BMJ Paediatrics Open

Early detection of neurodevelopmental disorders in African children living in informal settlements in Nairobi

Giulia Segre,[1] Cecilia Cargnelutti,[2] Carlotta Bersani,[2] Washington Njogu,[3] Elisa Roberti ,[1] Rita Campi,[1] Maria Vittoria De Vita,[4] Gianfranco Morino,[4] Maria Paola Canevini,[2] Maurizio Bonati [1]

To cite: Segre G, Cargnelutti C, Bersani C, *et al*. Early detection of neurodevelopmental disorders in African children living in informal settlements in Nairobi. *BMJ Paediatrics Open* 2023;**7**:e002117. doi:10.1136/bmjpo-2023-002117

► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/bmjpo-2023-002117).

Received 6 June 2023
Accepted 28 September 2023

[1]Department of Medical Epidemiology, Istituto di Ricerche Farmacologiche Mario Negri IRCCS, Milano, Italy
[2]Department of Health Sciences, Università degli Studi di Milano, Milano, Italy
[3]RU Neema Hospital, Nairobi, Kenya
[4]World Friends Kenya, Nairobi, Kenya

Correspondence to
Dr Maurizio Bonati; maurizio.bonati@marionegri.it

ABSTRACT

Background Children in low-income and middle-income countries (LMICs) are at a substantially increased risk of delayed physical, emotional and sociocognitive outcomes, with consequential neurodevelopmental disorders. Evidence based, cost-effective and culturally appropriate screening tools are recommended for early identification of developmental disorders.

Methods The present study aims to assess the feasibility of early screening for neurodevelopmental disorders in children living in informal settlements in Nairobi, Kenya (Korogocho). The selected tools (ie, the CDC checklist and the Modified Checklist for Autism in Toddlers, Revised (M-CHAT-R)), widely used in high-income countries, are applied in two different populations: one from Kenya (LMIC) and one from Italy, to compare the different scores.

Results Of 509 children screened, 8.6% were classified at-risk based on the results of the screening tools. Significant risk factors are history of low birth weight and Apgar score, presence of neurological disorders, malnutrition and/or rickets, younger age of the child and older age of the mother. Caesarean section delivery, first pregnancy and mothers' older age were common risk factors among the Kenyan and the Italian samples. The Italian sample had a significantly greater rate of missed milestones.

Conclusions Our data demonstrate the feasibility of using the CDC and M-CHAT-R tools in informal settlement dwellers. Further studies are needed to explore the opportunity for early diagnosis of developmental disorders in LMICs.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Children in low-income and middle-income countries (LMICs) are at greater risk of delayed developmental outcomes and neurodevelopmental disorders. Evaluation of children with appropriate tools enables early identification of developmental disorders.

WHAT THIS STUDY ADDS

⇒ Approaches and tools currently used in highly developed countries are feasible and useful for early screening of neurodevelopmental disorders in children living in informal settlements in LMICs.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Carrying out further collaborative initiatives between clinical practice and research can lead to improved outcomes in intellectual disabilities, especially in vulnerable populations of similar contexts. Increasing resources for the implementation of these screening tools in children living in LMICs would permit the early detection of developmental disorders, leading to more timely and effective interventions.

INTRODUCTION

Children born and raised in low-income and middle-income countries (LMICs) are more likely to be exposed to poor sanitation, crowded living conditions, inadequate diets, reduced psychosocial stimulation and violence due to lack of resources. These conditions lead to increased risks of infectious diseases, inadequate healthcare and lower school enrolment rates, with reduced opportunities for prevention and follow-up programmes.[1] Furthermore, these children are raised in sociocultural environments and backgrounds where mental healthcare is highly stigmatised. Stigma is one of the main barriers for the full implementation of mental health services in LMICs. Over 80% of those persons living in LMICs who are in need of mental healthcare do not receive any effective treatment, due to the scarcity of skilled healthcare staff, persistent social inequalities and the stigma associated with mental illness.[2 3] One international study using population-wide data from 16 countries found even higher rates of reported stigma among people with mental disorders in developing (31.2%) than in developed (20%) countries.[4] Generating information about effective interventions to reduce stigma and discrimination in LMIC is now an important mental health priority worldwide;

many initiatives to reduce stigma have been launched in these settings.[2]

All these risk factors can contribute to the delayed physical, social, emotional and cognitive development of children living in LMICs and, possibly, to neurodevelopmental disorders (NDD).[5–7] Assessing and monitoring development of children in LMICs through screening programmes can offer helpful epidemiological information and allow early identification and treatment of developmental disorders. This would permit the early identification of the target populations and an evaluation of the impact of the interventions, which are necessary before neuronal pruning is completed,[8 9] especially where resources are scant.

Global prevalence of developmental complex disorders varies substantially, with the greatest numbers of children (80%) living in LMIC.[10 11] An epidemiological study, conducted in 16 LMIC,[12] showed that an average of 20.40% of children screened positive for at least one developmental disorders. Moreover, the results of a recent study reported that children with those difficulties, living in these regions, tend to be more neglected and physically punished by their caregivers.[13]

General lack of information about the global burden of NDD and developmental delay (DD) in LMICs likely contributes to the worldwide inequities experienced by the patients and their families.[14] Especially in rural and urban areas such as in sub-Saharan Africa, high illiteracy rates present in small communities contribute to a delay in, or lower detection of, complex disorders in children.[15] The prevalence and clinical manifestation of common and complex disorders, such as Autism Spectrum Disorder (ASD), are poorly explored.[16–18]

Yet, detecting early risk signs of ASD should be a priority as the majority of children with ASD (60%–90%) often present other medical, mental health, neurodevelopmental and functional conditions that need early treatment. Genetic and environmental factors, as well as their interactions, contribute to autism phenotypes, although their precise causal mechanisms are still debated in the literature.[19] While the diagnosis can be made as soon as 2 years of age, in LMIC there is still a considerable delay.[20 21]

An ideal developmental screening tool for children living in LMICs must be brief, cost-effective, based on appropriate data and good psychometric properties available in local languages, validated on a representative population of healthy children, and require minimal training[22 23]

These characteristics permit the overcoming of difficulties in using or adapting tools originally designed for a different context. Oftentimes these tools do not have such characteristics and it is difficult to apply them in other contexts. For screening for ASD in LMICs, for example, out of the five most commonly used tools, the only assessment tool that could be adopted was the Modified Checklist for Autism in Toddlers, Revised (M-CHAT-R)/F.[24]

Identifying appropriate screening tools for ASD that are feasible within LMICs communities is a challenge. Most assessment tools are self-reports that rely on adequate reading and literacy levels. The optimal strategy for LMICs would be to have healthcare providers administer these tools to increase confidence and reduce comprehension difficulties for multilingual individuals, according to the specific culture.[25] Screening, however, assumes that therapeutic interventions are guaranteed later, but this is not always possible. The inadequacy of mental health professionals in LMIC affects availability and accessibility of diagnoses and of services that could improve autistic children's prognoses and care.

In LMICs, complex, non-communicable disorders may be hidden and not acknowledged due to stigma, especially for mental health disorders; there is no screening and early detection. Although previous studies observed a high prevalence of mental disorders among children in Kenya,[26] in particular settings such as slums, affordable programmes or referral procedures of care are missing. It is important to implement screening measures before school age to prevent these disorders from interfering with psychological, social and educational development, especially in areas where healthcare is not guaranteed.

The present exploratory study first aimed to demonstrate the feasibility of early screening of NDD in the urban areas of Nairobi to detect gaps in the children's physiological development using tools that are widely used in high-income countries (HICs) and in a few LMIC contexts (aim 1). Provided that the first aim was met, the second objective was to compare the outcomes of the same assessment tools (ie, the detection of children at risk for NDDs) in two different populations: one from the informal settlements of Kenya (LMIC context) and one from Italy (HIC) (aim 2).

METHODS

This cross-sectional study was designed in the framework of an ongoing collaboration between the University of Milan, the Mario Negri Institute, and the NGO World Friends Amici del Mondo-RUNH working in Kenya.

Patient and public involvement

No patients were involved in the research process.

Aim 1

Newborns and children aged up to 30 months of life, and their mothers, who spontaneously accessed the Child Welfare Clinic from April to May 2020, were enrolled in the study. The target area was the informal settlement of Korogocho, in the North-East area of Nairobi, surrounding the Ruaraka Uhai Neema Hospital. Children have regular access to the Clinic to receive routine checkups on growth and nutrition, vaccine or nutritional follow-up. The Clinic is carried out by a local staff member, either a nurse or a nutritionist but can also be attended by community health workers/volunteers supporting local staff. Culturally adapted tools were used to evaluate children's development in terms of

age-appropriate developmental milestones. The choice of evaluating milestones is due to the fact that failure to reach such milestones is often a hallmark of neurodevelopmental delays or a risk for NDDs, sociocommunication disorders or generalised delays.

Specifically, the clinical assessment collected data on:

- General and clinical history of mothers and children: We searched for known risk factors related to children's development through children's personal and sociodemographic information, mother's characteristics and history of pregnancy and delivery.
- The CDC's Learn the Signs, Act Early Milestones Developmental Milestones Checklists from the American Academy of Pediatrics were used in the present study with children aged up to 48 months. This tool has specific checklists for different age ranges covering developmental milestones from 2 months up to 5 years of age. The healthcare workers that conducted the assessment filled in the 24 items of the CDC (Centers for Disease Control and Prevention). , which contains culturally adapted questions that evaluate the child's development within the Motor, Cognitive, Social-Emotional and Language-Communication domains (CDC-Developmental Milestones 2019, Bright Future 2020; eg, at the 24-month assessment, a child screened positive for language delay if the mother reported that the child could not 'use two-word phrases' and/or 'follow simple instructions'. Cognitive/adaptive delay was positive if the mother reported that the child did not 'know what to do with common things like a brush, phone, fork or spoon', 'copy actions and words' and/or if the child did not 'remember skills that he/she had learnt'. Motor delay was positive if the mother reported that the child could not 'walk steadily'. Social-emotional delay was positive if the mother reported concerns about how the child 'acts, gets along with others or shows feelings').[27] *Any* DD was defined as having language, cognitive/adaptive, motor and/or social-emotional delay. Children were categorised as 'pass' if they reached the developmental milestones according to age as expected, while they were classified as 'fail' if they showed impairment in even one of the four CDC domains.
- The M-CHAT-R: The M-CHAT-R screening tool contains 20 questions about children's behaviour between 16 and 30 months. It has been used with a selected subsample of children aged 16–30 months, resident in Nairobi. This screening tool is considered valid for the early detection of alert signs in children and has a high sensitivity in detecting ASD.[28] The M-CHAT has already been translated and validated for use in other populations living in Argentina,[29] Mexico,[30] Sri Lanka[31] and Taiwan.[32] It was also used in a tertiary hospital cohort in Kenya.[33] In HICs, its use is highly recommended to paediatricians as a routine screening of children's development and skills.[34 35] The presence of an atypical behaviour is assigned a score of 1, and the total score (ie, the sum of all items scored as 1) is calculated accordingly. (1) A total score of ≤2 indicates low risk of ASD, and no further follow-up is recommended; (2) a total score ≥3 indicates risk of ASD. For all items except for three questions (2, 5 and 12), the response 'no' indicated a warning sign. Children were categorised as 'pass' if they scored between 0 and 2. The remaining children, even though they may not develop ASD, are likely to manifest other developmental disorders and were, therefore, considered at-risk.

Aim 2

The subsample of the Nairobi participants was compared with children enrolled in the Italian NASCITA (NAscere e creSCere in ITAlia) cohort study. The methods of the NASCITA study and the baseline cohort characteristics have been described elsewhere.[36] Briefly, all Italian children receive primary healthcare from a family paediatrician until they are 6 years old as part of the national health system's organisation. The population consists of infants born during the enrolment period (1 April 2019–31 July 2020) and seen by the paediatricians for seven well-child visits (from 45 days of life to 72 months) to monitor growth and development. The present study focuses on the data collected from a specific subsample at the 2 years well-child visit. This study was activated to monitor children between 16 and 30 months of age and detect early alert signs of neurodevelopment disorder through the M-CHAT-R questionnaire and CDC checklist. Specifically, a 1:2 match on gender and age (with a range of ±2 months) between the Nairobi and the NASCITA participants was performed to compare child characteristics.

In the NASCITA cohort study, at the age 2-year well-child visit, the M-CHAT-R was completed by parents and the CDC was filled in by the family paediatrician. In the Nairobi sample, this screening tool was administered with the help of the health providers: the parents filled in the questionnaire together with the previously trained community health volunteers to overcome the linguistic and readability biases. This strategy has previously been shown to improve tool efficacy in LMIC countries.[22 37 38]

Statistical analysis

Aim 1

Data are reported as the number and percentage of responders. Data analysis was performed using frequency distributions for categorical variables and summarised using proportions. Continuous variables were summarised using means, SD, median, range and quartiles. To identify factors influencing risk of mental health disorders according to the CDC checklist (gender, first pregnancy, mother's age, age of the child, low birth weight (LBW), gestational age, type of delivery, Apgar score, birth asphyxia, malnutrition and/or rickets, neurological disorders, other medical conditions) OR were computed, considering the significance of the CI.

Statistical significance was evaluated using 95% CIs and a two-tailed p<0.05. A log-binomial regression model was used to assess statistically significant variables potentially affecting fails in the CDC checklist. All variables were entered into the model, and a stepwise regression analysis was conducted. The Hosmer-Lemeshow test was used to determine the goodness of fit of the logistic regression model.

Aim 2

Descriptive statistics were calculated separately for Kenyan and Italian children, and differences were evaluated using χ^2 tests for categorical variables and t-tests for continuous variables. Statistical significance was set at p<0.05; all tests were two sided. ORs and 95% CIs were obtained from conditional logistic regression to account for the matching variables. Both unadjusted and adjusted multivariable models were used to compare Kenyan and Italian children and used CDC and M-CHAT-R as categorical dependent variables. The multivariable model included, as potential confounders, data on mothers' characteristics (age at delivery, first pregnancy), history of delivery (gestational age at birth: preterm or at term; type of delivery: spontaneous vaginal delivery (SVD) or caesarean section (CS); birth weight: normal or low; Apgar score: normal or low). The entire clinical evaluation during medical assessment focused on behaviour, social interaction, language and communication, motor skills, and, in general, developmental milestone achievement according to age at the time of evaluation. All variables were entered into the model, and a stepwise conditional regression analysis was conducted. To measure multicollinearity, we calculate in our samples the variance inflation factor (VIF). This analysis was conducted in R (R Core Team, 2014).

Missing values are excluded from the analysis and only subjects with complete records are included in the multivariable models. SAS software V.9.4 (SAS, Institute) was used.

RESULTS

Aim 1

A toal of 509 children resident in Korogocho and accessing the health service during the study were enrolled. The population was equally distributed for gender (F 47.3%, M 52.7%). The age distribution of enrolled children covers infants from birth until 48 months of age. More specifically, 256 children (50.3%) aged less than 12 months of life, 188 children (36.9%) aged from 12 to 24 months of life, 56 children (11%) from 24 to 36 months of life, and 7 children (1.8%) from 36 to 48 months old were recruited. The majority of the sample (95.5%) had normal birth weight, while 23 subjects (4.5 %) reported LBW or very LBW (LBW/VLBW). In all, 486 subjects were delivered at term, while 23 were preterm for gestational age. Three-quarters of the sample (75.2%) were born with SVD, while 125 children were born with caesarian section. At the time of the clinical assessment, 40 subjects (7.9 %) reported neurological disorders (eg, seizure or epilepsy, hypotonia or hypertonia, cerebral palsy, or a neurological malformation such as hydrocephalus) and 16 children (3.1%) other conditions. In terms of nutritional status, 474 (93.1%) were well nourished, while 35 (6.9%) presented a condition of (Moderate Acute Malnutrition, 2<z<3 or Severe Acute Malnutrition, z<3 DS). The mean maternal age at delivery was 26.73 years old (ranging from 17 to 47 years), and 176 were first-time mothers.

Regarding the CDC assessment, 424 subjects in the age range of 0–15 months were evaluated and assessed with CDC checklists. In this group, 396 (93.4%) reached developmental milestones according to age as expected (pass), while 28 (6.6%) failed. There were 76 children aged 16–30 months who completed the CDC checklist, of whom 10 (13.2%) screened positive for impairment in developmental milestones, and 15 children aged 24 months and older, of whom 7 (46.6%) screened positive for impairment in developmental milestones.

Of the sample of 509 children, 44 (8.6%) failed in at least one of the CDC domains and could therefore be considered at risk for mental health disorders, while 465 (91.4%) did not show such risk. In particular, 22 (50%) children failed in language-communication, 34 (77.3%) in the motor domain, 19 (43.2%) in the cognitive and 10 (22.7%) in the social-emotional domain. The domain in which most gaps were found was language communication.

The characteristics of the population were then compared according to the presence of risk of mental health disorders (table 1). In the univariate analysis, the age of the child (OR 3.30, p<0.0001), age of the mother (OR 2.11, 95% CI 1.06 to 4.21), weight at birth (OR 3.18, 95% CI 1.12 to 9.04) and Apgar score at birth (OR 37.16, 95% CI 9.57 to 144.34) were identified as significant risk factors. Also, asphyxia (OR 21.80, 95% CI 6.10 to 77.90), malnutrition and/or rickets (OR 41.34, 95% CI 18.14 to 94.21) and the presence of neurological disorders (OR 55.22, 95% CI 24.32 to 125.35) or other conditions (OR 5.29, 95% CI 1.75 to 16.00) were found to be significant risk factors. The VIF values of the variables included in our four models do not exceed the threshold value of 2.5; as demonstrated,[39 40] in weak models, such as logistic regression, values above 2.5 may be a cause for concernments, which corresponds to an R^2 of 0.60 with the other variables. Therefore, we can reasonably say that they are not affected by multicollinearity.

The logistic regression (table 2) confirmed that Apgar score at birth (OR 46.98, 95% CI 6.98 to 315.89), malnutrition and/or rickets (OR 10.64, 95% CI 3.04 to 37.19) and neurological disorders (OR 17.58, 95% CI 5.45 to 56.72) were significant predictors for risk of mental health disorders.

Table 1 Characteristics of the sample according to the presence of risk of mental health disorders (as indicated by a fail in at least one of the four CDC domains)

	CDC						
	Fail (n=44)		Pass (n=465)				
	N.	%	N.	%	OR or F	95% CI	P value
Age (Mother)							
≤29	23	60.5	304	76.4	Ref		
30+	15	39.5	94	23.6	2.11	1.06 to 4.21	0.0341
Total	38	100.0	398	100.0			
Missing	6		67				
Gestational Age							
AT TERM (≥37 weeks)	41	93.2	445	95.7	Ref		
PRE TERM (< 37 weeks)	3	6.8	20	4.3	1.63	0.46 to 5.71	0.4465
Total	44	100.0	465	100.0			
Delivery							
CS (Caesarean section)	13	29.5	112	24.1	1.32	0.67 to 2.61	0.4270
SVD (spontaneous/vaginal)	31	70.5	352	75.9	Ref		
Total	44	100.0	464	100.0			
Missing			1				
Gender							
Female	18	41.9	223	48.5	Ref		
Male	25	58.1	237	51.5	1.31	0.69 to 2.46	0.4072
Total	43	100.0	460	100.0			
Missing	1		5				
Age of the Child* (Months)	14.8±11.5; 11.5; 1–48		7.2±6.3; 5; 1–40		3.30		<0.0001
First Time Mother							
YES	3	6.8	66	14.2	Ref		
NO	41	93.2	399	85.8	2.26	0.68 to 7.51	0.1831
Total	44	100.0	465	100.0			
Birth Weight							
LOW BIRTH WEIGHT (≤2500)	5	11.4	18	3.9	3.18	1.12 to 9.04	0.0296
NORMAL WEIGHT (>2500)	39	88.6	447	96.1	Ref		
Total	44	100.0	465	100.0			
APGAR							
LOW (0–6)	9	22.5	3	0.8	37.16	9.57 to 144.34	<0.0001
NORMAL (7-10)	31	77.5	384	99.2	Ref		
Total	40	100.0	387	100.0			
Missing	4		78				
BIRTH ASPHYXIA							
No	37	84.1	461	99.1	Ref		
Yes	7	15.9	4	0.9	21.80	6.10 to 77.90	<0.0001
Total	44	100.0	465	100.0			
Malnutrition+Rickets							
No	21	47.7	453	97.4	Ref		
Yes	23	52.3	12	2.6	41.34	18.14 to 94.21	<0.0001
Total	44	100.0	465	100.0			
Neurological Disorder							

Continued

Table 1 Continued

	CDC						
	Fail (n=44)		Pass (n=465)				
	N.	%	N.	%	OR or F	95% CI	P value
No	17	38.6	452	97.2	Ref		
Yes	27	61.4	13	2.8	55.22	24.32 to 125.35	<0.0001
Total	44	100.0	465	100.0			
Other condition							
No	39	88.6	454	97.6	Ref		
Yes	5	11.4	11	2.4	5.29	1.75 to 16.00	0.0032
Total	44	100.0	465	100.0			
M-CHAT-R (16–30 months)							
FAIL	2	20.0	0	0.0	>999.99	<0.001 to >999.99	0.9799
PASS	8	80.0	64	100.0	Ref		
Total	10	100.0	64	100.0			

*Mean±SD; median; range.
BIRTH ASPHYXIA, failure to establish breathing at birth; CDC, Centers for Disease Control and Prevention; M-CHAT-R, Modified Checklist for Autism in Toddlers, Revised; SVD, spontaneous vaginal delivery.

Seventy-four children of this sample (aged 16–30) were also screened with the M-CHAT-R, and 2 were at risk of ASD (2.7%).

Aim 2

The Kenyan children matched with the Italian: 32 females and 44 males from Nairobi, and 64 females and 88 males from Italy. The mean age of the Kenyan children was 18.9 months (SD=2.8, range 16–30), and that of the Italian children was 19.3 (SD=2.6, range 14–28). Of the 152 Italian children enrolled, 48 (31.6%) failed the CDC and 16 (10.5%) the M-CHAT-R assessment (table 3). A significant difference between the two samples was found in both the CDC (OR 0.33, 95% CI 0.156 to 0.711) and M-CHAT-R (OR 0.21, 95% CI 0.04 to 0.95) assessments: Italian children tended to fail more frequently, with the main differences reported in the socio-emotional and cognitive domains.

A statistically significant difference was found for maternal age and mothers in their first pregnancy, also confirmed by the stepwise logistic regression (table 4), respectively OR 0.09, 95% CI 0.04 to 0.23 for maternal age and OR 7.87, 95% CI 2.36 to 26.26 for mothers in their first pregnancy. Kenyan mothers were younger and had more children than Italian mothers.

Considering the CDC assessment conducted in the two populations, a comparison was made between children who failed the assessment (n=58) and those who passed it (n=170). The only significant risk variable for both samples was delivery via caesarian section (OR 5.1, 95% CI 1.88 to 13.85) (online supplemental table 1).

Considering the M-CHAT-R assessment conducted in both populations, a comparison was made between children who failed the assessment (n=18) and those who passed it (n=208) (online supplemental table 1). The only significant risk variable was maternal age at delivery, in particular for mothers older than 30 years (OR 5.36, 95% CI 1.14 to 25.18). The results of the conditional stepwise logistic regression analysis (table 5) confirmed that CS delivery (OR 8.37, 95% CI 2.39 to 29.28) was a significant risk factor for failing the CDC, while being pregnant for the first time (OR 3.4, 95% CI 1.21 to 9.57) was found to be a protective factor. Mothers younger than 29 years appeared to have a lower risk factor for failing the M-CHAT-R assessment (OR 0.19, 95% CI 0.04 to 0.88).

Table 2 Results of logistic regression model by CDC (FAIL) of Kenyan children

	OR	95% CI	P value
Apgar (low vs normal)	46.98	6.98 to 315.89	<0.0001
Malnutrition+rickets (yes vs no)	10.64	3.04 to 37.19	0.0002
Neurological disorder (yes vs no)	17.58	5.45 to 56.72	<0.0001

X^2=3.8604 (p=0.8695).
CDC, Centers for Dusease Control and Prevention.

DISCUSSION

In LMICs, there are not enough community-based data on children's developmental status and disabilities. Furthermore, little is known about the epidemiology and clinical presentation of ASD in South East Asia, South America and Africa.[17 41–43] This lack of information on mental disorders in LMICs might be due to the scarce use

Table 3 Comparison of Kenyan and Italian children's characteristics (match 1:2)

	Kenya (N=76)		Italy (N=152)				
	N	%	N	%	OR or F	95% CI	P value
Age (mother)							
≤29	53	82.8	30	20.1	**Ref**		
30+	11	17.2	119	79.9	0.09	0.04 to 0.20	<0.0001
Total	64	100.0	149	100.0			
Missing	12		3				
Gestational age							
At term (≥37 weeks)	70	92.1	145	95.4	Ref		
Pre term (<37 weeks)	6	7.9	7	4.6	1.804	0.572 to 5.689	0.3139
Total	76	100.0	152	100.0			
Delivery							
Caesarean section	24	31.6	52	34.2	0.884	0.487 to 1.606	0.6863
SVD (spontaneous/vaginal)	52	68.4	100	65.8	Ref		
Total	76	100.0	152	100.0			
Gender							
Female	32	42.1	64	42.1			
Male	44	57.9	88	57.9			
Total	76	100.0	152	100.0			
Age of the child** months	18.9±2.8; 18; 16–30		19.3±2.6; 19; 14–28		1.16		0.4395
First time mother							
Yes	14	18.4	68	44.7	Ref		
No	62	81.6	84	55.3	3.227	1.694 to 6.145	0.0004
Total	76	100.0	152	100.0			
BW							
LBW (≤2500)	8	10.5	13	8.6	1.259	0.497 to 3.193	0.6272
NW (>2500)	68	89.5	139	91.4	Ref		
Total	76	100.0	152	100.0			
Apgar							
Low (0–6)	3	4.3	1	0.7	6.000	0.624 to 57.681	0.1207
Normal (7–10)	66	95.7	150	99.3	Ref		
Total	69	100.0	151	100.0			
Missing	7		1				
CDC							
Fail	10	13.2	48	31.6	0.333	0.156 to 0.711	0.0045
Pass	66	86.8	104	68.4	Ref		
Total	76	100.0	152	100.0			
M-CHAT-R							
Fail	2	2.7	16	10.5	0.207	0.045 to 0.955	0.0435
Pass	72	97.3	136	89.5	Ref		
Total	74	100.0	152	100.0			
Missing	2						

*Mean±SD; median; range.
CDC, Centers for Diseaseontrol and Prevention; LBW, low birth weight; M-CHAT-R, Modified Checklist for Autism in Toddlers, Revised; NW, Normal Weight; SVD, spontaneous vaginal delivery.

Table 4 Results of conditional stepwise logistic regression analysis

	Outcome (Kenya)		
	OR	95% CI	P value
First time mother			
No vs yes	7.869	2.358 to 26.258	0.0008
Age (mother)			
30+ vs ≤29	0.092	0.037 to 0.228	<0.0001

of practical and validated diagnostic strategies. Communities also differ, due to cultural reasons, in their ASD awareness,[44 45] which is known to be low in LMICs.[10 15]

In LMICs, there is a significant need for screening tools for the early identification of developmental disorders and NDD[22] to be integrated into health service delivery, particularly in the informal settlements, as a standard practice so a timely diagnosis and a corresponding intervention can be made. For developmentally delayed children, prevalence rates may be higher than reported since children with milder and more subtle signs are likely to go unnoticed.[46] Following AAP recommendations, developmental surveillance at all visits and standardised autism-specific screening tests at 18 and 24 months should be implemented in LMICs.

This study demonstrated the feasibility of implementing routine child screening in LMICs by adapting assessment tools commonly used in Western countries. Indeed, the results showed that a developmental screening is also feasible in populations with challenging environmental conditions.

As for the percentage of at-risk children detected, 6.6% of the sample showed a delay in achieving milestones, and 2.7% showed a risk of ASD, based on the M-CHAT-R results. Similar percentages were reported in other populations assessed with different tools in the same target area (eg, SYCa 6–36: A screening tool for psychological difficulties among children aged 6–36 months; CGIS: clinical global impression severity score),[47] confirmed the practical applicability of these instruments in the Kenyan slums.

Furthermore, the fact that urban children are more likely to screen positive has been previously reported in African populations.[48] This result is likely due to parents' weaker attitude towards observing and perceiving their children's NDDs in the informal settlements. If cultural norms indeed shape caregiver concerns,[49] less knowledge about the early signs of ASD may affect caregivers' recognition of the same signs in their child, leading them to overlook subtle delays,[50] as well as to influence the type of information they report to the child's doctor.[51] Both factors may further delay early diagnosis.[45] Former research in South Africa found that caregivers lacked information on the causes of disability.[52] On the other hand, Italian parents focus more on their children's developmental milestones and, therefore, more quickly detect and refer a delay or a problem to specialists.

The domains most commonly reported as problematic were language-communication for the Kenyan sample and socioemotional and cognitive domains for the Italian sample, according to previous literature that reported parental concerns related to language or behaviour.[53] Again, this difference is likely due to the different observation habits of the parents in the two populations. Moreover, the M-CHAT-R has never been implemented in Kenyan informal settlements, while many Italian paediatricians use this tool as a routine assessment.

There are few epidemiological studies on mental health disorders among children and adolescents in Kenya.[54] Two studies[26 55] were conducted, however, on primary school children in Kenya, highlighting a high prevalence of mental health disorders. Yet, given the increasing developmental burden in LMICs,[56] early identification of at-risk children and following up on diagnosis is essential to improve clinical outcomes. It is important, however, to act on a double binary to achieve an efficient impact on the population: on one hand, community interventions are needed to raise parents' awareness, providing them with information on their children's neurodevelopment; on the other hand, clinicians working in the slums should be trained to employ screening tools and facilitate early diagnosis.

The cascade effect of healthy development can prevent many other disorders later in childhood or adulthood. Early detection of developmental problems is crucial for the child's development and for planning and informing policies. After screening, however, it is mandatory to guarantee appropriate interventions to those who test positive. The responsibility is even greater in LMICs, where this goal is still largely unfulfilled.

The present exploratory study's findings should be interpreted cautiously due to some limitations. First of all, our findings are not representative of all Kenyan children, but of the population living in the informal

Table 5 Results of conditional stepwise logistic regression analysis

	Outcome CDC fail		
Model 1	**OR**	**95% CI**	**P value**
Delivery			
CS versus SVD	**8.373**	2.394 to 29.282	0.0009
Only child			
Yes versus no	**3.400**	1.205 to 9.569	0.0207
Model 2	**Outcome M-CHAT-R fail**		
	OR	**95% CI**	**P value**
Mother's age			
≤29 vs 30+	**0.187**	0.040 to 0.878	0.0336

CDC, Centers for Disease Control and Prevention; CS, caesarean section; M-CHAT-R, Modified Checklist for Autism in Toddlers, Revised; SVD, spontaneous vaginal delivery.

settlement of Korogocho within Nairobi. As mentioned above, for the purpose of the present study, we have recruited newborns and children aged up to 30 months of life, and their mothers, who spontaneously accessed the Child Welfare Clinic, reducing the samples heterogeneity; we were therefore not able to determine how well the characteristics of this cohort represented the overall population in Kenya or LMIC. Results cannot thus be generalised to the general Kenyan population or other cohorts, considering the different cultural, linguistic and economic characteristics of populations living in metropolitan settings, in particular in LMICs. The cross-sectional design implies that further assessment should be conducted to monitor the longitudinal development of at-risk children. It is also important to highlight that the detected risk variables for failing the developmental assessment had significant effects but also wide CIs, so the validity of the findings should be confirmed by future studies. Lastly, Italian and Kenyan children were compared with a 2:1 match after controlling children for gender and age. Future studies should aim at having larger cohorts so that a direct comparison is possible.

The strengths of this study are several. The findings show that screening for NDDs is feasible in LMIC informal settlements using tools and approaches currently implemented in highly developed countries. Such screenings would collect information through validated, shared instruments that can be used in further clinical and research studies. A comparative perspective and a collaborative partnership with those with more assets can lead to better use of the available resources.

Reporting guidelines

The study follows the Strengthening the Reporting of Observational Studies in Epidemiology reporting guidelines.

Twitter Elisa Roberti @elisa_r19 and Maurizio Bonati @@mumchild_irfmn

Acknowledgements The authors would like to acknowledge Chiara Pandolfini for language editing.

Contributors GS and MB conceptualised and designed the study and drafted the initial manuscript. CC, CB, WN and MVDV directed the study's implementation, designed data collection instruments and supervised data collection. RC carried out the statistical analyses and managed the data. MPC, ER and GM participated in the conceptualisation and design of the study, critically reviewed the manuscript for important intellectual content and provided input into data analysis. MB supervised data analysis, and critically reviewed the manuscript for important intellectual content. MB is the guarantor and accepts full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish. All authors reviewed and revised the manuscript, and approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and this research was approved by the ethics committee of the Strathmore University Ethics Review Committee (# under SU-IERC0795/20) in line with the relevant national and institutional guidelines on care and clinical research. Participants gave written informed consent before taking part in the study.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request.

ORCID iDs

Elisa Roberti http://orcid.org/0000-0003-3525-9015
Maurizio Bonati http://orcid.org/0000-0003-3997-3726

REFERENCES

1 UNICEF. Kenya National Bureau of Statistics. child poverty in Kenya: a multidimensional approach. Nairobi. 2017.
2 Mascayano F, Toso-Salman J, Ho YCS, *et al*. Including culture in programs to reduce stigma toward people with mental disorders in Low- and middle-income countries. *Transcult Psychiatry* 2020;57:140–60.
3 Saxena S, Thornicroft G, Knapp M, *et al*. Resources for mental health: scarcity, inequity, and inefficiency. *Lancet* 2007;370:878–89.
4 Alonso J, Buron A, Bruffaerts R, *et al*. Association of perceived stigma and mood and anxiety disorders: results from the world mental health surveys. *Acta Psychiatr Scand* 2008;118:305–14.
5 Black RE, Victora CG, Walker SP, *et al*. Maternal and child Undernutrition and overweight in low-income and middle-income countries. *The Lancet* 2013;382:427–51.
6 Suchdev PS, Boivin MJ, Forsyth BW, *et al*. Assessment of Neurodevelopment, nutrition, and inflammation from fetal life to adolescence in low-resource settings. *Pediatrics* 2017;139:S23–37.
7 Huq T, Alexander EC, Manikam L, *et al*. A systematic review of household and family alcohol use and childhood neurodevelopmental outcomes in Low- and middle-income countries. *Child Psychiatry Hum Dev* 2021;52:1194–217.
8 Engle PL, Black MM, Behrman JR, *et al*. Strategies to avoid the loss of developmental potential in more than 200 million children in the developing world. *The Lancet* 2007;369:229–42.
9 Mung'ala-Odera V, Newton CRJC. Identifying children with neurological impairment and disability in resource-poor countries. *Child Care Health Dev* 2007;33:249–56.
10 Durkin MS, Elsabbagh M, Barbaro J, *et al*. Autism screening and diagnosis in low resource settings: challenges and opportunities to enhance research and services worldwide. *Autism Res* 2015;8:473–6.
11 UNICEF. *Children with disabilities*. New York, 2013.
12 Bornstein MH, Hendricks C. Screening for developmental disabilities in developing countries. *Soc Sci Med* 2013;97:307–15.
13 Bizzego A, Lim M, Schiavon G, *et al*. Children with developmental disabilities in Low- and middle-income countries: more neglected and physically punished. *Int J Environ Res Public Health* 2020;17:7009.
14 Bitta M, Kariuki SM, Abubakar A, *et al*. Burden of neurodevelopmental disorders in low and middle-income countries: A systematic review and meta-analysis. *Wellcome Open Res* 2018;2:121.
15 Abubakar A, Ssewanyana D, Newton CR. A systematic review of research on autism spectrum disorders in sub-Saharan Africa. *Behav Neurol* 2016;2016:3501910.
16 Baxter AJ, Brugha TS, Erskine HE, *et al*. The epidemiology and global burden of autism spectrum disorders. *Psychol Med* 2015;45:601–13.
17 de Vries PJ. Thinking globally to meet local needs. *Curr Opin Neurol* 2016;29:130–6.

18 Elsabbagh M, Divan G, Koh Y-J, *et al*. Global prevalence of autism and other pervasive developmental disorders. *Autism Res* 2012;5:160–79.
19 Bölte S, Girdler S, Marschik PB. The contribution of environmental exposure to the etiology of autism spectrum disorder. *Cell Mol Life Sci* 2019;76:1275–97.
20 Singhi P, Malhi P. Early diagnosis of autism spectrum disorder: what the Pediatricians should know. *Indian J Pediatr* 2023;90:364–8.
21 Prahbhjot M, Singhi P. Age at diagnosis for autism spectrum disorders: does it differ by place of residence *Indian J Public Health* 2022;66:166–70.
22 Marlow M, Servili C, Tomlinson M. A review of screening tools for the identification of autism spectrum disorders and developmental delay in infants and young children: recommendations for use in Low- and middle-income countries. *Autism Res* 2019;12:176–99.
23 Goldfeld S, Yousafzai A. Monitoring tools for child development: an opportunity for action. *Lancet Glob Health* 2018;6:S2214-109X(18)30040-8:e232–3.:.
24 Bauer K, Morin KL, Renz TE III, *et al*. Autism assessment in Low- and middle-income countries: feasibility and usability of Western tools. *Focus Autism Other Dev Disabl* 2022;37:179–88.
25 Romero Otalvaro AM, Grañana N, Gaeto N, *et al*. ASQ-3: validation of the ages and stages questionnaire for the detection of neurodevelopmental disorders in Argentine children. *Arch Argent Pediatr* 2018;116:7–13.
26 Ndetei DM, Mutiso V, Musyimi C, *et al*. The prevalence of mental disorders among upper primary school children in Kenya. *Soc Psychiatry Psychiatr Epidemiol* 2016;51:63–71.
27 The Centers for Disease Control and Prevention. CDC's developmental milestones. 2019.
28 Khowaja MK, Hazzard AP, Robins DL. Sociodemographic barriers to early detection of autism: screening and evaluation using the M-CHAT, M-CHAT-R, and follow-up. *J Autism Dev Disord* 2015;45:1797–808.
29 Manzone LA. AdaptaciÓN Y ValidaciÓN del MODIFIED CHECKLIST FOR AUTISM IN TODDLER para PoblaciÓN Urbana Argentina. *Psicodebate* 2013;13:79. 10.18682/pd.v13i0.363 Available: https://dspace.palermo.edu/ojs/index.php/psicodebate/issue/view/29
30 Albores-Gallo L, Roldán-Ceballos O, Villarreal-Valdes G, *et al*. M-CHAT Mexican version validity and reliability and some cultural considerations. *ISRN Neurol* 2012;2012:408694.
31 Perera H, Wijewardena K, Aluthwelage R. Screening of 18-24-month-old children for autism in a semi-urban community in Sri Lanka. *J Trop Pediatr* 2009;55:402–5.
32 Tsai J-M, Lu L, Jeng S-F, *et al*. Validation of the modified checklist for autism in toddlers, revised with follow-up in Taiwanese toddlers. *Res Dev Disabil* 2019;85:205–16.
33 Samia P, Kanana M, King J, *et al*. Childhood autism spectrum disorder: insights from a tertiary hospital cohort in Kenya. *Afr J Health Sci* 2020;33:12–21.
34 Stenberg N, Bresnahan M, Gunnes N, *et al*. Identifying children with autism spectrum disorder at 18 months in a general population sample. *Paediatr Perinat Epidemiol* 2014;28:255–62.
35 Chlebowski C, Robins DL, Barton ML, *et al*. Large-scale use of the modified checklist for autism in low-risk toddlers. *Pediatrics* 2013;131:e1121–7.
36 Pansieri C, Clavenna A, Pandolfini C, *et al*. NASCITA Italian birth cohort study: a study protocol. *BMC Pediatr* 2020;20:80.
37 Choueiri R, Lindenbaum A, Ravi M, *et al*. Improving early identification and access to diagnosis of autism spectrum disorder in toddlers in a culturally diverse community with the rapid interactive screening test for autism in toddlers. *J Autism Dev Disord* 2021;51:3937–45.
38 Choueiri R, Garrison WT, Tokatli V. Early identification of autism spectrum disorder (ASD): strategies for use in local communities. *Indian J Pediatr* 2023;90:377–86.
39 Midi H, Sarkar SK, Rana S. Collinearity diagnostics of binary logistic regression model. *J Interdiscip Mathemat* 2010;13:253–67.
40 Bayman EO, Dexter F. Multicollinearity in logistic regression models. *Anesth Analg* 2021;133:362–5.
41 Franz L, Chambers N, von Isenburg M, *et al*. Autism spectrum disorder in sub-Saharan Africa: A comprehensive Scoping review. *Autism Res* 2017;10:723–49.
42 Qiu J, Shen B, Zhao M, *et al*. A nationwide survey of psychological distress among Chinese people in the COVID-19 epidemic: implications and policy recommendations. *Gen Psychiatr* 2020;33:e100213.
43 Paula CS, Cukier S, Cunha GR, *et al*. Challenges, priorities, barriers to care, and stigma in families of people with autism: similarities and differences among six Latin American countries. *Autism* 2020;24:2228–42.
44 Burkett K, Morris E, Manning-Courtney P, *et al*. African American families on autism diagnosis and treatment: the influence of culture. *J Autism Dev Disord* 2015;45:3244–54.
45 Zuckerman KE, Lindly OJ, Reyes NM, *et al*. Parent perceptions of community autism spectrum disorder stigma: measure validation and associations in a multi-site sample. *J Autism Dev Disord* 2018;48:3199–209.
46 Sajedi F, Vameghi R, Kraskian Mujembari A. Prevalence of undetected developmental delays in Iranian children. *Child Care Health Dev* 2014;40:379–88.
47 Nackers F, Roederer T, Marquer C, *et al*. A screening tool for psychological difficulties in children aged 6 to 36 months: cross-cultural validation in Kenya, Cambodia and Uganda. *BMC Pediatr* 2019;19:108.
48 Kakooza-Mwesige A, Ssebyala K, Karamagi C, *et al*. "Adaptation of the "ten questions" to screen for autism and other neurodevelopmental disorders in Uganda". *Autism* 2014;18:447–57.
49 Daley TC. From symptom recognition to diagnosis: children with autism in urban India. *Soc Sci Med* 2004;58:1323–35.
50 Tek S, Landa RJ. Differences in autism symptoms between minority and non-minority toddlers. *J Autism Dev Disord* 2012;42:1967–73.
51 Blacher J, Cohen SR, Azad G. In the eye of the beholder: reports of autism symptoms by Anglo and Latino mothers. *Research in Autism Spectrum Disorders* 2014;8:1648–56.
52 Masasa T, Irwin-Carruthers S, Faure M. Knowledge of, beliefs about and attitudes to disability: implications for health professionals. *South African Family Practice* 2005;47:40–4.
53 Weitlauf AS, Vehorn A, Miceli A, *et al*. Black families' experiences of developmental screening: review of well-child visits to inform enhanced autism spectrum disorder risk assessment. *J Dev Behav Pediatr* 2022;43:503–10.
54 Kieling C, Baker-Henningham H, Belfer M, *et al*. Child and adolescent mental health worldwide: evidence for action. *The Lancet* 2011;378:1515–25.
55 Magai DN, Malik JA, Koot HM. Emotional and behavioral problems in children and adolescents in central Kenya. *Child Psychiatry Hum Dev* 2018;49:659–71.
56 Ademosu T, Ebuenyi I, Hoekstra RA, *et al*. Burden, impact, and needs of Caregivers of children living with mental health or neurodevelopmental conditions in low-income and middle-income countries: a Scoping review. *Lancet Psychiatry* 2021;8:919–28.