources, such as websites [145], scientific databases [32], [173], panel data [172], corpuses [46], [93], [101] and follow-up [120]. Figure 15 illustrates previous data sources in chart form.

VIII. CONCLUSION

The number of topics related to early childhood continued to increase. However, these studies have limitations, which remain unaddressed. Early childhood is an emerging topic that warrants attention. The main contribution of this article is a comprehensive survey and classification of works related to early childhood. Some patterns were observed in literature. The identified articles are grouped into three categories: development, health and other. We comprehensively analyzed the majority of the articles to highlight their challenges, motivations and recommendations related to the area of early childhood, data analysis and data types and found some gaps. Various recommendations were provided toward addressing and handling these components. These instructions should be followed by researchers, social workers and other individuals engaged in early childhood. These recommendations provide future researchers with solutions to many of the challenges their peers encountered in the area of early childhood studies. Most of these challenges are related to the data of children. They include its nature, sampling, collection, findings and lack of studies in this area. This review also summarizes the ideas presented in the related literature, which provide a valuable reference for researchers.

REFERENCES

[1] J. M. Caemmerer and T. Z. Keith, "Longitudinal, reciprocal effects of social skills and achievement from kindergarten to eighth grade," *J. School Psychol.*, vol. 53, pp. 265–281, Aug. 2015.

[2] K.-E. Kim, J.-H. Choi, and Y. H. Kim, "Effect of infant health problem, mother's depression and marital relationship on infant abuse in Korea: Mediating pathway of marital relationship," *Asian Nursing Res.*, vol. 8, pp. 110–117, Jun. 2014.

[3] L.-C. Girard, J.-B. Pingault, O. Doyle, B. Falissard, and R. E. Tremblay, "Expressive language and prosocial behaviour in early childhood: Longitudinal associations in the UK Millennium Cohort Study," *Eur. J. Develop. Psychol.*, vol. 14, no. 4, pp. 381–398, 2017.

[4] D. Keyser, H. Ahn, and J. Unick, "Predictors of behavioral problems in young children 3 to 9 years old: The role of maternal and child factors," *Children Youth Services Rev.*, vol. 82, pp. 149–155, Nov. 2017.

[5] M. Wang and K. J. Saudino, "Genetic and environmental influences on individual differences in emotion regulation and its relation to working memory in toddlerhood," *Emotion*, vol. 13, pp. 1055–1067, Dec. 2013.

[6] S. M. A. Matos et al., "Growth patterns in early childhood: Better trajectories in Afro-Ecuadorians independent of sex and socioeconomic factors," *Nutrition Res.*, vol. 44, pp. 51–59, Aug. 2017.

[7] W. B. Schott, B. T. Crookston, E. A. Lundeen, A. D. Stein, and J. R. Behrman, "Periods of child growth up to age 8 years in Ethiopia, India, Peru and Vietnam: Key distal household and community factors," *Social Sci. Med.*, vol. 97, pp. 278–287, Nov. 2013.

[8] X. Long, A. Benischek, D. Dewey, and C. Lebel, "Age-related functional brain changes in young children," *NeuroImage*, vol. 155, pp. 322–330, Jul. 2017.

[9] E. M. Taveras, S. L. Rifas-Shiman, K. L. Bub, M. W. Gillman, and E. Oken, "Prospective study of insufficient sleep and neurobehavioral functioning among school-age children," *Academic Pediatrics*, vol. 17, no. 6, pp. 625–632, Aug. 2017.

[10] J. E. Hardee et al., "Patterns of neural connectivity during an attention bias task moderate associations between early childhood temperament and internalizing symptoms in young adulthood," Biol. Psychiatry, vol. 74, pp. 273–279, Aug. 2013.

[11] Y. Zhang et al., "Characterizing early child growth patterns of height-for-age in an urban slum cohort of Bangladesh with functional principal component analysis," BMC Pediatrics, vol. 17, p. 84, Mar. 2017.

[12] J. R. Gagne and K. J. Saudino, "The development of inhibitory control in early childhood: A twin study from 2–3 years," Develop. Psychol., vol. 52, no. 3, pp. 391–399, 2016.

[13] A. S. Meuwissen and M. M. Englund, "Executive function in at-risk children: Importance of father-figure support and mother parenting," J. Appl. Develop. Psychol., vol. 44, pp. 72–80, May/Jun. 2016.

[14] X. Zhang and D. Lin, "Pathways to arithmetic: The role of visual-spatial and language skills in written arithmetic, arithmetic word problems, and nonsymbolic arithmetic," Contemp. Educ. Psychol., vol. 41, pp. 188–197, Apr. 2015.

[15] B. Jensen, P. Jensen, and A. W. Rasmussen, "Does professional development of preschool teachers improve children's socio-emotional outcomes?" Labour Econ., vol. 45, pp. 26–39, Apr. 2017.

[16] F. Li and M. T. Godinet, "The impact of repeated maltreatment on behavioral trajectories from early childhood to early adolescence," Children Youth Services Rev., vol. 36, pp. 22–29, Jan. 2014.

[17] S. M. De Luca, Y. Yueqi, and Y. Padilla, "A longitudinal examination of how mothers' and fathers' mental health and thoughts of death are related to their child's self-reported levels of parental connectedness," Children Youth Services Rev., vol. 79, pp. 235–241, Aug. 2017.

[18] B. Aubert-Broche et al., "A new method for structural volume analysis of longitudinal brain MRI data and its application in studying the growth trajectories of anatomical brain structures in childhood," NeuroImage, vol. 82, pp. 393–402, Nov. 2013.

[19] X. Guo, K. C. Dominick, A. A. Minai, H. Li, C. A. Erickson, and L. J. Lu, "Diagnosing autism spectrum disorder from brain resting-state functional connectivity patterns using a deep neural network with a novel feature selection method," Frontiers Neurosci., vol. 11, p. 460, Aug. 2017.

[20] E. Erdoğan, M. Ener, and F. Arıca, "The strategic role of infant mortality in the process of economic growth: An application for high income OECD countries," Procedia-Social Behav. Sci., vol. 99, pp. 19–25, Nov. 2013.

[21] C. R. Greenwood, D. Walker, J. Buzhardt, W. J. Howard, L. McCune, and R. Anderson, "Evidence of a continuum in foundational expressive communication skills," Early Childhood Res. Quart., vol. 28, pp. 540–554, 3rd Quart., 2013.

[22] J. Staff, J. L. Maggs, K. Cundiff, and R. J. Evans-Polce, "Childhood cigarette and alcohol use: Negative links with adjustment," Addictive Behav., vol. 62, pp. 122–128, Nov. 2016.

[23] K. E. Speirs, J. T. Hayes, S. Musaad, A. Van Brackle, M. Sigman-Grant, and The All 4 Kids Obesity Resiliency Research Team, "Is family sense of coherence a protective factor against the obesogenic environment?" Appetite, vol. 99, pp. 268–276, Apr. 2016.

[24] W. R. Mills-Koonce et al., "Mothers' and fathers' sensitivity and children's cognitive development in low-income, rural families," J. Appl. Develop. Psychol., vol. 38, pp. 1–10, May/Jun. 2015.

[25] J. L. Schleider, M. R. Abel, and J. R. Weisz, "Implicit theories and youth mental health problems: A random-effects meta-analysis," Clin. Psychol. Rev., vol. 35, pp. 1–9, Feb. 2015.

[26] M. Guevara, M. van Dijk, and P. van Geert, "Microdevelopment of peer interactions and scientific reasoning in young children / Microdesarrollo de la interacción entre pares y el razonamiento científico en niños pequeños," Infancia y Aprendizaje, vol. 39, no. 4, pp. 727–771, 2016.

[27] R. Miller, "Childhood health and prenatal exposure to seasonal food scarcity in Ethiopia," World Develop., vol. 99, pp. 350–376, Nov. 2017.

[28] C.-W. Liu, L. Bramer, B.-J. Webb-Robertson, K. Waugh, M. J. Rewers, and Q. Zhang, "Temporal profiles of plasma proteome during childhood development," J. Proteomics, vol. 152, pp. 321–328, Jan. 2017.

[29] T. Field, "Infant sleep problems and interventions: A review," Infant Behav. Develop., vol. 47, pp. 40–53, May 2017.

[30] A. Paternina-Caicedo et al., "Effect of rotavirus vaccine on childhood diarrhea mortality in five Latin American countries," Vaccine, vol. 33, pp. 3923–3928, Jul. 2015.

[31] A. W. Buckley et al., "State-dependent differences in functional connectivity in young children with autism spectrum disorder," EBioMedicine, vol. 2, pp. 1905–1915, Dec. 2015.

[32] J. Trautmann, J. Alhusen, and D. Gross, "Impact of deployment on military families with young children: A systematic review," Nursing Outlook, vol. 63, pp. 656–679, Nov./Dec. 2015.

[33] D. M. Strobino, S. Ahmed, K. Mistry, E. Wasserman, M. B. Hossain, and C. Minkovitz, "Maternal depressive symptoms and attained size among children in the first 2 years of life," Academic Pediatrics, vol. 16, pp. 75–81, Jan./Feb. 2016.

[34] E. Netsi, I. S. Santos, A. Stein, F. C. Barros, A. J. Barros, and A. Matijasevich, "A different rhythm of life: Sleep patterns in the first 4 years of life and associated sociodemographic characteristics in a large Brazilian birth cohort," Sleep Med., vol. 37, pp. 77–87, Sep. 2017.

[35] N. Sadeghi, M. Prastawa, P. T. Fletcher, J. Wolff, J. H. Gilmore, and G. Gerig, "Regional characterization of longitudinal DT-MRI to study white matter maturation of the early developing brain," NeuroImage, vol. 68, pp. 236–247, Mar. 2013.

[36] S. Ducharme et al., "Trajectories of cortical thickness maturation in normal brain development—The importance of quality control procedures," NeuroImage, vol. 125, pp. 267–279, Jan. 2016.

[37] T. Royal-Thomas, D. McGee, D. Sinha, C. Osmond, and T. Forrester, "Association of maternal blood pressure in pregnancy with blood pressure of their offspring through adolescence," J. Perinatal Med., vol. 43, no. 2, pp. 695–701, 2015.

[38] A. J. Simpkin et al., "The epigenetic clock and physical development during childhood and adolescence: Longitudinal analysis from a UK birth cohort," Int. J. Epidemiol., vol. 46, pp. 549–558, Apr. 2017.

[39] E. Tamilia, D. Formica, A. Scaini, and F. Taffoni, "An automated system for the analysis of newborns' oral-motor behavior," IEEE Trans. Neural Syst. Rehabil. Eng., vol. 24, no. 12, pp. 1294–1303, Dec. 2016.

[40] M. P. McCormick, E. E. O'Connor, E. Cappella, and S. G. McClowry, "Teacher–child relationships and academic achievement: A multi-level propensity score model approach," J. School Psychol., vol. 51, pp. 611–624, Oct. 2013.

[41] M. M. Torres, C. E. Domitrovich, and K. L. Bierman, "Preschool interpersonal relationships predict kindergarten achievement: Mediated by gains in emotion knowledge," J. Appl. Develop. Psychol., vol. 39, pp. 44–52, Jul./Aug. 2015.

[42] P. Shaw et al., "Mapping the development of the basal ganglia in children with attention-deficit/hyperactivity disorder," J. Amer. Acad. Child Adolescent Psychiatry, vol. 53, pp. 780–789, Jul. 2014.

[43] M. H. Bellin et al., "Stress and quality of life in caregivers of inner-city minority children with poorly controlled asthma," J. Pediatric Health Care, vol. 27, pp. 127–134, Mar./Apr. 2013.

[44] C. E. Baker and I. U. Iruka, "Maternal psychological functioning and children's school readiness: The mediating role of home environments for African American children," Early Childhood Res. Quart., vol. 28, pp. 509–519, 3rd Quart., 2013.

[45] G. R. Maslow et al., "Preliminary outcomes from an integrated pediatric mental health outpatient clinic," Child Adolescent Psychiatric Clinics, vol. 26, pp. 761–770, Oct. 2017.

[46] M. T. Carlson, M. Sonderegger, and M. Bane, "How children explore the phonological network in child-directed speech: A survival analysis of children's first word productions," J. Memory Lang., vol. 75, pp. 159–180, Aug. 2014.

[47] M. C. Heatly, H. J. Bachman, and E. Votruba-Drzal, "Developmental patterns in the associations between instructional practices and children's math trajectories in elementary school," J. Appl. Develop. Psychol., vol. 41, pp. 46–59, Nov./Dec. 2015.

[48] H.-J. Jeon, C. A. Peterson, and J. DeCoster, "Parent–child interaction, task-oriented regulation, and cognitive development in toddlers facing developmental risks," J. Appl. Develop. Psychol., vol. 34, pp. 257–267, Nov./Dec. 2013.

[49] S. Nair, J. L. de la Vara, M. Sabetzadeh, and L. Briand, "An extended systematic literature review on provision of evidence for safety certification," Inf. Softw. Technol., vol. 56, pp. 689–717, Jul. 2014.

[50] L. Martin, M. Byrnes, S. McGarry, S. Rea, and F. Wood, "Posttraumatic growth after burn in adults: An integrative literature review," Burns, vol. 43, pp. 459–470, May 2017.

[51] S. B. Agyei, F. R. van der Weel, and A. L. van der Meer, "Longitudinal study of preterm and full-term infants: High-density EEG analyses of cortical activity in response to visual motion," Neuropsychologia, vol. 84, pp. 89–104, Apr. 2016.

[52] S. Lloyd-Fox et al., "Cortical specialisation to social stimuli from the first days to the second year of life: A rural Gambian cohort," Develop. Cogn. Neurosci., vol. 25, pp. 92–104, Jun. 2017.

[53] Z. Tan *et al.*, "Children with intracranial arachnoid cysts: Classification and treatment," *Medicine*, vol. 94, p. e1749, Nov. 2015.

[54] M. D. Albaugh *et al.*, "Age-related volumetric change of limbic structures and subclinical anxious/depressed symptomatology in typically developing children and adolescents," *Biol. Psychol.*, vol. 124, pp. 133–140, Mar. 2017.

[55] W. Yuan *et al.*, "Left hemisphere structural connectivity abnormality in pediatric hydrocephalus patients following surgery," *NeuroImage, Clin.*, vol. 12, pp. 631–639, Feb. 2016.

[56] B. H. Apouey, "Child physical development in the UK: The imprint of time and socioeconomic status," *Public Health*, vol. 141, pp. 255–263, Dec. 2016.

[57] Y. Lu, "Internal migration, international migration, and physical growth of left-behind children: A study of two settings," *Health Place*, vol. 36, pp. 118–126, Nov. 2015.

[58] E. Puentes *et al.*, "Early life height and weight production functions with endogenous energy and protein inputs," *Econ. Hum. Biol.*, vol. 22, pp. 65–81, Sep. 2016.

[59] A. S. Brown, D. Gyllenberg, S. Hinkka-Yli-Salomäki, A. Sourander, and I. W. McKeague, "Altered growth trajectory of head circumference during infancy and schizophrenia in a National Birth Cohort," *Schizophrenia Res.*, vol. 182, pp. 115–119, Apr. 2017.

[60] L. Zwaigenbaum *et al.*, "Early head growth in infants at risk of autism: A baby siblings research consortium study," *J. Amer. Acad. Child Adolescent Psychiatry*, vol. 53, pp. 1053–1062, Oct. 2014.

[61] S. Ifflaender, M. Rüdiger, D. Konstantelos, K. Wahls, and W. Burkhardt, "Prevalence of head deformities in preterm infants at term equivalent age," *Early Hum. Develop.*, vol. 89, pp. 1041–1047, Dec. 2013.

[62] J. Hoover-Fong, J. McGready, K. Schulze, A. Y. Alade, and C. I. Scott, "A height-for-age growth reference for children with achondroplasia: Expanded applications and comparison with original reference data," *Amer. J. Med. Genet. A*, vol. 173, pp. 1226–1230, May 2017.

[63] K. M. Jones, P. R. Champion, and L. J. Woodward, "Social competence of preschool children born very preterm," *Early Hum. Develop.*, vol. 89, pp. 795–802, Oct. 2013.

[64] S. K. Fenstermacher and K. J. Saudino, "Exploring links among imitation, mental development, and temperament," *Infancy*, vol. 21, pp. 536–559, Sep./Oct. 2016.

[65] P. J. Fowler, D. B. Henry, M. Schoeny, J. Taylor, and D. Chavira, "Developmental timing of housing mobility: Longitudinal effects on externalizing behaviors among at-risk youth," *J. Amer. Acad. Child Adolescent Psychiatry*, vol. 53, pp. 199–208, Feb. 2014.

[66] S. P. Singh, C. Winsper, D. Wolke, and A. Bryson, "School mobility and prospective pathways to psychotic-like symptoms in early adolescence: A prospective birth cohort study," *J. Amer. Acad. Child Adolescent Psychiatry*, vol. 53, pp. 518–527, May 2014.

[67] E. Flouri, E. Midouhas, and H. Joshi, "The role of urban neighbourhood green space in children's emotional and behavioural resilience," *J. Environ. Psychol.*, vol. 40, pp. 179–186, Dec. 2014.

[68] T. X. Tan and K. Marfo, "Pre-adoption adversity and behavior problems in adopted Chinese children: A longitudinal study," *J. Appl. Develop. Psychol.*, vol. 42, pp. 49–57, Jan./Feb. 2016.

[69] M. Price, C. Higa-McMillan, S. Kim, and B. C. Frueh, "Trauma experience in children and adolescents: An assessment of the effects of trauma type and role of interpersonal proximity," *J. Anxiety Disorders*, vol. 27, pp. 652–660, Oct. 2013.

[70] M. A. Gottfried, "The influence of tardy classmates on students' socio-emotional outcomes," *Teachers College Rec.*, vol. 116, no. 3, p. n3, 2014.

[71] M. L. Zajicek-Farber, L. M. Mayer, L. G. Daughtery, and E. Rodkey, "The buffering effect of childhood routines: Longitudinal connections between early parenting and prekindergarten learning readiness of children in low-income families," *J. Social Service Res.*, vol. 40, no. 5, pp. 699–720, 2014.

[72] I. Li, C. Pawan, and K. Stansbury, "Emerging effortful control in infancy and toddlerhood and maternal support: A child driven or parent driven model?" *Infant Behav. Develop.*, vol. 37, pp. 216–224, May 2014.

[73] A. D. Paradis, G. M. Fitzmaurice, K. C. Koenen, and S. L. Buka, "A prospective investigation of neurodevelopmental risk factors for adult antisocial behavior combining official arrest records and self-reports," *J. Psychiatric Res.*, vol. 68, pp. 363–370, Sep. 2015.

[74] M. Wang and K. J. Saudino, "Positive affect: Phenotypic and etiologic associations with prosocial behaviors and internalizing problems in toddlers," *Frontiers Psychol.*, vol. 6, p. 416, Apr. 2015.

[75] J. E. MacLean, D. A. Fitzgerald, and K. A. Waters, "Developmental changes in sleep and breathing across infancy and childhood," *Paediatric Respiratory Rev.*, vol. 16, pp. 276–284, Sep. 2015.

[76] C. Koulouglioti, R. Cole, M. Moskow, B. McQuillan, M.-A. Carno, and A. Grape, "The longitudinal association of young children's everyday routines to sleep duration," *J. Pediatric Health Care*, vol. 28, pp. 80–87, Jan./Feb. 2014.

[77] B. G. Gibbs and R. Forste, "Breastfeeding, parenting, and early cognitive development," *J. Pediatrics*, vol. 164, pp. 487–493, 2014.

[78] G. Kalb and J. C. van Ours, "Reading to young children: A head-start in life?" *Econ. Educ. Rev.*, vol. 40, pp. 1–24, Jun. 2014.

[79] T. Matsui and T. Yamamoto, "Developing sensitivity to the sources of information: Early use of the Japanese quotative particles tte and to in mother–child conversation," *J. Pragmatics*, vol. 59, pp. 5–25, Dec. 2013.

[80] M. Kavšek, "Infants' responsiveness to rivalrous gratings," *Vis. Res.*, vol. 76, pp. 50–59, Jan. 2013.

[81] K. Libertus and R. J. Landa, "The early motor questionnaire (EMQ): A parental report measure of early motor development," *Infant Behav. Develop.*, vol. 36, pp. 833–842, Dec. 2013.

[82] R. V. Gonçalves, E. M. Figueiredo, C. B. Mourão, E. A. Colosimo, S. T. Fonseca, and M. C. Mancini, "Development of infant reaching behaviors: Kinematic changes in touching and hitting," *Infant Behav. Develop.*, vol. 36, pp. 825–832, Dec. 2013.

[83] A. B. Cunha, D. de Almeida Soares, R. de Paula Carvalho, K. Rosander, C. von Hofsten, and E. Tudella, "Maturational and situational determinants of reaching at its onset," *Infant Behav. Develop.*, vol. 41, pp. 64–72, Nov. 2015.

[84] Y.-C. Chiang, D.-C. Lin, C.-Y. Lee, and M.-C. Lee, "Effects of parenting role and parent–child interaction on infant motor development in Taiwan Birth Cohort Study," *Early Hum. Develop.*, vol. 91, pp. 259–264, Apr. 2015.

[85] K. Uzark, C. Smith, J. Donohue, S. Yu, and J. C. Romano, "Infant motor skills after a cardiac operation: The need for developmental monitoring and care," *Ann. Thoracic Surg.*, vol. 104, no. 2, pp. 681–686, Aug. 2017.

[86] J. M. Campbell, E. C. Marcinowski, J. Latta, and G. F. Michel, "Different assessment tasks produce different estimates of handedness stability during the eight to 14 month age period," *Infant Behav. Develop.*, vol. 39, pp. 67–80, May 2015.

[87] A. G. Boxum *et al.*, "Postural adjustments in infants at very high risk for cerebral palsy before and after developing the ability to sit independently," *Early Hum. Develop.*, vol. 90, pp. 435–441, Sep. 2014.

[88] A. D. Goodworth, Y.-H. Wu, D. Felmlee, E. Dunklebarger, and S. Saavedra, "A trunk support system to identify posture control mechanisms in populations lacking independent sitting," *IEEE Trans. Neural Syst. Rehabil. Eng.*, vol. 25, no. 1, pp. 22–30, Jan. 2017.

[89] Y. Liu, S. S.-S. Yeung, D. Lin, and R. K. S. Wong, "English expressive vocabulary growth and its unique role in predicting English word reading: A longitudinal study involving Hong Kong Chinese ESL children," *Contemp. Educ. Psychol.*, vol. 49, pp. 195–202, Apr. 2017.

[90] E. Hoff, R. Rumiche, A. Burridge, K. M. Ribot, and S. N. Welsh, "Expressive vocabulary development in children from bilingual and monolingual homes: A longitudinal study from two to four years," *Early Childhood Res. Quart.*, vol. 29, pp. 433–444, 4th Quart., 2014.

[91] S. Verdon, S. McLeod, and A. Winsler, "Language maintenance and loss in a population study of young Australian children," *Early Childhood Res. Quart.*, vol. 29, pp. 168–181, 2nd Quart., 2014.

[92] S. McLeod, S. Verdon, and L. B. Kneebone, "Celebrating young Indigenous Australian children's speech and language competence," *Early Childhood Res. Quart.*, vol. 29, pp. 118–131, 2nd Quart., 2014.

[93] X. Yang and C. Yang, "Control in Mandarin-speaking children's early naturalistic production," *Lingua*, vol. 163, pp. 1–22, Aug. 2015.

[94] R. Mykhaylyk, Y. Rodina, and M. Anderssen, "Ditransitive constructions in Russian and Ukrainian: Effect of givenness on word order," *Lingua*, vol. 137, pp. 271–289, Dec. 2013.

[95] M. Hager and N. Müller, "Ultimate attainment in bilingual first language acquisition," *Lingua*, vol. 164, pp. 289–308, Sep. 2015.

[96] N. K. Vavatzanidis, D. Mürbe, A. Friederici, and A. Hahne, "The basis for language acquisition: Congenitally deaf infants discriminate vowel length in the first months after cochlear implantation," *J. Cogn. Neurosci.*, vol. 27, pp. 2427–2441, 2015.

[97] E. Wimmer, M. Rothweiler, and M. Penke, "Acquisition of who-question comprehension in German children with hearing loss," *J. Commun. Disorders*, vol. 67, pp. 35–48, May 2017.

[98] E. Veneziano, "A cognitive-pragmatic model for the change from single-word to multiword speech: A constructivist approach," *J. Pragmatics*, vol. 56, pp. 133–150, Sep. 2013.

[99] J. Gao, A. Li, Z. Xiong, J. Shen, and Y. Pan, "Normative database of word production of Putonghua-speaking children—Beijing articulahon norms project: CASS_CHILD_WORD," in *Proc. Int. Conf. Oriental (COCOSDA), Conf. Asian Spoken Lang. Res. Eval. (O-COCOSDA/CASLRE)*, Nov. 2013, pp. 1–6.

[100] A. L. Quittner *et al.*, "Effects of maternal sensitivity and cognitive and linguistic stimulation on cochlear implant users' language development over four years," *J. Pediatrics*, vol. 162, pp. 343–348, Feb. 2013.

[101] J. Faes, J. Gillis, and S. Gillis, "Phonemic accuracy development in children with cochlear implants up to five years of age by using Levenshtein distance," *J. Commun. Disorders*, vol. 59, pp. 40–58, Jan./Feb. 2016.

[102] R. Treiman, T. C. Pollo, C. Cardoso-Martins, and B. Kessler, "Do young children spell words syllabically? Evidence from learners of Brazilian Portuguese," *J. Exp. Child Psychol.*, vol. 116, pp. 873–890, Dec. 2013.

[103] C. Spencer and C. Weber-Fox, "Preschool speech articulation and non-word repetition abilities may help predict eventual recovery or persistence of stuttering," *J. Fluency Disorders*, vol. 41, pp. 32–46, Mar. 2014.

[104] N. J. Aldrich *et al.*, "Infant twins' social interactions with caregivers and same-age siblings," *Infant Behav. Develop.*, vol. 41, pp. 127–141, Nov. 2015.

[105] M. P. McCormick, E. E. O'Connor, and S. P. Barnes, "Mother–child attachment styles and math and reading skills in middle childhood: The mediating role of children's exploration and engagement," *Early Childhood Res. Quart.*, vol. 36, pp. 295–306, 3rd Quart., 2016.

[106] L. Barnard-Brak, T. Stevens, and W. Ritter, "Reading and mathematics equally important to science achievement: Results from nationally-representative data," *Learn. Individual Differences*, vol. 58, pp. 1–9, Aug. 2017.

[107] T. Nguyen *et al.*, "Which preschool mathematics competencies are most predictive of fifth grade achievement?" *Early Childhood Res. Quart.*, vol. 36, pp. 550–560, 3rd Quart., 2016.

[108] Y.-S. Lee, Y. S. Park, and H. Ginsburg, "Socio-economic status differences in mathematics accuracy, strategy use, and profiles in the early years of schooling," *Proc. ZDM*, vol. 48, pp. 1065–1078, Nov. 2016.

[109] N. Kohli, A. L. Sullivan, S. Sadeh, and C. Zopluoglu, "Longitudinal mathematics development of students with learning disabilities and students without disabilities: A comparison of linear, quadratic, and piecewise linear mixed effects models," *J. School Psychol.*, vol. 53, pp. 105–120, Apr. 2015.

[110] B. S. Sunny *et al.*, "Failing to progress or progressing to fail? Age-for-grade heterogeneity and grade repetition in primary schools in Karonga district, northern Malawi," *Int. J. Educ. Develop.*, vol. 52, pp. 68–80, Jan. 2017.

[111] M. Vandecandelaere, S. Vansteelandt, B. De Fraine, and J. van Damme, "The effects of early grade retention: Effect modification by prior achievement and age," *J. School Psychol.*, vol. 54, pp. 77–93, Feb. 2016.

[112] K. F. Medeiros, C. J. Cress, and M. C. Lambert, "Mastery motivation in children with complex communication needs: Longitudinal data analysis," *Augmentative Alternative Commun.*, vol. 32, pp. 208–218, 2016.

[113] L. K. Slone and C. M. Sandhofer, "Consider the category: The effect of spacing depends on individual learning histories," *J. Exp. Child Psychol.*, vol. 159, pp. 34–49, Jul. 2017.

[114] P. L. Morgan, G. Farkas, M. M. Hillemeier, and S. Maczuga, "Science achievement gaps begin very early, persist, and are largely explained by modifiable factors," *Educ. Researcher*, vol. 45, pp. 18–35, Jan. 2016.

[115] D. Lin, H. Sun, and X. Zhang, "Bidirectional relationship between visual spatial skill and Chinese character reading in Chinese kindergartners: A cross-lagged analysis," *Contemp. Educ. Psychol.*, vol. 46, pp. 94–100, Jul. 2016.

[116] D. R. Becker, A. Miao, R. Duncan, and M. M. McClelland, "Behavioral self-regulation and executive function both predict visuomotor skills and early academic achievement," *Early Childhood Res. Quart.*, vol. 29, pp. 411–424, 4th Quart., 2014.

[117] J. Y. Choi, S. Jeon, and C. Lippard, "Dual language learning, inhibitory control, and math achievement in head start and kindergarten," *Early Childhood Res. Quart.*, vol. 42, pp. 66–78, 1st Quart., 2018.

[118] M. R. Miller, U. Müller, G. F. Giesbrecht, J. I. Carpendale, and K. A. Kerns, "The contribution of executive function and social under-standing to preschoolers' letter and math skills," *Cogn. Develop.*, vol. 28, pp. 331–349, Oct./Dec. 2013.

[119] A. Sansavini *et al.*, "Language, motor and cognitive development of extremely preterm children: Modeling individual growth trajectories over the first three years of life," *J. Commun. Disorders*, vol. 49, pp. 55–68, May/Jun. 2014.

[120] Y. Xiao, A. D. Friederici, D. S. Margulies, and J. Brauer, "Longitudinal changes in resting-state fMRI from age 5 to age 6 years covary with language development," *NeuroImage*, vol. 128, pp. 116–124, Mar. 2016.

[121] K. R. Kryski, H. J. Smith, H. I. Sheikh, S. M. Singh, and E. P. Hayden, "HPA axis reactivity in early childhood: Associations with symptoms and moderation by sex," *Psychoneuroendocrinology*, vol. 38, pp. 2327–2336, Oct. 2013.

[122] S. T. Baker, A. M. Leslie, C. R. Gallistel, and B. M. Hood, "Bayesian change-point analysis reveals developmental change in a classic theory of mind task," *Cogn. Psychol.*, vol. 91, pp. 124–149, Dec. 2016.

[123] C. A. Kildare and W. Middlemiss, "Impact of parents mobile device use on parent-child interaction: A literature review," *Comput. Hum. Behav.*, vol. 75, pp. 579–593, Oct. 2017.

[124] H. Xu, L. M. Wen, L. L. Hardy, and C. Rissel, "A 5-year longitudinal analysis of modifiable predictors for outdoor play and screen-time of 2- to 5-year-olds," *Int. J. Behav. Nutrition Phys. Activity*, vol. 13, p. 96, Aug. 2016.

[125] A. Raudino, D. M. Fergusson, L. J. Woodward, and L. J. Horwood, "The intergenerational transmission of conduct problems," *Social Psychiatry Psychiatric Epidemiol.*, vol. 48, pp. 465–476, Mar. 2013.

[126] S. Nath, G. Russell, W. Kuyken, L. Psychogiou, and T. Ford, "Does father–child conflict mediate the association between fathers' postnatal depressive symptoms and children's adjustment problems at 7 years old?" *Psychol. Med.*, vol. 46, pp. 1719–1733, Jun. 2016.

[127] H. Goelman, B. Zdaniuk, W. T. Boyce, J. M. Armstrong, and M. J. Essex, "Maternal mental health, child care quality, and children's behavior," *J. Appl. Develop. Psychol.*, vol. 35, pp. 347–356, Jul./Aug. 2014.

[128] S. Nam and J. Chun, "Influencing factors on mothers' parenting style of young children at risk for developmental delay in South Korea: The medi-ating effects of parenting stress," *Children Youth Services Rev.*, vol. 36, pp. 81–89, Jan. 2014.

[129] R. J. Brooker and K. A. Buss, "Harsh parenting and fearfulness in toddler-hood interact to predict amplitudes of preschool error-related negativity," *Develop. Cogn. Neurosci.*, vol. 9, pp. 148–159, Jul. 2014.

[130] S. J. Lee, I. Altschul, and E. T. Gershoff, "Wait until your father gets home? Mother's and fathers' spanking and development of child aggres-sion," *Children Youth Services Rev.*, vol. 52, pp. 158–166, May 2015.

[131] S. V. Loginova and H. R. Slobodskaya, "The mediating role of parenting in the relation between personality and externalizing problems in Russian children," *Personality Individual Differences*, vol. 106, pp. 275–280, Feb. 2017.

[132] R. Shah *et al.*, "Determinants and pattern of care seeking for preterm newborns in a rural Bangladeshi cohort," *BMC Health Services Res.*, vol. 14, p. 417, Sep. 2014.

[133] R. Shah *et al.*, "Incidence and risk factors of preterm birth in a rural Bangladeshi cohort," *BMC Pediatrics*, vol. 14, p. 112, Apr. 2014.

[134] R. Shah *et al.*, "Neonatal mortality risks among preterm births in a Rural Bangladeshi Cohort," *Paediatric Perinatal Epidemiol.*, vol. 28, pp. 510–520, Nov. 2014.

[135] K. E. Waldie *et al.*, "Maternal smoking in pregnancy moderates the effect of the brain-derived neurotrophic factor (BDNF) gene polymorphism on childhood IQ across multiple ages," *Intelligence*, vol. 43, pp. 47–51, Mar./Apr. 2014.

[136] C. Ladd-Acosta *et al.*, "Presence of an epigenetic signature of prena-tal cigarette smoke exposure in childhood," *Environ. Res.*, vol. 144, pp. 139–148, Jan. 2016.

[137] J. R. Mann, S. Mcdermott, C. Pan, and J. W. Hardin, "Maternal hyperten-sion and intrapartum fever are associated with increased risk of ischemic stroke during infancy," *Develop. Med. Child Neurol.*, vol. 55, pp. 58–64, Jan. 2013.

[138] T. M. Derrington *et al.*, "Racial/ethnic differences in hospital use and cost among a statewide population of children with Down syndrome," *Res. Develop. Disabilities*, vol. 34, pp. 3276–3287, Oct. 2013.

[139] T. C. Cheng and C. C. Lo, "Racial disparities in children's health: A longitudinal analysis of mothers based on the multiple disadvantage model," *J. Community Health*, vol. 41, pp. 753–760, Aug. 2016.

[140] B. H. Apouey and P.-Y. Geoffard, "Parents' education and child body weight in France: The trajectory of the gradient in the early years," *Econ. Hum. Biol.*, vol. 20, pp. 70–89, Mar. 2016.

[141] L. M. Gauld, L. A. Keeling, C. E. Shackleton, and P. D. Sly, "Forced oscillation technique in spinal muscular atrophy," *Chest*, vol. 146, pp. 795–803, Sep. 2014.

[142] T. R. Geisbush, N. Visyak, L. Madabusi, S. B. Rutkove, and B. T. Darras, "Inter-session reliability of electrical impedance myography in children in a clinical trial setting," *Clin. Neurophysiol.*, vol. 126, pp. 1790–1796, Sep. 2015.

[143] C. M. Pasick, P. L. Shay, C. A. Stransky, C. B. Solot, M. A. Cohen, and O. A. Jackson, "Long term speech outcomes following late cleft palate repair using the modified Furlow technique," *Int. J. Pediatric Otorhinolaryngol.*, vol. 78, pp. 2275–2280, Dec. 2014.

[144] T. Bradley-Hewitt *et al.*, "The impact of echocardiographic screening for rheumatic heart disease on patient quality of life," *J. Pediatrics*, vol. 175, pp. 123–129, Aug. 2016.

[145] J. J. Tharayil, S. Chiang, R. Moss, J. M. Stern, W. H. Theodore, and D. M. Goldenholz, "A big data approach to the development of mixed-effects models for seizure count data," *Epilepsia*, vol. 58, pp. 835–844, May 2017.

[146] M. Zare, Z. Rezvani, and A. A. Benasich, "Automatic classification of 6-month-old infants at familial risk for language-based learning disorder using a support vector machine," *Clin. Neurophysiol.*, vol. 127, pp. 2695–2703, 2016.

[147] I. Shklyar, A. Pasternak, K. Kapur, B. T. Darras, and S. B. Rutkove, "Composite biomarkers for assessing Duchenne muscular dystrophy: An initial assessment," *Pediatric Neurol.*, vol. 52, pp. 202–205, Feb. 2015.

[148] S. Moodley, "Paediatric diagnostic audiology testing in South Africa," *Int. J. Pediatric Otorhinolaryngol.*, vol. 82, pp. 1–7, Mar. 2016.

[149] J. M. A. Hermanns, J. J. Asscher, B. J. H. Zijlstra, P. J. Hoffenaar, and M. Dekovič, "Long-term changes in parenting and child behavior after the home-start family support program," *Children Youth Services Rev.*, vol. 35, pp. 678–684, Apr. 2013.

[150] B. L. Green, J. M. Tarte, P. M. Harrison, M. Nygren, and M. B. Sanders, "Results from a randomized trial of the healthy families oregon accredited statewide program: Early program impacts on parenting," *Children Youth Services Rev.*, vol. 44, pp. 288–298, Sep. 2014.

[151] D. Watson, A. Cameron, and N. Aghtaie, "The role of 'embeddedness' in the delivery of integrated children's services," *Children Youth Services Rev.*, vol. 47, pp. 370–377, Dec. 2014.

[152] R. A. Gordon, A. C. Colaner, M. L. Usdansky, and C. Melgar, "Beyond an 'Either–Or' approach to home-and center-based child care: Comparing children families who combine care types with those who use just one," *Early Childhood Res. Quart.*, vol. 28, pp. 918–935, 4th Quart., 2013.

[153] B. B. Nelson *et al.*, "Developmental and health services in Head Start preschools: A tiered approach to early intervention," *Academic Pediatrics*, vol. 13, pp. 145–151, Mar./Apr. 2013.

[154] R. B. Weber, D. Grobe, and E. E. Davis, "Does policy matter? The effect of increasing child care subsidy policy generosity on program outcomes," *Children Youth Services Rev.*, vol. 44, pp. 135–144, Sep. 2014.

[155] D. Crampton and S. Yoon, "Crisis nursery services and foster care prevention: An exploratory study," *Children Youth Services Rev.*, vol. 61, pp. 311–316, Feb. 2016.

[156] M. Palmer, S. Mitra, D. Mont, and N. Groce, "The impact of health insurance for children under age 6 in Vietnam: A regression discontinuity approach," *Social Sci. Med.*, vol. 145, pp. 217–226, Nov. 2015.

[157] A. F. Darrouzet-Nardi, L. C. Miller, N. Joshi, S. Mahato, M. Lohani, and B. L. Rogers, "Child dietary quality in rural Nepal: Effectiveness of a community-level development intervention," *Food Policy*, vol. 61, pp. 185–197, May 2016.

[158] E. Bendavid and J. Bhattacharya, "The relationship of health aid to population health improvements," *JAMA Internal Med.*, vol. 174, no. 6, pp. 881–887, 2014.

[159] N. Contzen, I. H. Meili, and H.-J. Mosler, "Changing handwashing behaviour in southern ethiopia: A longitudinal study on infrastructural and commitment interventions," *Social Sci. Med.*, vol. 124, pp. 103–114, Jan. 2015.

[160] L. E. Davies and C. Oliver, "Self-injury, aggression and destruction in children with severe intellectual disability: Incidence, persistence and novel, predictive behavioural risk markers," *Res. Develop. Disabilities*, vols. 49–50, pp. 291–301, Feb./Mar. 2016.

[161] A. E. Simon and L. J. Akinbami, "Asthma action plan receipt among children with asthma 2-17 years of age, United States, 2002-2013," *J. Pediatrics*, vol. 171, pp. 283–289, Apr. 2016.

[162] L. B. Grabenhenrich *et al.*, "Early-life determinants of asthma from birth to age 20 years: A German birth cohort study," *J. Allergy Clin. Immunol.*, vol. 133, pp. 979–988, Apr. 2014.

[163] G. Devereux *et al.*, "Early-life residential exposure to soil components in rural areas and childhood respiratory health and allergy," *Sci. Total Environ.*, vols. 466–467, pp. 338–344, Jan. 2014.

[164] P. R. Wood *et al.*, "*Mycoplasma pneumoniae* and health outcomes in children with asthma," *Ann. Allergy, Asthma Immunol.*, vol. 119, pp. 146–152, Aug. 2017.

[165] C. Powell *et al.*, "Magnesium sulphate in acute severe asthma in children (MAGNETIC): A randomised, placebo-controlled trial," *Lancet Respiratory Med.*, vol. 1, pp. 301–308, Jun. 2013.

[166] J.-H. Chen, "Asthma and child behavioral skills: Does family socioeconomic status matter?" *Social Sci. Med.*, vol. 115, pp. 38–48, Aug. 2014.

[167] S. F. Rumisha, T. Smith, S. Abdulla, H. Masanja, and P. Vounatsou, "Assessing seasonal variations and age patterns in mortality during the first year of life in Tanzania," *Acta Tropica*, vol. 126, pp. 28–36, Apr. 2013.

[168] G. A. Stevens *et al.*, "Trends and mortality effects of vitamin A deficiency in children in 138 low-income and middle-income countries between 1991 and 2013: A pooled analysis of population-based surveys," *Lancet Global Health*, vol. 3, pp. e528–e536, Sep. 2015, doi: 10.1016/S2214-109X(15)00039-X.

[169] S. Wigley and A. Akkoyunlu-Wigley, "The impact of democracy and media freedom on under-5 mortality, 1961–2011," *Social Sci. Med.*, vol. 190, pp. 237–246, Oct. 2017.

[170] S. Pérez-Moreno, M. C. Blanco-Arana, and E. Bárcena-Martín, "Economic cycles and child mortality: A cross-national study of the least developed countries," *Econ. Hum. Biol.*, vol. 22, pp. 14–23, Sep. 2016.

[171] C. M. McDonald *et al.*, "The effect of multiple anthropometric deficits on child mortality: Meta-analysis of individual data in 10 prospective studies from developing countries," *Amer. J. Clin. Nutrition*, vol. 97, pp. 896–901, Apr. 2013.

[172] A. Sharma, "Did infant mortality decline cause fertility decline? Evidence from a panel data analysis of developing countries," *Econ. Bull.*, vol. 35, no. 1, pp. 283–290, 2015.

[173] C. L. F. Walker, J. Perin, J. L. Liu, J. Katz, J. M. Tielsch, and R. Black, "Does comorbidity increase the risk of mortality among children under 3 years of age?" *BMJ Open*, vol. 3, no. 8, p. e003457, 2013.

[174] S. Tomita, D. M. Parker, J. A. Jennings, and J. Wood, "Household demography and early childhood mortality in a rice-farming village in northern laos," *PloS ONE*, vol. 10, p. e0119191, Mar. 2015.

[175] J. Min, Z. Li, X. Liu, and Y. Wang, "The association between early menarche and offspring's obesity risk in early childhood was modified by gestational weight gain," *Obesity*, vol. 22, pp. 19–23, Jan. 2014.

[176] L. P. M. Pluymen, H. A. Smit, A. H. Wijga, U. Gehring, J. C. De Jongste, and L. Van Rossem, "Cesarean delivery, overweight throughout childhood, and blood pressure in adolescence," *J. Pediatrics*, vol. 179, pp. 111–117, Dec. 2016.

[177] C. N. Rachmi, K. E. Agho, M. Li, and L. A. Baur, "Are stunted young Indonesian children more likely to be overweight, thin, or have high blood pressure in adolescence?" *Int. J. Public Health*, vol. 62, pp. 153–162, Jan. 2017.

[178] C. Tamayo, C. Manlhiot, K. Patterson, S. Lalani, and B. W. McCrindle, "Longitudinal evaluation of the prevalence of overweight/obesity in children with congenital heart disease," *Can. J. Cardiol.*, vol. 31, pp. 117–123, Feb. 2015.

[179] S. B. Sisson *et al.*, "Obesogenic environments in tribally-affiliated child-care centers and corresponding obesity rates in preschool children," *Preventive Med. Rep.*, vol. 3, pp. 151–158, Jun. 2016.

[180] M. Goheen *et al.*, "Anemia offers stronger protection than sickle cell trait against the erythrocytic stage of falciparum malaria and this protection is reversed by iron supplementation," *EBioMedicine*, vol. 14, pp. 123–130, Dec. 2016.

[181] H. E. Clapham *et al.*, "Dengue virus (DENV) neutralizing antibody kinetics in children after symptomatic primary and postprimary DENV infection," *J. Infectious Diseases*, vol. 213, no. 9, pp. 1428–1435, May 2016.

[182] S. Guerra *et al.*, "Relation between circulating CC16 concentrations, lung function, and development of chronic obstructive pulmonary disease across the lifespan: A prospective study," *lancet Respiratory Med.*, vol. 3, pp. 613–620, Aug. 2015.

[183] Y.-L. Liu *et al.*, "Incidence of cancer in children aged 0–14 years in Taiwan, 1996–2010," *Cancer Epidemiol.*, vol. 39, pp. 21–28, Feb. 2015.

[184] V. Dussel *et al.*, "Feasibility of conducting a palliative care randomized controlled trial in children with advanced cancer: Assessment of the PediQUEST study," *J. Pain Symptom Manage.*, vol. 49, pp. 1059–1069, Jun. 2015.

[185] G. Ndeezi *et al.*, "Burden of sickle cell trait and disease in the uganda sickle surveillance study (US3): A cross-sectional study," *Lancet Global Health*, vol. 4, pp. e195–e200, Mar. 2016.

[186] P. A. Sirois *et al.*, "Stimulant medications and cognition, behavior, and quality of life in children and youth with HIV," *Pediatric Infectious Disease J.*, vol. 35, pp. e12–e18, Jan. 2016.

[187] B. A. Warady *et al.*, "Predictors of rapid progression of glomerular and nonglomerular kidney disease in children and adolescents: The chronic kidney disease in children (CKiD) cohort," *Amer. J. Kidney Diseases*, vol. 65, pp. 878–888, Jun. 2015.

[188] N. A. Feasey *et al.*, "ombe, B. Denis, "Modelling the contributions of malaria, HIV, malnutrition and rainfall to the decline in paediatric invasive non-typhoidal *Salmonella* disease in Malawi," *PLoS Neglected Tropical Diseases*, vol. 9, p. e0003979, Jul. 2015.

[189] J.-F. Trape *et al.*, "The rise and fall of malaria in a west African rural community, Dielmo, Senegal, from 1990 to 2012: A 22 year longitudinal study," *Lancet Infectious Diseases*, vol. 14, pp. 476–488, Jun. 2014.

[190] I. Ssewanyana *et al.*, "Avidity of anti-malarial antibodies inversely related to transmission intensity at three sites in Uganda," *Malaria J.*, vol. 16, p. 67, Feb. 2017.

[191] M. Maheu-Giroux and M. C. Castro, "Impact of community-based larviciding on the prevalence of malaria infection in Dar es Salaam, Tanzania," *PloS ONE*, vol. 8, p. e71638, Aug. 2013.

[192] R. A. Simmons *et al.*, "A longitudinal cohort study of malaria exposure and changing serostatus in a malaria endemic area of rural Tanzania," *Malaria J.*, vol. 16, p. 309, Aug. 2017.

[193] T. Lewis, E. McElroy, N. Harlaar, and D. Runyan, "Does the impact of child sexual abuse differ from maltreated but non-sexually abused children? A prospective examination of the impact of child sexual abuse on internalizing and externalizing behavior problems," *Child Abuse Neglect*, vol. 51, pp. 31–40, Jan. 2016.

[194] S. Yoon, "Child maltreatment characteristics as predictors of heterogeneity in internalizing symptom trajectories among children in the child welfare system," *Child Abuse Neglect*, vol. 72, pp. 247–257, Oct. 2017.

[195] L. M. McKelvey, J. P. Selig, and L. Whiteside-Mansell, "Foundations for screening adverse childhood experiences: Exploring patterns of exposure through infancy and toddlerhood," *Child Abuse Neglect*, vol. 70, pp. 112–121, Aug. 2017.

[196] K. M. Raissian, "Does unemployment affect child abuse rates? Evidence from New York State," *Child Abuse Neglect*, vol. 48, pp. 1–12, Oct. 2015.

[197] M. Mika *et al.*, "The nasal microbiota in infants with cystic fibrosis in the first year of life: A prospective cohort study," *Lancet Respiratory Med.*, vol. 4, pp. 627–635, Aug. 2016.

[198] S. Mahalingaiah, M. R. Winter, and A. Aschengrau, "Association of prenatal and early life exposure to tetrachloroethylene (PCE) with polycystic ovary syndrome and other reproductive disorders in the cape cod health study: A retrospective cohort study," *Reproductive Toxicol.*, vol. 65, pp. 87–94, Oct. 2016.

[199] A. Aschengrau *et al.*, "No association between unintentional head injuries and early-life exposure to tetrachloroethylene (PCE)-contaminated drinking water," *J. Occupat. Environ. Med.*, vol. 58, pp. 1040–1045, Oct. 2016.

[200] H. K. Lai *et al.*, "Emergency department visits of young children and long-term exposure to neighbourhood smoke from household heating—The Growing Up in New Zealand child cohort study," *Environ. Pollut.*, vol. 231, pp. 533–540, Dec. 2017.

[201] K. M. Jensen *et al.*, "Greater risk of hospitalization in children with down syndrome and OSA at higher elevation," *Chest*, vol. 147, pp. 1344–1351, May 2015.

[202] L.-W. Chen *et al.*, "Associations of maternal dietary patterns during pregnancy with offspring adiposity from birth until 54 months of age," *Nutrients*, vol. 9, p. 2, 2016.

[203] P. Poletti *et al.*, "Evaluating vaccination strategies for reducing infant respiratory syncytial virus infection in low-income settings," *BMC Med.*, vol. 13, p. 49, Mar. 2015.

[204] H. Ahangari, C. Atkinson-Palombo, and N. W. Garrick, "Progress towards zero, an international comparison: Improvements in traffic fatality from 1990 to 2010 for different age groups in the USA and 15 of its peers," *J. Saf. Res.*, vol. 57, pp. 61–70, Jun. 2016.

[205] M. Zampoli, K. Pillay, H. Carrara, H. J. Zar, and B. Morrow, "Microbiological yield from induced sputum compared to oropharyngeal swab in young children with cystic fibrosis," *J. Cystic Fibrosis*, vol. 15, pp. 605–610, Sep. 2016.

[206] R. M. Burke *et al.*, "Predictors of inflammation in a cohort of Bolivian infants and toddlers," *Amer. J. Tropical Med. Hygiene*, vol. 95, no. 4, pp. 954–963, 2016.

[207] B. Park *et al.*, "Association between serum levels of uric acid and blood pressure tracking in childhood," *Amer. J. Hypertension*, vol. 30, pp. 713–718, Jul. 2017.

[208] S. Matsuda, K. Kasuga, T. Hanai, T. Demura, and K. Komura, "The effect of the kindergarten barefoot policy on preschool children's toes," *J. Physiological Anthropol.*, vol. 36, p. 4, Jul. 2017.

[209] E. S. Powell, L. P. Smith-Taillie, and B. M. Popkin, "Added sugars intake across the distribution of US children and adult consumers: 1977-2012," *J. Acad. Nutrition Dietetics*, vol. 116, pp. 1543–1550, Oct. 2016.

[210] X. Fang, R. Jing, G. Zeng, H. W. Linnan, X. Zhu, and M. Linnan, "Socioeconomic status and the incidence of child injuries in China," *Social Sci. Med.*, vol. 102, pp. 33–40, Feb. 2014.

[211] R. W. Christiana, R. A. Battista, J. J. James, and S. M. Bergman, "Pediatrician prescriptions for outdoor physical activity among children: A pilot study," *Preventive Med. Rep.*, vol. 5, pp. 100–105, Mar. 2017.

[212] F. Lê, A. D. Roux, and H. Morgenstern, "Effects of child and adolescent health on educational progress," *Social Sci. Med.*, vol. 76, pp. 57–66, Jan. 2013.

[213] A.-K. Kroksmark, M.-L. Stridh, and A.-B. Ekström, "Long-term follow-up of motor function and muscle strength in the congenital and childhood forms of myotonic dystrophy type 1," *Neuromuscular Disorders*, vol. 27, no. 9, pp. 826–835, Sep. 2017.

[214] W. T. Story and R. M. Carpiano, "Household social capital and socioeconomic inequalities in child undernutrition in rural India," *Social Sci. Med.*, vol. 181, pp. 112–121, May 2017.

[215] K. S. Imai, S. K. Annim, V. S. Kulkarni, and R. Gaiha, "Women's empowerment and prevalence of stunted and underweight children in rural India," *World Develop.*, vol. 62, pp. 88–105, Oct. 2014.

[216] T. Shoda *et al.*, "Timing of eczema onset and risk of food allergy at 3 years of age: A hospital-based prospective birth cohort study," *J. Dermatological Sci.*, vol. 84, pp. 144–148, Nov. 2016.

[217] H. Hartman *et al.*, "Parental timing of allergenic food introduction in urban and suburban populations," *Ann. Allergy, Asthma Immunol.*, vol. 117, pp. 56–60, Jul. 2016.

[218] K. M. Mallan, A. Fildes, A. M. Magarey, and L. A. Daniels, "The relationship between number of fruits, vegetables, and noncore foods tried at age 14 months and food preferences, dietary intake patterns, fussy eating behavior, and weight status at age 3.7 years," *J. Acad. Nutrition Dietetics*, vol. 116, pp. 630–637, Apr. 2016.

[219] C. G. Russell, A. Worsley, and K. J. Campbell, "Strategies used by parents to influence their children's food preferences," *Appetite*, vol. 90, pp. 123–130, Jul. 2015.

[220] T. B. Cornwell, A. R. McAlister, and N. Polmear-Swendris, "Children's knowledge of packaged and fast food brands and their BMI. Why the relationship matters for policy makers," *Appetite*, vol. 81, pp. 277–283, Oct. 2014.

[221] M. Wright, D. Sotres-Alvarez, M. A. Mendez, and L. Adair, "The association of trajectories of protein intake and age-specific protein intakes from 2 to 22 years with BMI in early adulthood," *Brit. J. Nutrition*, vol. 117, pp. 750–758, Mar. 2017.

[222] K. P. Kremer, A. Flower, J. Huang, and M. G. Vaughn, "Behavior problems and children's academic achievement: A test of growth-curve models with gender and racial differences," *Children Youth Services Rev.*, vol. 67, pp. 95–104, Aug. 2016.

[223] D. H. Merritt and S. Klein, "Do early care and education services improve language development for maltreated children? Evidence from a national child welfare sample," *Child Abuse Neglect*, vol. 39, pp. 185–196, 2015.

[224] L. M. Brotman *et al.*, "Effects of parent corps in prekindergarten on child mental health and academic performance follow-up of a randomized clinical trial through 8 years of age," *JAMA Pediatrics*, vol. 170, no. 12, pp. 1149–1155, 2016.

[225] I. U. Iruka, N. Gardner-Neblett, J. S. Matthews, and D.-M. C. Winn, "Preschool to kindergarten transition patterns for African American boys," *Early Childhood Res. Quart.*, vol. 29, pp. 106–117, 2nd Quart., 2014.

[226] H. Wang, X. Tian, S. Wu, and Z. Hu, "Growth disparity of motherless children might be attributed to a deficient intake of high-quality nutrients," *Nutrition Res.*, vol. 36, pp. 1370–1378, Dec. 2016.

[227] K. Wermke, C. Linz, A. Hasenberg, F. Kunz, P. Meyer-Marcotty, and T. Schweitzer, "Six month-old infants with deformational plagiocephaly do not differ from unaffected infants with respect to vocal control," *Int. J. Pediatric Otorhinolaryngol.*, vol. 102, pp. 15–20, Nov. 2017.

[228] P. Rzehak *et al.*, "Body mass index trajectory classes and incident asthma in childhood: Results from 8 European Birth Cohorts—A global allergy and asthma European network initiative," *J. Allergy Clin. Immunol.*, vol. 131, pp. 1528–1536, Jun. 2013.

[229] F. M. Al Gharaibeh, "The effects of divorce on children: Mothers' perspectives in UAE," *J. Divorce Remarriage*, vol. 56, no. 5, pp. 347–368, 2015.

[230] L. E. Hawkinson, A. S. Griffen, N. Dong, and R. A. Maynard, "The relationship between child care subsidies and children's cognitive development," *Early Childhood Res. Quart.*, vol. 28, pp. 388–404, 2nd Quart., 2013.

[231] B. Taye *et al.*, "Effect of *Helicobacter pylori* infection on growth trajectories in young Ethiopian children: A longitudinal study," *Int. J. Infectious Diseases*, vol. 50, pp. 57–66, Sep. 2016.

[232] M. Bhattacharya, D. Ehrenthal, and H. Shatkay, "Identifying growth-patterns in children by applying cluster analysis to electronic medical records," in *Proc. IEEE Int. Conf. Bioinf. Biomed. (BIBM)*, Nov. 2014, pp. 348–351.

[233] P. L. Morgan *et al.*, "Minorities are disproportionately underrepresented in special education: Longitudinal evidence across five disability conditions," *Educ. Researcher*, vol. 44, no. 5, pp. 278–292, 2015.

[234] N. G. Ambrose, E. Yairi, T. M. Loucks, C. H. Seery, and R. Throneburg, "Relation of motor, linguistic and temperament factors in epidemiologic subtypes of persistent and recovered stuttering: Initial findings," *J. Fluency Disorders*, vol. 45, pp. 12–26, Sep. 2015.

[235] H. Zengin-Bolatkale, E. G. Conture, and T. A. Walden, "Sympathetic arousal of young children who stutter during a stressful picture naming task," *J. Fluency Disorders*, vol. 46, pp. 24–40, Dec. 2015.

[236] S. Burgess, L. Audet, and S. Harjusola-Webb, "Quantitative and qualitative characteristics of the school and home language environments of preschool-aged children with ASD," *J. Commun. Disorders*, vol. 46, pp. 428–439, Sep./Dec. 2013.

A. H. ALAMOODI received the B.Sc. degree in information and communication technology and the M.Sc. degree in computer networking from the Limkokwing University of Creative Technology, Malaysia, in 2015 and 2017, respectively. He is currently pursuing the Ph.D. degree with the Universiti Pendidikan Sultan Idris, Tanjung Malim, Malaysia. His research interests include artificial intelligent (AI), AI applications on telemedicine and e-health, image processing (skin detectors), pattern recognition (classification and prediction), machine learning (neural network, fuzzy logic, and Bayesian) methods, multiple-criteria decision-making, early childhood, panel data, longitudinal data, and cross-sectional time series data.

B. B. ZAIDAN received the B.Sc. degree in applied mathematics from Al-Nahrain University, Baghdad, Iraq, in 2004, and the M.Sc. degree in data communications and information security from the University of Malaya, Malaysia, in 2009. He is currently a Senior Lecturer with the Department of computing, University Pendidikan Sultan Idris. He led, or a was member of, many funded research projects. He has published more than 160 papers in various international conferences and journals. His research interests include image processing (skin detectors), pattern recognition (classification and prediction), machine learning (neural network, fuzzy logic, and Bayesian) methods, multiplecriteria decision-making, early childhood, panel data, longitudinal data, and cross-sectional time series data.

A. A. ZAIDAN received the B.Eng. degree (Hons.) in computer engineering from the University of Technology, Baghdad, Iraq, in 2004, the M.Sc. degree in data communications and computer network from the University of Malaya, Malaysia, in 2009, and the Ph.D. degree in artificial intelligence from Multimedia University, Malaysia, in 2013. He is currently an Associate Professor with the Department of Computing, University Pendidikan Sultan Idris. He led, or was a member of, many funded research projects. He has published more than 160 papers in various international conferences and journals. His research interests include image processing (skin detectors), pattern recognition (classification and prediction), machine learning (neural network, fuzzy logic, and Bayesian) methods, multiple-criteria decision making, early childhood, panel data, longitudinal data, and cross-sectional time series data.

SUZANI MOHAMAD SAMURI received the B.Eng. degree from the Universiti Teknologi Petronas, Malaysia, in 2003, and the Ph.D. degree in automatic control and systems engineering from The University of Sheffield, U.K., in 2012. She gained industrial experience for five years. In 2012, she joined the Universiti Pendidikan Sultan Idris as a Lecturer, where she was promoted to Senior Lecturer with the Department of Computing. She is the leader and a member of more than 17 national and international grants. In 2014, she was appointed as the Coordinator of the National Child Data Centre (NCDC) that is responsible to develop, maintain, and improvise a system, profiling children's data from as early as three-month old to four-year old in Malaysia. The NCDC system received several national and international awards, and it is currently being used by more than 5000 childcare centers in Malaysia. Her current position allows her to explore new research areas related to big data, data visualization, and learning analytic powered by various computational intelligence tools. She has been actively involved in the areas of intelligent system, data mining, and modeling and decision support system. She is the author or the co-author of various international journals papers. Her research interests include data-driven modeling, fuzzy/neuro-fuzzy systems, intelligent-system-based modeling and control, evolutionary computing, big data, data mining, data visualization, and learning analytics.

AMELIA RITAHANI ISMAIL received the bachelor's degree in management information systems from International Islamic University, Malaysia, in 2001, the M.Sc. degree in computer science from the University Technology Malaysia, Malaysia, in 2005, and the Ph.D. degree in computer science from the University of York, U.K., in 2012. She is currently an Associate Professor with the Department of Computer Science, Kulliyyah of Information and Communication Technology, International Islamic University. Her research interests include artificial immune systems, machine learning, swarm intelligence, bio-inspired computing, computational models of immune functions, and swarm robotic systems.

OMAR ZUGHOUL received the B.S. degree in computer information system from Yarmouk University, Irbid, Jordan, in 2011, and the M.Sc. degree in software engineering from UNITEN University, Malaysia, in 2014. He is currently pursuing the Ph.D. degree with Universiti Pendidikan Sultan Idris (UPSI), Tanjung Malim, Malaysia. His research interests include student evaluation, student assessment, student appraisal, and educational domains.

MOMANI FAIEZ received the B.Sc. degree in computer information system from Philadelphia University, Amman, Jordan, in 2011, and the M.Sc. degree in information technology from Universiti Tenaga Nasional, Bangi, Malaysia, in 2014. He is currently pursuing the Ph.D. degree with Universiti Pendidikan Sultan Idris (UPSI), Tanjung Malim, Malaysia. His research interests include student evaluation, student assessment, student appraisal, and educational domains.

GHAILAN A. ALSHAFEAY received the B.Sc. degree in computer science from Al Mustansiriya University, Baghdad, Iraq, in 2004, and the M.Sc. degree in information communication technology and management from Akram (IUKL) University, Kuala Lumpur, Malaysia, in 2015. He is currently pursuing the Ph.D. degree with Universiti Pendidikan Sultan Idris (UPSI), Tanjung Malim, Malaysia. His research interests include augmented reality, and AI applications on augmented reality in education.

M. A. CHYAD received the B.Sc. degree in computer science and technology from Diyala University, Diyala, Iraq, in 2010, and the M.Sc. degree in information technology in computer networking from Infrastructure University Kuala Lumpur (IUKL) Kajang, Selangor, Malaysia, in 2015. He is currently pursuing the Ph.D. degree with Universiti Pendidikan Sultan Idris (UPSI), Tanjung Malim, Malaysia. His research interests include artificial intelligent, and AI applications on skin detection and recognition machine learning (neural network, fuzzy logic, and Bayesian) methods.

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