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ORIGINAL ARTICLE

A community-based study of early childhood sensory stimulation in home environment associated with growth and psychomotor development in Pakistan

Bilal Iqbal Avan · Syed Ahsan Raza · Betty R. Kirkwood

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Abstract
Objectives Sensory stimulation (SS) is a non-nutritional modifiable risk factor for early childhood development. We assessed SS in home environment and examined its influence on physical growth and psychomotor development (PD).
Methods A cross-sectional study was conducted in 26 communities in Pakistan among children aged <3 ($n = 1{,}219$). They were assessed at home visits using (1) Bayley's Infant Developmental Scale for PD, (2) home observation for measurement of the environment inventory for SS, (3) anthropometry and (4) socio-economic questionnaire.
Results In rural homes, SS provided was lower as compared to urban counterparts (Adj mean diff: 4.47, 95 % CI 3.78, 5.16) and showed an association with stunting (Adj mean diff: −1.30, 95 % CI −1.93, −0.66), and underweight (Adj mean diff: −1.04, 95 % CI −1.71, −0.38) not explained by type of neighbourhood or socio-economic status. SS was associated with PD more than combined contribution of socio-economic status and rural–urban factors (Adj mean diff: 0.47, 95 % CI 0.30, 0.63).
Conclusions SS in rural homes may be a significant factor influencing the child development. There is a need to corroborate these results by additional research for integration in health policy initiatives.

Keywords Sensory stimulation · Psychomotor development · Physical growth · Anthropometry · Socio-economic status · Rural–urban neighbourhood · Developing countries

Introduction

Care for development, one of the public health initiatives in child health by World health Organization (WHO) (2001) recognizes the critical importance of sensory stimulation in a family setup in early years of life and calls for the action to achieve optimal child development. It is estimated that there are more than 200 million children of <5 years of age who do not achieve their full developmental potential in developing countries (Grantham-McGregor et al. 2007) and there is consistent and strong evidence on four key risk factors of adverse outcome for child development i.e. stunting, inadequate cognitive stimulation, iodine deficiency and iron deficiency anaemia (Walker et al. 2007). This paper focuses on the non-nutritional risk factor in this list, and addresses the role of inadequate sensory stimulation in home on psychomotor development. In particular, we present results on the levels of sensory stimulation provided in the urban and rural homes of Pakistani children disaggregated by socio-economic quintiles, and examine their associations with nutritional status and psychomotor development in light of a conceptual framework presented in Fig. 1.

B. I. Avan (✉)
Informed Decisions for Actions in Maternal and Newborn Health (IDEAS), Department of Disease Control, Faculty of Infectious and Tropical Diseases, London School of Hygiene and Tropical Medicine, London, UK
e-mail: bilal.avan@lshtm.ac.uk

S. A. Raza
Department of Social and Preventive Medicine, Faculty of Medicine, University of Montreal, Montreal, QC, Canada

B. R. Kirkwood
Nutrition and Public Health Intervention Research Unit, Department of Epidemiology and Population Health, London School of Hygiene and Tropical Medicine, London, UK

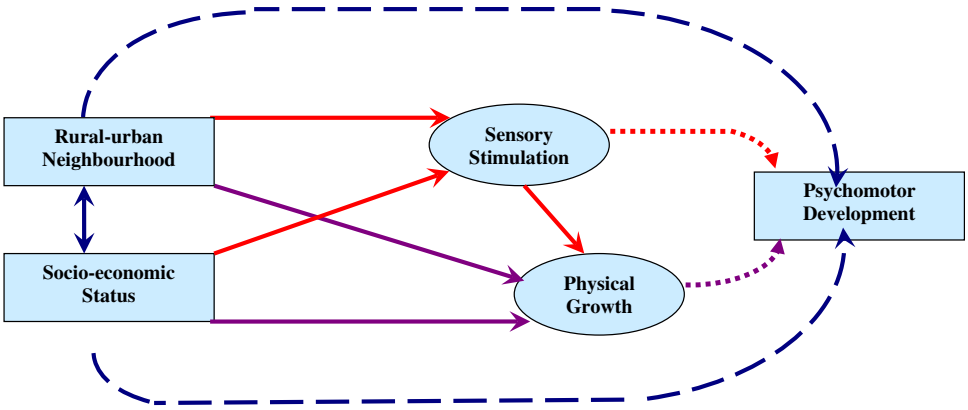

Fig. 1 Framework of fundamental directions of relationship between psychomotor status, sensory stimulation and undernutrition during early childhood (0–3 years)

Sensory stimulation (SS), encompasses the physical, social and emotional environments in which children are cared and nurtured, is known to influence brain development (Parisi 1998) and a wide range of child development outcomes (Bradley 1985). The association between the socio-economic status and sensory stimulation available in the home appears to be universal and cross-cultural (Andrade et al. 2005; de Onis et al. 2001). However, there is also strong evidence that every culture has its own specific set of expected competencies (Garcia et al. 1995). Consequently, families create resources and opportunities to provide the sensory stimulation necessary for the achievement of these expected skills. Most of the cross-cultural literature on sensory stimulation from the developed countries is focussed on inner city vs. general urban differences in terms of child development (Bradley et al. 2001; Burton and Jarrett 2000; Chow et al. 2005). However, for countries like Pakistan, exploration of rural–urban cultural differences is more relevant where 67 % of its population resides in rural neighbourhoods (Census 1998) and provide distinctively different community characteristics for child outcomes (Bellinger 2001). Research has shown that rural–urban difference in psychomotor development is not fully explained by the socio-economic variations (Avan and Kirkwood 2010). Consequently, it necessities further inquiry whether such differences are explained by the differences in the sensory stimulation available in rural–urban areas. To the best of our knowledge, this will be the first time patterns of sensory stimulation have been compared between rural and urban homes.

This paper also aims to contribute to the relatively little evidence base on the affect of sensory stimulation on growth and psychomotor development. Although, there is already sufficient evidence to conclude that it affects cognitive development, there is limited and inconsistent evidence of its effect on psychomotor development (Grantham-McGregor et al. 2007). A cluster randomized trial conducted in Jamaica found that enhancing a parent's sensory stimulation of undernourished children improved fine motor but not gross motor development (Powell et al. 2004). In addition, evidence for the role of sensory stimulation on physical growth of children is largely confined to few studies conducted on non-organic failure to thrive (Grantham-McGregor et al. 2007), and is contradictory (Februhartanty et al. 2007; Hamadani et al. 2006). Findings from these studies represent only a small fraction of undernourished children and have been mostly facility based. Despite an interest in the role of both sensory stimulation and nutrition on child development, much of the available research evaluates them separately whereas in reality they act simultaneously so that their risk is cumulative (Walker et al. 2007). Furthermore, there is scientific evidence showing that brain development resists undernutrition provided the level of sensory stimulation of the child is adequate (Guesry 1998). The study aimed to assess sensory stimulation differentials in home environment by socio-economic status and rural–urban neighbourhoods and examined the contributions of sensory stimulation, over and above the role of physical growth, in psychomotor development.

Methods

Study setting and participants

A cross-sectional study was carried out from May to November 2002 in Sindh Province, Pakistan, in 26 communities whose health services were provided by two non-governmental organizations (NGOs): Aga Khan Health Services of Pakistan, and Health & Nutrition Development Society, both of whom facilitated access to their communities. All families with young children were identified through door-to-door visits, and a single child under the age of three was selected at random for inclusion in the study. Exclusion criteria were twins, adopted or physically handicapped children, and those whose families had been resident in the area for <6 months.

Out of a total population of 33,934, every eligible child (1,244) was selected and assessed in their home setting. There were only three refusals due to reasons unrelated to the study. Six hundred and fifty-one children (52.3 %) were boys, 454 (36.5 %) were in their first, 454 (36.5 %) in their second and 336 (27.0 %) in their third year of life. These Communities were designated as rural if they were farm-based and as urban otherwise. There were 15 rural (613 children) and 11 urban (631 children). For further methodological details please refer to Avan and Kirkwood (2010)

Anthropometric and psychomotor assessment

All children were weighed and measured according to standard procedures recommended by WHO (1995). Their weights and heights were compared with the new WHO growth standards (WHO 2007), and expressed in terms of z scores. Stunting, wasting and underweight were defined as height-for-age (HAZ), weight-for-height (WHZ) and weight-for-age (WAZ) z scores below -2, respectively. Stunting is inadequate linear growth resulting from chronic insufficiency in nutrition or episodes of illness or both. A deficit in weight relative to height due to an acute shortfall in nutrition and are termed wasted. The condition of being underweight is a result of undernutrition and can be either acute or chronic in nature (WHO 2005). Measurements of 25 children were flagged by WHO Anthro software (WHO 2007) as having unlikely values and were excluded; the analysis is, therefore, based on a sample of 1,219 children. Psychomotor development (PD) was assessed using the Bayley Scale of Infant Development II (BSID II), which yields a normalized, standardized score called the PD index (Bayley 1993).

Assessment of sensory stimulation in the home

The assessment of sensory stimulation was carried out using the standardized protocol for the Home Observation for Measurement of the Environment (HOME) inventory (Caldwell and Bradley 2001), which has been widely used in diverse populations to assess the sensory stimulation potential of the child's environment (Walker et al. 2007; Bradley and Caldwell 1979; Bradley et al. 1979; Burston et al. 2005; Caldwell and Bradley 1984; Elardo et al. 1975). This inventory covers 45 items clustered into six domains or subscales: Responsivity (parental response to the child's behaviour by verbal, physical and emotional encouragement for desired behaviours); Acceptance (parental acceptance of less than desired behaviour from the child and avoidance of unnecessary restriction); Organization (regularity and predictability in the family's schedule without being monotonous); Learning materials (availability of age-appropriate play and -learning materials); Involvement (active parental involvement in child's learning; Variety (routine inclusion of events and people to bring diversity of experience in child's life without significant disorganization).

Responses to each of the items (yes–no) were obtained by observing the child's interactions with the environment and people, by assessment of the relevant available resources, and by posing questions to the primary caregiver. On the basis of pre-testing in the local communities, a few explanations and hints were added to include some culturally relevant observations, but overall the integrity of inventory remained intact. For example, one of the items for the Avoidance domain was 'No more than one instance of physical punishment during past week'. The exemplar added for the infant was 'any incident of child neglect such as not able to feed the baby on time'. Total scores were calculated for overall and each sub-scale (Yes responses score 1, and No responses score 0). Higher HOME scores (maximum 45) demonstrate the availability of an enriched environment with essential multisensory stimulation required for child development, whereas lower scores were seen as child neglect (Drotar and Crawford 1987). The reliability of the HOME scale was assessed using Cronbach's α, a coefficient of internal consistency for psychometric instruments. The overall HOME score α was 0.86 (high internal consistency), with values for each domain ranging from 0.50 to 0.85, findings were consistent with the HOME assessments in the similar settings (Aboud and Akhter 2011).

Socioeconomic index

Information on the demographic, social and economic background of the child's family was collected from the child's mother (or primary caregiver) using a pre-tested, structured questionnaire. Principal component analysis was used to generate a socioeconomic (SE) index based on the nine factors found to be strongly related to the psychomotor development (PD) index (Avan and Kirkwood 2010). Four of these factors were considered as social (maternal education, paternal education, maternal occupation and paternal occupation) and five as economic (per capita income, number of rooms in the house, number of people/room, water supply and main mode of transport). The SE index scores were then grouped to divide families into socio-economic quintiles with '1' being the quintile with the lowest SE index scores (and, therefore, the poorest) and '5' as quintile with the highest SE index scores (and, therefore, the richest).

Study personnel and quality control measures

A field team of ten members comprised clinical psychologists, community health nurses, sociologists and

physicians. They received conceptual and practical training on study instruments for 4 weeks in both clinical and community settings until good intra- and inter-observer correlations were achieved. All activities were overseen by a designated field supervisor with responsibility for quality assurance of data collection. In addition to specific quality control measures for the respective study instruments, there were regular refresher trainings, guidance and monitoring of the teams by cross-checking in the field and observations of interviews by study investigators and field supervisor.

Statistical analysis

HOME scores (total and subscales) are presented by age and gender; differences were tested using multivariate linear regression and Students *t* test and ANOVA. To check out the key background assumptions for the regression analysis, Kolmogorov–Smirnov tests were used to assess the normal distributions key variables, while outliers from anthropometric data fixed criteria proposed by the WHO. Scattered plots of the standardized residuals for linear assumption were satisfied for key relationships of HOME with anthropometric measures and PDI. Fours sets of multiple linear regressions were carried out: (1) compare mean HOME scores (total and domains) between rural and urban neighbourhoods and between socio-economic status adjusting for the child's age and gender; (2) examine the association between PD index and HOME scores adjusting for age, gender, SE quintile, and neighbourhood; (3) assess the difference in HOME scores of children who were stunted, underweight, or wasted, and those who were not, including adjustment for age, gender, SE quintile, and neighbourhood; and (4) to assess the difference in PD index between households subdivided into quintiles based on their HOME scores with adjustment for age, gender, SE quintile, neighbourhood, and undernutrition.

Results

Mean HOME scores by age and gender

The average HOME score in our study sample was 26.90 out of a possible total of 45 (Table 1), suggesting that children received on average about 60 % of the ideal level of sensory stimulation. The achievement on the different HOME domains was uneven; the highest percentage scores were attained in Parental Responsivity (77.36 %) and Acceptance (76.63 %), while the lowest score was obtained in the Learning materials (34.22 %).

Sensory stimulation available at home significantly increased with age with the overall HOME scores increasing from an average of 24.9 in the first year to an average 28.8 in the third year of life, a relative change of 15.5 % (p value for trend <0.001). Although the mean HOME and domain scores were persistently higher for female children, there were no statistically significant gender differentials (data not shown).

HOME by socio-economic quintile and rural–urban neighbourhood

Overall mean HOME scores were 19 % higher for urban than for rural areas mainly due to differences in the Responsivity, Learning material and Parental involvement domains (Table 1). In contrast, parents in rural areas on average showed more acceptance of child behaviours than those in urban families (p value <0.001). In general, children of higher socio-economic status enjoyed better sensory stimulation available at home (Table 2). This was true for all of the domains, except Acceptance (Table 3). The highest differential with SE index was observed in Learning materials; mean scores were about 500 % higher for children from the highest socio-economic quintile as compared to the lowest one.

Table 1 Description of mean (SD) of sensory stimulation (HOME and its domains) by rural–urban neighbourhood in Sindh, Pakistan, 2002

HOME	No. of items	Mean (SD)	Urban, $n = 619$ Mean (SD)	Rural, $n = 600$ Mean (SD)	p value[a]
Responsivity	11	8.51 (2.16)	9.00 (1.98)	8.00 (2.23)	0.000
Acceptance	8	6.13 (1.25)	5.88 (1.39)	6.38 (1.03)	0.000
Organization	6	4.20 (1.33)	4.53 (1.22)	3.86 (1.36)	0.000
Learning material	9	3.08 (2.77)	4.21 (2.76)	1.93 (2.25)	0.000
Parental involvement	6	2.50 (1.51)	2.92 (1.62)	2.07 (1.25)	0.000
Variety	5	2.49 (1.10)	2.66 (1.11)	2.31 (1.07)	0.000
HOME (total score)	45	26.90 (6.75)	29.20 (6.71)	24.54 (5.93)	0.000

[a] Adjusted for age and gender

Table 2 Description of mean (SD) of sensory stimulation (HOME and its domains) by socio-economic status in Sindh, Pakistan, 2002

HOME	Socio-economic quintiles					p value[a]	p value[b]
	I, $n = 244$ Mean (SD)	II, $n = 242$ Mean (SD)	III, $n = 247$ Mean (SD)	IV, $n = 241$ Mean (SD)	V, $n = 245$ Mean (SD)		
Responsivity	7.64 (2.28)	7.85 (2.36)	8.47 (2.20)	8.96 (1.83)	9.63 (1.48)	0.000	0.000
Acceptance	6.36 (0.98)	6.15 (1.18)	6.12 (1.31)	6.05 (1.24)	5.94 (1.47)	0.000	0.715
Organization	3.47 (1.29)	3.87 (1.26)	4.05 (1.39)	4.58 (1.09)	5.04 (0.99)	0.000	0.000
Learning material	1.02 (1.33)	1.56 (1.68)	2.72 (2.43)	4.11 (2.56)	6.05 (2.19)	0.000	0.000
Parental involvement	1.81 (1.05)	1.96 (1.11)	2.24 (1.37)	2.80 (1.49)	3.70 (1.64)	0.000	0.000
Variety	2.08 (0.97)	2.20 (0.93)	2.37 (1.14)	2.68 (1.04)	3.12 (1.11)	0.000	0.000
HOME (total score)	22.38 (4.46)	23.57 (5.13)	25.98 (6.11)	29.19 (5.70)	33.47 (5.65)	0.000	0.000

[a] Adjusted for age and gender

[b] Adjusted for age, gender and neighbourhood

Table 3 Relationship of increase in PD Index score associated with each unit increase of the sensory stimulation (HOME and its domains) as measured by linear regression in Sindh, Pakistan, 2002

Factors	Model A[a]		Model B[b]	
	Regression coefficient (95 % CI)	p value	Regression coefficient (95 % CI)	p value
Responsivity	1.69 (1.26, 2.11)	0.000	1.02 (0.58, 1.46)	0.000
Acceptance	−0.16 (−0.90, 0.58)	0.665	0.52 (−0.20, 1.24)	0.154
Organization	2.20 (1.50, 2.91)	0.000	0.81 (0.06, 1.56)	0.033
Learning material	1.60 (1.27, 1.92)	0.000	0.80 (0.38, 1.22)	0.000
Parental involvement	2.65 (2.05, 3.25)	0.000	1.54 (0.89, 2.19)	0.000
Variety	2.17 (1.29, 3.04)	0.000	0.84 (−0.06, 1.73)	0.067
HOME (total score)	0.73 (0.59, 0.86)	0.000	0.47 (0.30, 0.63)	0.000

[a] Adjusted for age and gender

[b] Adjusted for age, gender, SE index and neighbourhood

Relationship between HOME and psychomotor development

Table 3 shows that the PD index increases with increasing HOME scores, except for that of the Acceptance domain; overall, the age-and -gender adjusted PD index is increased by 0.73 units with every unit increase in HOME score. This was attenuated to 0.47 units after additional adjustment for SE quintile and neighbourhood. A similar pattern was observed for all the HOME domains except Acceptance; for example, the PD index is increased by 1.02 with every increase in Responsivity score irrespective of SE quintile and neighbourhood.

Relationship between HOME and undernutrition

Overall HOME scores were significantly associated with stunting and underweight (Table 4); mean HOME scores were 1.30 units lower among stunted children (p value <0.001), and 1.04 units lower among underweight children (p value $= 0.002$). Stunting was associated with lower scores in the Responsivity, Organization, Learning material, Parental involvement, and Variety of experience domains, while underweight was associated with lower scores in the Organization and Learning material domains. Neither total HOME nor domain scores were significantly associated with wasting.

Nutrition as a mediator between HOME and PD index

The association of sensory stimulation in the home with psychomotor development of the child even after controlling for all other predictors including undernutrition is presented in Table 5. HOME scores (0–45) are categorized into quintiles in this analysis. The mean psychomotor scores of the child decreases with decreasing availability of sensory stimulation at home (p value for trend <0.001). The association between sensory stimulation and PD index becomes attenuated but remains significant even after controlling for SE index and neighbourhood. In addition, the association remains significant even when anthropometric indicators were introduced into the model (p value for trend <0.001), highlighting the fact that HOME is a significant predictor of PD index even after controlling for nutritional status of children.

Table 4 Relationship of sensory stimulation (HOME and its domains) and undernutrition in Sindh, Pakistan, 2002

Factors	Stunted, $N = 1{,}219$		Underweight, $N = 1{,}219$		Wasted, $N = 1{,}219$	
	Mean HOME difference[a] (95 % CI)	p value	Mean HOME difference[a] (95 % CI)	p value	Mean HOME difference[a] (95 % CI)	p value
Responsivity	−0.24 (−0.49, −0.01)	0.049	−0.17 (−0.43, 0.08)	0.185	−0.08 (−0.38, 0.22)	0.602
Acceptance	−0.01 (−0.16, 0.14)	0.864	0.04 (−0.12, 0.19)	0.642	0.13 (−0.05, 0.31)	0.165
Organization	−0.23 (−0.37, −0.09)	0.002	−0.24 (−0.39, −0.09)	0.002	−0.06 (−0.24, 0.12)	0.506
Learning material	−0.46 (−0.71, −0.21)	0.000	−0.53 (−0.79, −0.26)	0.000	−0.23 (−0.54, 0.09)	0.154
Parental involvement	−0.18 (−0.35, −0.02)	0.027	−0.08 (−0.25, 0.09)	0.374	−0.15 (−0.35, 0.05)	0.130
Variety	−0.17 (−0.29, −0.05)	0.005	−0.06 (−0.19, 0.06)	0.316	0.06 (−0.08, 0.21)	0.393
HOME (total score)	−1.30 (−1.93, −0.66)	0.000	−1.04 (−1.71, −0.38)	0.002	−0.33 (−1.11, 0.46)	0.414

[a] Adjusted for age, gender, SE index and neighbourhood

Discussion

Some noteworthy conclusions can be drawn about sensory stimulation from our study. First, rural homes seem to be significantly devoid of sensory stimulation as compared to their urban counterparts irrespective of differences in socio-economic status. Second, SS may generate itself as a strong independent entity influencing psychomotor development, stunting and being underweight. Third, SS may influence psychomotor development directly, over and above the combined contribution of socio-economic status and rural–urban neighbourhood. Furthermore, this independent effect is only marginally mediated via the nutritional status of the child.

In a study by Elardo et al. (1975), the internal consistency of the HOME is 0.89 and for the individual domains, it ranges from 0.44 to 0.89. Our Cronbach's coefficient values are similar to the original test demonstrating a high quality of study observations. It is important to highlight that this study is based on the most extensive assessment of sensory stimulation in early childhood ever undertaken in developing countries.

On average, our study households provided 60 % of the ideal sensory stimulation on the HOME with a trend of decreasing scores in lower socio-economic strata and rural neighbourhood. As mentioned previously, HOME estimates from developing countries were based on small-scale studies reporting scores between 63 and 64 % (Aboud 2007; Bandura et al. 1985). In addition to developing countries, HOME score estimates in North America range from 81 to 62 % (Bradley et al. 1989).

In his paper on human competence, Ogbu (1981) highlighted that child-rearing practices in resource-deprived societies are more survival-orientated so that the focus is to shift the child from distress to a state of contentment; caregivers are physically more responsive, showing such abundant affection at times that inconsistent demands on disciplining of child are made. On the other hand, well-resourced societies are relatively more oriented towards achievement of optimal child development; caregivers are more inclined to provide age-appropriate stimuli, play and independence (Bradley and Corwyn 2005). In general, the patterns of sensory stimulation domains in our study are very much congruent to the survival model of resource-deprived societies: maximum sensory stimulation was observed in the Responsivity and Acceptance domains and minimum in the provision of age appropriate Learning materials.

Determinants of sensory stimulation available at home

We found that socio-economic status and HOME are strongly linked so the conclusion confirms the Kohn hypothesis about parenting behaviour i.e. the higher the parents' socio-economic status, the more likely they value child development, provides stimulation and freedom to explore (Masud et al. 1994). Above all, we have attempted to delineate the differences between rural and urban neighbourhoods in sensory stimulation available for child development e.g. overall rural households lack caregiver's encouragement on child's developmental achievements, avoid disciplinary constrains, create fewer expectations for mature behaviours and fail to provide age-appropriate learning materials. It is important to emphasize that difference in various sensory stimulation domains between rural and urban neighbourhood dwellers is independent of the socio-economic status indicating distinct life styles, beliefs and cultural practices.

Sensory stimulation and undernutrition

In our study, we also found that undernutrition, specifically stunting and being underweight are significantly associated

Table 5 Relationship between PD index and sensory stimulation (HOME score *quintile*), adjusted for the Undernutrition status in Sindh, Pakistan, 2002

HOME			Adjusted[a]		Adjusted[b]		Adjusted[c]	
Quintiles (range of HOME scores)	Number of children	Mean PDI (SD)	Mean PDI difference (95 % CI)	*p* value	Mean PDI difference (95 % CI)	*p* value	Mean PDI difference (95 % CI)	*p* value
I: (8–21)	285	91.04 (16.14)	−13.35 (−16.20, −10.51)	0.000	−8.20 (−11.59, −4.82)	0.000	−7.68 (−11.07, −4.29)	0.000
II: (22–25)	258	93.21 (17.48)	−10.47 (−13.35, −7.59)	0.000	−6.23 (−9.55, −2.92)	0.000	−5.75 (−9.06, −2.44)	0.001
III: (26–28)	206	94.28 (16.66)	−8.82 (−11.84, −5.80)	0.000	−5.53 (−8.76, −2.30)	0.001	−5.34 (−8.56, −2.11)	0.001
IV: (29–33)	272	99.14 (15.70)	−3.49 (−6.32, −0.67)	0.015	−1.42 (−4.30, 1.47)	0.335	−1.42 (−4.29, 1.46)	0.334
V: (34–44)	221	102.15 (14.89)						
p value for trend				0.000		0.000		0.000
Adjusted R^2			9.9 %		12.7 %		13.9 %	

[a] Adjusted for age and gender

[b] Adjusted for age, gender, SE index and neighbourhood

[c] Adjusted for age, gender, SE index, neighbourhood, stunted, underweight and wasted

with HOME irrespective of socio-economic status. Similarly, a study conducted among two Indonesian tribes found that in the tribe which had the relatively lower prevalence of undernutrition, HOME was significantly associated with stunting and being underweight, whereas in the tribe with a relatively higher prevalence of undernutrition, HOME was associated with all three anthropometric indicators (Februhartanty et al. 2007). This shows that the association between sensory stimulation and growth status might be affected by population characteristics and levels of undernutrition.

Sensory stimulation and psychomotor development

The increase in sensory stimulation at home was associated with psychomotor development irrespective of socio-economic status and neighbourhood. A similar association is supported by the literature (Doussoulin Sanhueza 2006), but our study takes a noteworthy further step by identifying the specific pathways significantly associated with the psychomotor development (which include the Responsivity, Acceptance, Learning material and Parental involvement while the Variety domain was marginally significant). Beyond confirming on independent associations between sensory stimulation and growth, and psychomotor development, the findings also provide the evidence to support our inference that sensory stimulation influence on the PD index may also be partially mediated by undernutrition status of child.

Limitations

HOME is criticized for being based on Western child-rearing ideologies, and mimics the standards of white middle-class families. However, its successful cross-cultural use with local adaptive changes and quality control measures (Vasiliki Totsika and Sylva 2004), and association with child outcomes worldwide reflects the universal appeal of the HOME. Maternal mental health is known to influence HOME scores (Feldman et al. 1985), however, the control of this confounding factors lay beyond the scope of our study.

The possibility of reverse causality in the observed associations cannot be ruled out due to the cross-sectional study design. However, because 0–3 year age group considered, the plausible direction of the association is from sensory stimulations to child development status. It is very unlikely that children can determine or influence sensory stimulation available in the home environment. Nonetheless, prospective multiple assessment would have been ideal to establish these relationships.

An important alternative explanation to some of our findings might appeal to social isolation hypothesis. Due to

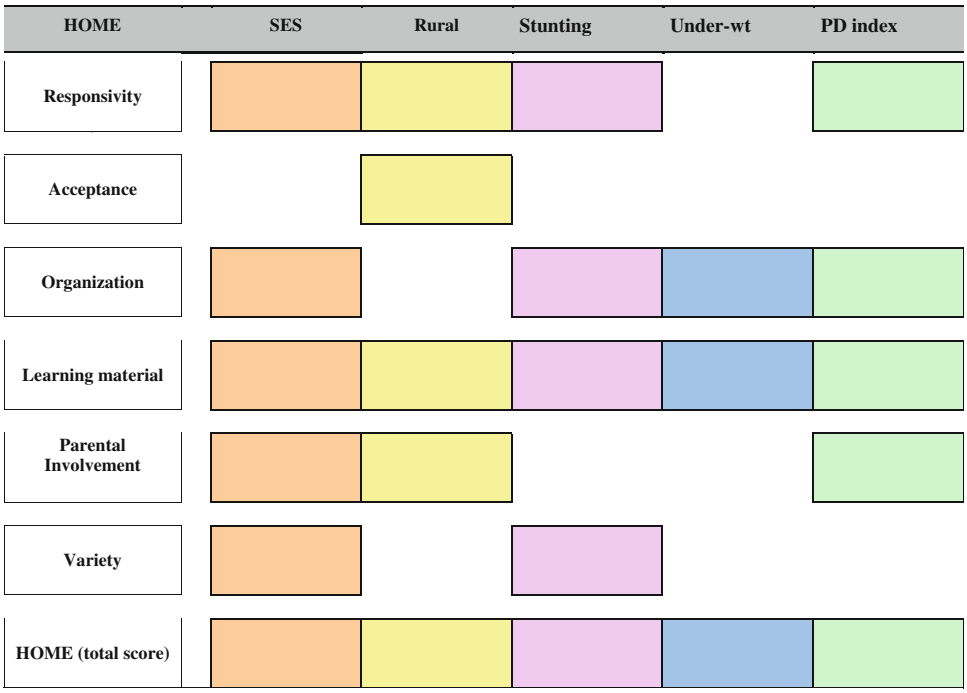

Fig. 2 Summary of significant sensory stimulation (HOME and its domains) associations with SES, rural vs. urban neighbourhood, physical growth and psychomotor development

their physical frailty and younger physical stature, severely undernourished children are more dependent and less likely to generate age-appropriate sensory stimulation from their caregivers, are, therefore, less likely to explore their surroundings (Graves 1976). Thus it can be hypothesized that very poor physical growth leads to less availability of sensory stimulation in these children. However, this proposition would apply to extremely malnourished children and not to the entire spectrum of under nutrition.

Implications for policy and future research

Despite evidence that sensory stimulation significantly determines growth and development, its integration into child survival and developmental initiatives still has a long way to go. Apart from the socio-political awareness and a commitment to change, there are specific policy and research issues to be considered: most research on sensory stimulation in the developing countries is methodologically deficient. Attempts to influence physical growth by enhancing sensory stimulation have proved adequate in some clinical settings but no successful results have been obtained at the community level (Hamadani et al. 2006). In general, evidence of effective sensory stimulation interventions to achieve optimal growth and development potential for underprivileged children from these countries does not exist and requires extensive research. From a programmatic point of view, some research has been conducted to assess the delivery of sensory stimulation to enhance the status of caregiving (Eickmann et al. 2003). However, the issue of planned exposure such as frequency, optimal timing and rigour for these interventions has yet to be fully explored.

From policy perspective, we must underscore that sensory stimulation is a collective term embracing various coherent conceptual domains. Since the usual trend in the realm of public health for the developing countries is to enhance sensory stimulation through maternal responsivity or interactions primarily targeting the cognitive outcome, it is, therefore, important that components of sensory stimulation and interventions based on this approach make sense logically. However, it would not be realistic to generalize about a limited approach to achieve holistic child development. One of the important messages of the study is to point out that other conceptual domains of sensory stimulation also act as pathways in various combinations to achieve specific growth and development outcomes, the summary based on the analysis in this article is illustrated in Fig. 2. It provides a reasonable framework to guide policy makers and ECD programmers on the types of sensory stimulation relevant to their initiatives so as to precisely target the psychosocial needs of undernourished and developmentally delayed children. Furthermore, identification of culturally appropriate child-rearing practices is vital, and these can be promoted via interventions which optimize the sensory stimulation to the child. In summary, a pressing need of our time is to develop comprehensive contents for sensory stimulation interventions that nurtured the development and growth indicators of the child.

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