EFFECTS OF HOME LANGUAGE ENVIRONMENT AND HOUSEHOLD CROWDING ON EARLY EXPRESSIVE LANGUAGE DEVELOPMENT

Abstract

Objective: This study examined prospective associations of the home language environment (HLE) and household crowding with expressive language development in two-year-old children, using the data from prospective cohort study in New Zealand.

Methods: A total of 5960 children were included. The HLE (playing games, talking in everyday activities, playing with toys, singing songs and reading books) and household crowding were measured when the children were nine months old. Language development was assessed using the MacArthur-Bates Communicative Development Inventories (CDIs) – II short form (A) at age two years. Maternal and child characteristics were measured antenatally and when the children were nine months old.

Results: Each HLE activity was associated with higher language scores. A high HLE score, defined as doing at least three of the five HLE activities at least once daily, was associated with an increase in the language score of 6.31 units (95% CI 5.00 ─ 7.62, p<0.0001). The effect of the HLE was less pronounced in highly crowded homes (Coef.=-2.24, 95% CI -0.47 ─ 4.97, p = 0.106), compared to low crowded homes with at least one other child (Coef.=6.19, 95% CI 4.28 ─ 8.10, p<0.0001) or with no other children (Coef.=8.19, 95% CI 5.69 ─ 10.70, p<0.0001).

Conclusion: These findings underscore the need to consider various aspects of the home environment in future interventions aiming to facilitate language development in young children.

Key words

Home language environment, language development, crowding, parent-child interaction

Introduction

Expressive language development is an important predictor of children's future social, behavioral and academic development and their wellbeing into adulthood.[1,2] Language skills are essential for any child to communicate with others in his or her environment, thereby facilitating the development of cognitive skills and socio-emotional regulation through social interactions. Notable developments in key language abilities occur during the first two years of life.[3] There are undeniable reasons to believe that there is an important relationship between environmental factors and early child development.

Children spend a substantial proportion of their early life at home and the child's home is a key component of their environment. Bronfenbrenner's ecological approach to human development highlights the significance of children's experience, and perceptions of their environments through which development occurs.[4] These environments involve a collection of nested settings called microsystem that influences children's development. An example of one such microsystem is the social interaction of a child with his/her parents. Early language development occurs within, and is affected by, the home environment where social interactions with caregivers such as shared reading or talking to the child takes place.[5-7]

A key aspect of the home environment is the size of dwelling that is available to each household member. Dwelling size and the number of household members determine the degree of household crowding experienced by the persons living there, and has relevance to many aspects of human life such as privacy, security, social relations, and health.[8] A high level of household crowding may result in poor physical health through shared physical proximity and spread of communicable diseases,[9] as well as psychological distress.[10] Children may be particularly vulnerable to household crowding because home is the environment in which they spend most of their time. More specifically, they may experience household crowding by both the space available to each person and by the number of siblings. For example, a study conducted in the United States showed that children suffered from physical illness and external behavior problems when exposed to more crowded living conditions.[8] Another study showed that children benefited less from parental resources associated with their intellectual development as the number of children in the family increases.[11]

Much remains unknown about the influence of household crowding on the home language environment (HLE) as a determinant of early expressive language skills. Children learn words faster when they are engaged in joint-attention activities.[6] Chaos or disorganization of the environment disrupts the proximal processes between parent and child, and is also, positively correlated with the level of crowding. Additionally, mothers living in crowded dwellings use less complex language when communicating with their children.[12] Parents living in more crowded homes are less responsive to their children in comparison with those living in less crowded homes.[13] The inhibited verbal responsiveness of parents in reaction to household crowding could lead to reduced verbal communication having a negative effect on the early language development of their children.

Individual environments play major roles in early language development. Language assessment at age two years is a well-known predictor of later language and cognitive development.[14] Hence, we hypothesized that there is an association of the HLE with expressive language development and that this association differs by the level of household crowding. Our specific aims were to: (i) describe the HLE, as defined by the frequency of language-based interactions mothers have with their children at home; (ii) determine the association of the HLE with the child's expressive language development; and (iii) investigate whether this association differs by the level of household crowding.

Methods

Study design and participants

This analysis used data from the *Growing Up in New Zealand* (GUiNZ) study, a contemporary child cohort study in New Zealand (NZ). The study recruited 6822 pregnant women who lived in the three contiguous district health board regions of Auckland, Counties Manukau and Waikato, and had an estimated delivery date between 25th April 2009 and 25th March 2010. The child cohort was created by the 6853 children born to these women and who survived to age six weeks. The sample is ethnically and socioeconomically diverse, and the birth parameters for the child cohort aligned with those of all births in NZ from 2007 to 2010.[15,16] Ethical approval for the study was granted by the NZ Ministry of Health Northern Y Regional Health and Disability Ethics Committee. Written informed consent was completed with each woman at enrolment.

This analysis used data collected at recruitment (when the mother was pregnant), and when the child was nine months and two years old. The data were collected through face-to-face computer-assisted personal interviews (CAPI) and computer-assisted telephone interviews (CATI). Figure (1) summarizes the cohort recruitment and completeness of data collection within the study up to when the children were two years old. The recruited cohort provides adequate statistical power for complex analyses of developmental outcomes across the whole cohort of children. For this particular analysis, the study has more than 80% power to detect a six-unit difference in the language score between children with high home language environment (HLE) and those with low HLE. A previous study reported that children who engaged in home literacy activities daily scored an average of 22 units higher on language assessments than those who experienced no literacy activity.[17]

Measurements

The dependent variable for this study was the total score from the 100 vocabulary items on the MacArthur-Bates Communicative Development Inventories (CDIs) – II short form (A).[18] The CDIs are used as a cost-effective, reliable and valid tool to assess language and communication skills in young children.[19] Two short forms are available – an infant form (Level I, for 8-18 months old) and a toddler form (Level II, Forms A and B, for 16-30 months old).

The independent variables, HLE and household crowding, were measured at the CAPI completed by mothers when the child was nine months old. Each child's HLE was assessed by asking the frequency that the mother: (1) played games with the child, (2) talked to the child during everyday activities, (3) played with toys with the child, (4) sang songs or told stories to

the child and (5) read books to the child.[20,21] Response options were categorized into three groups: ‘less than once a day’, ‘once a day’ and ‘more than once a day’. A composite HLE variable was derived from the combination of the five items and this HLE score was categorized as high HLE and low HLE. A high HLE score was defined as doing at least three of the five home literacy activities at least once a day. Household crowding was categorized as “highly crowded home” where the ratio of household occupants to rooms was greater than two,[22] “low crowded home with at least one other child aged under 18 years” and “low crowded home with no other children”.

Other variables describing maternal and child characteristics were collected when the mother was pregnant (demographics), when the child was six weeks old (child sex) and when the child was nine months old (maternal health, child health and development, the number of people under 18 years in the household and household tenure). Symptoms of maternal depression were assessed using the antenatal and postnatal administration of the Edinburgh Postnatal Depression Scale (EPDS), which is a validated measure of depression symptoms occurring ante- and postnatally.[23] The EPDS scale has ten items scored 0-3 with a maximum score of 30. Individuals with a score of 13 or greater are considered to have significant depressive symptoms, which will be referred to herein as EPDS-defined antenatal depression (EPDS-AD). At this cut-off, the EPDS has reported sensitivity and specificity for major depression during pregnancy of 0.83 and 0.90 respectively.[23,24] In these analyses, individual level socioeconomic status was measured using maternal education. Other available socioeconomic measures including household income and area level deprivation were considered, but were found to be too strongly correlated with the crowding measure. For example, the New Zealand Deprivation Index includes the variable “People living in equivalised households below a bedroom occupancy threshold”.

Statistical analysis

Analyses were restricted to the 5960 children for whom complete exposure and outcome data were available. The percentage of children with missing data was measured for each variable included in the analysis. Missing values (<10% for all variables) were treated as a separate category.[25] Multi-collinearity was determined using the variance inflation factor (VIF), with a VIF ≥ 10 considered as an unacceptable loss of precision due to collinearity. The VIFs of all independent variables were <10 and therefore all were included in the analysis.

Linear regression analyses were undertaken to assess the associations of each of the HLE components (playing games, talking in everyday activities, playing with toys, singing songs or telling stories and reading books to children) with the language score. In multivariate analyses, we adjusted for maternal age, maternal ethnicity, education, health and ante- and postnatal depressive symptoms; child health and presence of developmental delay, the number of people aged under 18 years, housing tenure and household crowding. We also assessed the association of each HLE component and the composite measure of the HLE with the language score and determined whether this association differed by the level of household crowding. A sensitivity analysis was undertaken for the sample who did not change their residence, and this analysis was compared with the main model. The statistical software package Stata MP Version 13 (StataCorp LLC, College Station, Texas) was used. A two-sided level for statistical significance was set at 0.05 for all analyses.

Results

Characteristics of the mothers and children included in and excluded from the analysis are presented in Table – 1. The mothers included in this analysis were more likely to be European, have higher education and better health, and the children included were more likely to have better maternal-reported health.

The majority of mothers reported that, more than once a day, they played games with their child (66%), talked with their child in everyday activities (95%), played with toys with their child (79%) or sang songs to their child (52%). However, a smaller proportion (17%) read to their child more than once a day (Table 2). In summary, 3525 (59%) of the cohort children had a high home language environment (HLE) score as defined by experiencing at least three of the five home literacy activities at least once a day at age nine months. The majority of the mothers reported living in a dwelling that was uncrowded (78%). A significant proportion (62%) of the cohort children lived with at least one other person aged under 18 years old in their home. Seventeen percent lived in overcrowded dwellings.

The mean expressive language outcome score of the cohort was 47.3 (SD 26) and the median score was 46 (IQR 43). The language score was significantly higher in children who participated in each HLE activity once a day or more than once a day compared to their counterparts. Each of the measured components of the HLE was associated with the Communicative Development Inventories (CDI) score after adjustment for relevant maternal and child characteristics as well as housing tenure and crowding. In uncrowded homes with at least one other child, for example, the study showed that playing games: once a day, Coef.=4.69, 95% CI 1.58 - 7.81, p=0.003; more than once a day, Coef.= 5.88, 95% CI 3.32 - 8.45, p=<0.0001 and singing songs: once a day, Coef.=4.64, 95% CI 1.98 - 7.31, p=0.001;

more than once a day, Coef.= 8.37, 95% CI 5.92 - 10.82, p<0.0001 were each associated with the expressive language outcome (Table 3).

In the multivariate model, we analyzed different individual components of the HLE, namely playing games, talking, playing with toys, singing songs and reading books, in relation to three levels of household crowding i.e., no other children in low crowded homes, at least one other child aged under 18 years in low crowded homes and highly crowded homes. The association between each HLE component and language development was more pronounced in low crowded homes. For example, reading books was associated with language development when there was no other child in a low crowded home: once a day, Coef.=5.33, 95% CI 2.77 ─ 7.90, p<0.0001; more than once a day, Coef.= 9.12, 95% CI 6.26 ─ 11.97, p<0.0001; when there was at least one other child in a low crowded homes: once a day, Coef.=6.35, 95% CI 4.30 ─ 8.40, p<0.0001; more than once a day, Coef.= 10.37, 95% CI 7.46 ─ 13.29, p<0.0001 and in a highly crowded home: once a day, Coef.=2.08, 95% CI -0.91 ─ 5.09, p=0.173; more than once a day, Coef.= 3.06, 95% CI -1.31 ─ 7.43, p<0.170 (Table 3). We also conducted a separate analysis by restricting the study sample to those who did not move home (n=2922) between the antenatal and two year DCW. The result was similar to the analysis conducted in the original sample.

Discussion

Main findings

In this ethnically and socioeconomically diverse cohort sample, most of the children (62%) were exposed to a relatively high home language environment (HLE) and 78% of the cohort children to a low crowded home. Each component of the HLE, namely playing games,

talking with child in everyday activities, playing with toys, singing songs or telling stories, and reading books, was positively associated with expressive language development and showed a dose-response relationship. The influence of the HLE on the outcome differed in relation to the level of household crowding i.e., the influence of HLE activities in highly crowded homes was not as pronounced as in low crowded homes.

Interpretations of the findings

In line with the previous studies,[20,21] this study examined five HLE activities in New Zealand households and found that talking in everyday activities was most common, followed by playing with toys and playing games. Shared reading was least common – only 52% of the children were engaged in shared reading once a day or more. In contrast, about 70% of families in Germany and in Australia reported that literacy activities such as reading of picture books occur at home on a more or less daily basis.[26] Consistent with the literature,[21,27] we found that children who experienced a high HLE achieved higher language scores than those living in in a low HLE. In addition, each HLE activity showed a significant association with the children's language development respectively. To our knowledge, this is the first demonstration of a dose-response relationship of multiple indices of HLE with early language development. However, we did not capture the children's exposure to responsive and rich language, which is thought to promote early language skills.[28]

Previous research[12,13] has demonstrated a relationship between chaos, in which household crowding is one of the indicators, and child language development. Our study extended these observations by looking specifically at crowding, and showing the specific relationship of household crowding with expressive language development. Our study found that the effect of

all HLE activities on language development was less pronounced in overcrowded homes. This, to some extent, supported the findings of earlier research, in which parents in crowded homes speak less to their children[13] and crowded dwellings can affect children's psychosocial wellbeing.[8] Linguistic input from the parents may also vary in relation to the presence of other children in the homes.

A previous study found that the presence of older siblings affected the amount of type of language the child was exposed to but did not affect the general language development.[29] Similarly, we found that the presence of other children did not affect the association of HLE with the expressive language outcome. Additionally, the effects of HLE practices were slightly more pronounced when at least one other child was present in the household than when there was no other child in the household.

Implications

It remains clear that parents should be encouraged to engage in early language activities with young children to optimize later language development. The development of policies that support parental work arrangements such as provision of sustained periods of time at home specifically in the first year of life,[30] may provide the quality HLE. Investment in the HLE appears to be an effective approach when household crowding is an issue for families. However, different approaches may be required for families living in crowded households to enable them to provide an optimal home environment for later language outcomes. Further study is needed to identify specific protective factors that enable some children in overcrowded homes to achieve good outcomes. These factors could then become the focus of interventions to facilitate improved language development.

Strengths and limitations

To our knowledge, this is the first prospective cohort study to investigate the effect of the HLE on early childhood language development in relation to the crowding status of the household. The GUINZ study allows a wide range of potential confounders such as maternal education and ethnicity to be considered. The sample was ethnically and socioeconomically diverse, adequately powered and there was minimal loss to follow-up. Stratification of crowding status in these analyses, clarified the issue of sibling competition or crowding caused by itself. The use of the CDIs – II short form (A) allowed for effective standardized parent-report evaluation of vocabulary in young children.

Some limitations need to be considered when interpreting the findings from this study. This analysis excluded about 10% of the original cohort children as information on exposure and/or outcome was not available. This may underestimate the strength of the observed associations as the excluded children had poorer health and the excluded mothers were more likely to be non-European and had poorer health and lower education. This also makes the study less generalizable especially to those families whose children may be at higher risk of being exposed to a low HLE and to have poorer language outcomes. Our tool that measured HLE has not been validated. There is no one standard measure of crowding internationally and each of them have their challenges. We used maternal education as a measure of socioeconomic status because other measures including the NZDep index variable were so strongly correlated to crowding. Social desirability bias is also likely as self-reported exposures and outcome were used. As language skills were assessed at age two years, late talkers were not accounted for. Residual confounding is likely as the study is an observational study and the potential

confounders such as the richness of maternal general verbal input including the number of utterances, word tokens and word types[31] was not measured. Other residual confounders such as maternal responsiveness[2] and mind-mindedness[7] may also be present, and were not measured. The difference in roles of mothers and fathers may be significant in daily HLE activities.[32] Similarly, other factors (e.g. trauma, racism, bilingual or multilingual status) and the type of family such as nuclear or extended family may affect the observed associations. These are areas that require future research.

Conclusion

In this study, three in five New Zealand children were exposed to high HLE environments and one in five lived in a crowded household. A high HLE score was associated with expressive language development but this relationship differs in relation to the crowding status of the home. The study underscores the importance of careful investigations of different aspects of the home environment that may affect the early development of children.

References

1. McCabe PC, Meller PJ. The relationship between language and social competence: how language impairment affects social growth. *Psychology in the Schools.* 2004;41(3):313-321.
2. Rohlfing KJ, Nomikou I. Intermodal synchrony as a form of maternal responsiveness: association with language development. *Language, Interaction and Acquisition.* 2014;5(1):117-136.
3. Brooks R, Meltzoff AN. Infant gaze following and pointing predict accelerated vocabulary growth through two years of age: a longitudinal, growth curve modeling study. *Journal of child language.* 2008;35(1):207-220.
4. Bronfenbrenner U. The ecology of human development: experiments by design and nature. In: Cambridge, MA: Harvard University Press; 1979.
5. Head-Reeves DM. *Paternal involvement among African-American fathers in two-parent families: influences in early child development*. The University of North Carolina at Chapel Hill; 2010.
6. Burgess S. The role of shared reading in the development of phonological awareness: a longitudinal study of middle to upper class children. *Early Child Development and Care.* 1997;127(1):191-199.
7. Laranjo J, Bernier A. Children's expressive language in early toddlerhood: links to prior maternal mind-mindedness. *Early Child Development and Care.* 2013;183(7):951-962.
8. Solari CD, Mare RD. Housing crowding effects on children's wellbeing. *Soc Sci Res.* 2012;41(2):464-476.
9. Vino T, Singh GR, Davison B, et al. Indigenous Australian household structure: a simple data collection tool and implications for close contact transmission of communicable diseases. *PeerJ.* 2017;5:e3958.

10. Li J, Liu Z. Housing stress and mental health of migrant populations in urban China. *Cities.* 2018;81:172-179.

11. Downey DB. Number of siblings and intellectual development: the resource dilution explanation. *American psychologist.* 2001;56(6-7):497-504.

12. Vernon-Feagans L, Garrett-Peters P, Willoughby M, et al. Chaos, poverty, and parenting: predictors of early language development. *Early Childhood Research Quarterly*. 2012;27(3):339-351.

13. Evans GW, Maxwell LE, Hart B. Parental language and verbal responsiveness to children in crowded homes. *Developmental psychology.* 1999;35(4):1020-1023.

14. Fenson L, Pethick S, Renda C, et al. Short-form versions of the MacArthur communicative development inventories. *Applied Psycholinguistics.* 2000;21(1):95-116.

15. Morton SMB, Carr PEA, Grant CC, et al. Cohort Profile: Growing Up in New Zealand. *International Journal of Epidemiology.* 2013;42(1):65-75.

16. Morton SMB, Grant CC, Carr PEA, et al. How do you recruit and retain a prebirth cohort? Lessons learnt from Growing Up in New Zealand. *Evaluation & the Health Professions.* 2014;37(4):411-433.

17. Liebeskind KG, Piotrowski JT, Lapierre MA, et al. The home literacy environment: exploring how media and parent–child interactions are associated with children's language production. *Journal of Early Childhood Literacy.* 2014;14(4):482-509.

18. Reese E, Keegan P, McNaughton S, et al. Te Reo Maori: indigenous language acquisition in the context of New Zealand English. *Journal of child language.* 2018;45(2):340-367.

19. Fenson L, Dale P, Reznick J, et al. The MacArthur Communicative Development Inventories: user's guide and technical manual. Baltimore, MD: Paul H. Brookes Publishing Company; 1993.

20. Sénéchal M, LeFevre JA, Thomas EM, et al. Differential effects of home literacy experiences on the development of oral and written language. *Reading research quarterly.* 1998;33(1):96-116.

21. Payne AC, Whitehurst GJ, Angell AL. The role of home literacy environment in the development of language ability in preschool children from low-income families. *Early Childhood Research Quarterly.* 1994;9(3-4):427-440.

22. Leventhal T, Newman S. Housing and child development. *Children and Youth Services Review.* 2010;32(9):1165-1174.

23. Cox JL, Holden JM, Sagovsky R. Detection of postnatal depression. Development of the 10-item Edinburgh Postnatal Depression Scale. *The British journal of psychiatry.* 1987;150(6):782-786.

24. Waldie KE, Peterson ER, D'Souza S, et al. Depression symptoms during pregnancy: evidence from growing up in New Zealand. *Journal of affective disorders.* 2015;186:66-73.

25. Horton NJ, Kleinman KP. Much ado about nothing: a comparison of missing data methods and software to fit incomplete data regression models. *The American Statistician.* 2007;61(1):79-90.

26. Niklas F, Tayler C, Schneider W. Home-based literacy activities and children's cognitive outcomes: a comparison between Australia and Germany. *International Journal of Educational Research.* 2015;71:75-85.

27. Rodriguez ET, Tamis-LeMonda CS, Spellmann ME, et al. The formative role of home literacy experiences across the first three years of life in children from low-income families. *Journal of Applied Developmental Psychology.* 2009;30(6):677-694.

28. Tamis-LeMonda CS, Bornstein MH, Baumwell L, et al. Responsive parenting in the second year: specific influences on children's language and play. *Infant and Child Development.* 1996;5(4):173-183.

29. Oshima-Takane Y, Goodz E, Derevensky JL. Birth order effects on early language development: Do secondborn children learn from overheard speech? *Child Development.* 1996;67(2):621-634.

30. Waldfogel J. Parental work arrangements and child development. *Canadian public policy.* 2007;33(2):251-271.

31. Hoff E, Naigles L. How children use input to acquire a lexicon. *Child development.* 2002;73(2):418-433.

32. Burgess SR. Home literacy environments (HLEs) provided to very young children. *Early Child Development and Care.* 2011;181(4):445-462.

Table – 1: Characteristics of the mothers and cohort children included in versus excluded from the analysis

		Included (n=5960)	Excluded (n=712)	p-value
Maternal characteristics				
Age (n=6672)	Mean (SD)	30.28 (5.92)	29.1 (6.1)	0.18
Self-prioritized ethnicity (n=6591)	n (%)			
1. European		3462 (58)	219 (31)	< 0.0001
2. Maori		822 (14)	174 (24)	
3. Pacific		760 (13)	168 (24)	
4. Asian		691 (12)	135 (19)	
5. Other		225 (4)	16 (2)	
Maternal education (n=6598)	n (%)			
1. High school qualification or less		1733 (29)	219 (31)	<0.0001
2. Trade certificate/diploma, bachelor or postgraduate degree		4203 (71)	450 (63)	
3. Missing		24 (0.4)	43 (6)	
Self-reported general health (n=6581)	n (%)			
1. Very good & Excellent		3742 (63)	374 (53)	0.03
2. Good		1526 (26)	238 (33)	
3. Fair & Poor		545 (9)	73 (10)	
4. Missing		147 (2)	27 (4)	
Maternal depression* (n=6415)	n (%)			
1. No depression		4164 (70)	452 (63)	0.06
2. Depression		1461 (25)	193 (27)	
3. Missing		335 (6)	67 (10)	
Child characteristics				
Sex (n=6672)	n (%)			
1. Boy		3087 (52)	376 (53)	0.55
2. Girl		2873 (48)	336 (47)	
Child general health† (9 months) (n=6519)	n (%)			
1. Very good + Excellent		5127 (86)	311 (44)	0.01
2. Good		513 (9)	219 (31)	
3. Fair + Poor		179 (3)	75 (10)	
4. Missing		141 (2)	107 (15)	
Developmental delay† (9 months) (n=6501)	n (%)			
1. Yes		557 (9)	108 (15)	0.04
2. No		5258 (88)	580 (82)	
3. Missing		145 (2)	24 (3)	

* Presence of maternal depression was determined from the antenatal and postnatal administration of the Edinburgh Postnatal Depression Scale.

† Child's general health and developmental delay were collected through self-report during the CAPI interview completed by the mother.

Table – 2: Characteristics of the home language environment and household crowding

Home characteristics	n (%)
Playing games	
1. Less than once a day	849 (14)
2. Once a day	1002 (17)
3. More than once a day	3962 (66)
4. Missing	147 (3)
Talking in everyday activities	
1. Less than once a day	72 (1)
2. Once a day	67 (1)
3. More than once a day	5673 (95)
4. Missing	148 (3)
Playing with toys	
1. Less than once a day	366 (6)
2. Once a day	743 (12)
3. More than once a day	4702 (79)
4. Missing	149 (3)
Singing songs	
1. Less than once a day	1138 (19)
2. Once a day	1578 (26)
3. More than once a day	3094 (52)
4. Missing	150 (3)
Reading books	
1. Less than once a day	2706 (45)
2. Once a day	2080 (35)
3. More than once a day	1025 (17)
4. Missing	149 (3)
Home Language Environment*	
1. High home language environment	3525 (59)
2. Low home language environment	2288 (38)
3. Missing	147 (2)
Household crowding†	
1. No other child in low crowded home	1962 (33)
2. At least one other child aged under 18 years in low crowded home	2701 (45)
3. No other children in highly crowded home	167 (3)
4. At least one other child aged under 18 years in highly crowded home	982 (17)
5. Missing	148 (2)

* The composite home language environment (HLE) was derived from the combination of the five items – by asking the frequency that mother had (1) played games with the child, (2) talked to the child during everyday activities, (3) played with toys with the child, (4) sung songs or told stories to the child and (5) read books to the child.

† Household crowding was categorized as “highly crowded home” where the ratio of household occupants to rooms was greater than two, “low crowded home with at least one other child aged under 18 years” and “low crowded home with no children”.

Table – 3: Association between exposure and outcome

	English Language Score	Expressive Language Outcome (unadjusted)				Expressive Language Outcome (Adjusted)*			
Variable	**Mean (SD)**	**Coef.**	**95% CI**		**p value**	**Coef.**	**95% CI**		**p value**
All children included in this analysis[*]									
Playing games less than once a day	41.96 (25.59)		Reference				Reference		
Playing games once a day	46.24 (25.05)	4.2897	1.8814	6.6980	<0.0001	2.7794	0.5399	5.0190	0.015
Playing games more than once a day	48.76 (26.70)	6.8087	4.8562	8.7613	<0.0001	4.8909	3.0665	6.715	<0.0001
Talking less than once a day	30.56 (19.98)		Reference				Reference		
Talking once a day	38.04 (23.46)	7.4753	-1.2960	16.246	0.095	5.6333	-2.5052	13.772	0.175
Talking more than once a day	47.66 (26.38)	17.098	10.970	23.227	<0.0001	8.9106	3.1971	14.624	0.002
Playing with toys less than once a day	37.80 (23.85)		Reference				Reference		
Playing with toys once a day	43.79 (25.89)	5.9894	2.6990	9.2798	<0.0001	2.9158	-0.1576	5.9893	0.063
Playing with toys more than once a day	48.63 (26.42)	10.8353	8.0392	13.631	<0.0001	4.5461	1.8929	7.1993	0.001
Singing songs less than once a day	42.40 (25.29)		Reference				Reference		
Singing songs once a day	46.75 (26.19)	4.3564	2.3505	6.3623	<0.0001	3.6859	1.8231	5.5487	<0.0001
Singing songs more than once a day	49.44 (26.58)	7.0430	5.2548	8.8311	<0.0001	6.2912	4.6191	7.9634	<0.0001
Reading books less than once a day	42.50 (25.28)		Reference				Reference		
Reading books once a day	49.84 (26.21)	7.3416	5.8548	8.8284	<0.0001	5.1744	3.7696	6.5791	<0.0001
Reading books more than once a day	54.98 (26.99)	12.478	10.608	14.348	<0.0001	8.7979	7.0048	10.591	<0.0001
Low home language environment‡	41.79 (25.14)		Reference				Reference		
High home language environment‡	50.93 (26.52)	9.1386	7.7665	10.5108	<0.0001	6.3157	5.0050	7.6263	<0.0001
Children living in low crowded home with no other children[†]									
Playing games less than once a day	45.39 (25.09)		Reference				Reference		
Playing games once a day	48.12 (25.61)	2.7340	-2.1961	7.6642	0.277	1.0733	-3.5551	5.7019	0.649
Playing games more than once a day	52.86 (26.34)	7.4675	3.4059	11.5291	<0.0001	4.4159	0.5968	8.2350	0.023
Talking less than once a day	26.83 (22.58)		Reference				Reference		
Talking once a day	35.80 (26.16)	8.9666	-9.7479	27.6812	0.348	7.0089	-10.4545	24.4725	0.431
Talking more than once a day	51.83 (26.15)	25.0029	10.1618	39.8440	0.001	16.5480	2.6355	30.4606	0.020

Table – 3: Association between exposure and outcome

	English Language Score	Expressive Language Outcome (unadjusted)				Expressive Language Outcome (Adjusted)*			
Variable	**Mean (SD)**	**Coef.**	**95% CI**		**p value**	**Coef.**	**95% CI**		**p value**
Children living in a low crowded home with no other children†									
Playing with toys less than once a day	39.93 (24.98)		Reference				Reference		
Playing with toys once a day	45.33 (26.33)	5.4000	-2.3137	13.1138	0.17	3.4147	-3.8249	10.6544	0.355
Playing with toys more than once a day	52.46 (26.11)	12.5330	5.9176	19.1484	<0.0001	6.6437	0.4109	12.8766	0.037
Singing songs less than once a day	47.25 (25.34)		Reference						
Singing songs once a day	50.30 (26.35)	3.0491	-0.7555	6.8539	0.116	2.0823	-1.4750	5.6397	0.251
Singing songs more than once a day	53.08 (26.27)	5.8325	2.5216	9.1433	0.001	4.9858	1.8643	8.1073	0.002
Reading books less than once a day	44.42 (25.12)		Reference						
Reading books once a day	53.25 (25.60)	8.8222	6.1558	11.4886	<0.0001	5.3376	2.7722	7.9029	<0.0001
Reading books more than once a day	58.27 (26.36)	13.8457	10.9519	16.7396	<0.0001	9.1237	6.2690	11.9783	<0.0001
Low home language environment‡	42.42 (24.64)		Reference						
High home language environment‡	54.80 (26.03)	12.3869	9.8132	14.9605	<0.0001	8.1962	5.6917	10.7007	<0.0001
Children living in a low crowded home with at least one other child aged under 18 years†									
Playing games less than once a day	44.08 (26.07)		Reference				Reference		
Playing games once a day	49.10 (24.48)	5.0142	1.7721	8.2564	0.002	4.6999	1.5847	7.8152	0.003
Playing games more than once a day	49.82 (26.49)	5.7391	3.0723	8.4060	<0.0001	5.8886	3.3227	8.4545	<0.0001
Talking less than once a day	31.06 (21.94)		Reference				Reference		
Talking once a day	38.00 (24.30)	6.9354	-7.1117	20.9826	0.333	9.4566	-4.1317	23.0450	0.172
Talking more than once a day	49.00 (26.08)	17.9430	8.7218	27.1642	<0.0001	13.2477	4.3134	22.1819	0.004
Playing with toys less than once a day	40.20 (24.48)		Reference				Reference		
Playing with toys once a day	46.74 (26.230	6.5438	1.8299	11.2577	0.007	4.9428	0.3924	9.4932	0.033
Playing with toys more than once a day	49.71 (26.09)	9.5069	5.4085	13.6053	<0.0001	6.9527	2.9691	10.9364	0.001
Singing songs less than once a day	43.41 (25.55)		Reference						
Singing songs once a day	48.22 (25.81)	4.8110	2.0384	7.5836	0.001	4.6456	1.9803	7.3108	0.001
Singing songs more than once a day	51.28 (26.20)	7.8744	5.3263	10.4226	<0.0001	8.3749	5.9206	10.8292	<0.0001
Reading books less than once a day	44.64 (25.48)		Reference				Reference		
Reading books once a day	51.69 (26.17)	7.0487	4.9342	9.1632	<0.0001	6.3575	4.3077	8.4073	<0.0001
Reading books more than once a day	55.81 (25.81)	11.1668	8.1533	14.1802	<0.0001	10.3772	7.4614	13.2930	<0.0001

Table – 3: Association between exposure and outcome

Variable	English Language Score Mean (SD)	Expressive Language Outcome (unadjusted) Coef.	95% CI		p value	Expressive Language Outcome (Adjusted)* Coef.	95% CI		p value
Children living in a low crowded home with at least one other child aged under 18 years†									
Low home language environment‡	44.79 (25.59)		Reference				Reference		
High home language environment‡	51.68 (26.12)	6.8940	4.9224	8.8655	<0.0001	6.1938	4.2807	8.1069	<0.0001
Children living in a highly crowded home†									
Playing games less than once a day	34.08 (23.30)		Reference				Reference		
Playing games once a day	36.01 (23.19)	1.9269	-2.8531	6.7070	0.429	-0.1362	-4.7175	4.4450	0.953
Playing games more than once a day	38.02 (25.02)	3.9358	0.1501	7.7216	0.042	2.7497	-0.8565	6.3560	0.135
Talking less than once a day	31.58 (17.00)		Reference				Reference		
Talking once a day	39.95 (21.01)	8.3721	-4.8659	21.6102	0.215	5.1290	-7.4573	17.7154	0.424
Talking more than once a day	37.05 (24.67)	5.4695	-3.5559	14.4949	0.235	1.7414	-6.8649	10.3478	0.691
Playing with toys less than once a day	33.91 (22.17)		Reference				Reference		
Playing with toys once a day	36.79 (23.60)	2.8815	-2.4419	8.2050	0.288	1.0007	-4.0598	6.0614	0.698
Playing with toys more than once a day	37.56 (25.00)	3.6486	-0.7807	8.0780	0.106	0.7177	-3.5261	4.9616	0.740
Singing songs less than once a day	34.72 (22.93)		Reference				Reference		
Singing songs once a day	37.31 (24.83)	2.5959	-1.4453	6.6371	0.208	3.3082	-0.5521	7.1686	0.093
Singing songs more than once a day	37.79 (24.89)	3.0747	-0.4776	6.6272	0.09	2.8445	-0.5820	6.2712	0.104
Reading books less than once a day	36.04 (23.94)		Reference				Reference		
Reading books once a day	37.78 (24.13)	1.7428	-1.4043	4.8901	0.277	2.0879	-0.9199	5.0958	0.173
Reading books more than once a day	39.43 (27.55)	3.3967	-1.1771	7.9706	0.145	3.0611	-1.3124	7.4346	0.170
Low home language environment‡	35.26 (23.39)		Reference				Reference		
High home language environment‡	38.81 (25.41)	3.5445	0.7176	6.3715	0.014	-2.2491	-0.4776	4.9759	0.106

* Adjusted for maternal age, self-prioritized ethnicity, maternal education, the number of people aged under 18 years, maternal health, maternal depression, child sex, health, presence of developmental delay, household tenure, crowding

† Adjusted for maternal age, self-prioritized ethnicity, maternal education, the number of people aged under 18 years, maternal health, maternal depression, child sex, health, presence of developmental delay, household tenure

‡The composite home language environment was derived from the combination of the five items – by asking the frequency that mother had (1) played games with the child, (2) talked to the child during everyday activities, (3) played with toys with the child, (4) sung songs or told stories to the child and (5) read books to the child.

Figure (1): Recruitment and collection of data from mothers of cohort children up to the child's age of two years