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ABBREVIATIONS

CFCS	Communication Function Classification System
FOCUS	Focus on the Outcomes of Communication Under Six
PSLP	Preschool Speech and Language Program

AIM To develop statistical models of communicative participation development of preschool children and explore variations by level of function.
METHOD This was a secondary analysis of data from a longitudinal study of preschool children with speech and language impairments (n=46 872; age range 18–67mo, mean age [SD] 41.76mo [11.92]; 67% male) accessing publicly funded services in Ontario, Canada. Two measures were used: Focus on the Outcomes of Communication Under Six (FOCUS), measuring changes in communicative participation skills, and the Communication Function Classification System (CFCS), classifying communicative function into one of five levels. We used mixed effects modeling to fit growth curves for children in each CFCS level. Models allowed for variation in initial FOCUS score at 18 months, rate of growth with age, and rate of acceleration/deceleration with age.
RESULTS Starting FOCUS score (18mo) varied inversely with CFCS level at entry to the program. Growth was initially rapid and then leveled off for children in Levels I to III. Growth was less rapid for children in Level IV, but leveled off, and was slow but continual for children in Level V.
INTERPRETATION This work can help us to move beyond traditional impairment-based thinking and shows that children can make meaningful communicative changes regardless of their function.

Speech and language impairments are highly prevalent in preschool children.[1–3] Prevalence estimates vary, but have been shown to be as high as 20%;[1] and rates are highest among children with risk factors known to be associated with speech and language impairments.[2,3] Knowledge of how speech and language skills develop in preschool children with impairments is important for clinicians, administrators, and policy makers; and can be used to facilitate identification, prognostication, counseling, and intervention planning for these children and their families.

Statistical models of growth have been created to show the development of impairment-based skills in children with speech and language impairments. These include models for the acquisition of expressive/receptive language,[4–6] grammar,[6] vocabulary,[7] and speech sounds.[8] While they are important in many ways, these models provide a narrow view, as they focus on skills specific to the child's impairments (e.g. use of grammatical markers) rather than looking at the whole picture of a child's communication (e.g. how children's communication skills affect their ability to engage and participate).

The World Health Organization's International Classification of Functioning, Disability and Health – Child and Youth Version (ICF-CY) promotes a useful conceptual framework to understand the difference between studying development of specific skills and the development of communicative participation.[9] Most research studying the development of children with speech-language impairments has focused on changes to the Body Functions and Structures (e.g. speech sounds) and Activities (e.g. receptive language skills) components; very little research has explored outcomes related to the Participation component;[10] and little has been published on the development of communicative participation skills – how children use their communication to engage in life.[11] We believe these are meaningful and practical outcomes, and are the outcomes important to families.[12]

Focusing on participation outcomes removes the need to discriminate between the various speech and language impairments – always a challenging task[13] – instead allowing us to compare children with a wide variety of impairments based on how they use communication functionally. From a participation-focused perspective, we are better

positioned to address parents' real-world concerns about their child's communicative functioning (e.g. 'Will my child be able to engage with our family/in school?' 'When will other people be able to understand my child?' 'Will my child make friends?').[14]

Many existing models of growth were developed using children with typical development;[6,7] children with specific impairments (e.g. specific language impairment and hearing impairment);[5,8] or children with specific diagnoses (e.g. Down syndrome).[4] While these models provide some valuable information for parents and clinicians, they do not provide the whole picture of a child's communication development. A clearer and more complete picture can be gleaned from models that focus on communicative function. Using this approach, we can facilitate a much-needed shift towards 'participation', supporting children to achieve their personal potential.

Our research group has worked collaboratively with Ontario, Canada's publicly funded Preschool Speech and Language Program (PSLP) to establish a large-scale program evaluation using preschool children's communicative participation skills as the primary outcome. In the PSLP children under 6 years of age with an identified concern related to speech and/or language development can access free assessment and intervention services from registered speech-language pathologists (SLPs).[15] Over 50 000 children are served in this program each year.[15] Our team was granted access to the PSLP program evaluation data to explore the development of children's communicative participation skills.

Using this data set, we planned to address a series of questions. The objective of this first investigation was to create growth curves for preschool children's communicative participation skills and to determine whether curves differed by level of communicative function. This broadly focused work differs from previous clinical studies as it examines an entire unselected population of preschool children with identified concerns related to communication. The PSLP evaluation project has been running since the autumn of 2012, but these data have not been reported publically.

What this paper adds

- Examining development by level of communicative function encourages us to think beyond impairments.
- Predicted development of communicative participation skills depends on level of communicative function.
- Children with communication impairments can make meaningful changes regardless of functional level.

METHOD

Study design

We completed an observational longitudinal study of a cohort of preschool children in Ontario, Canada. This work represents a secondary analysis of data collected prospectively by the PSLP at 31 locations across the province of over 13 million people.[15,16] All children accessing PSLP services were assessed approximately every 6 months for the duration of their time in the program. Assessments were completed by parents and SLPs during appointments either at PSLP centers or in community settings. Data were collected between 1 October 2012 and 1 May 2016. During their time in the program, children and families accessed a variety of assessment and intervention services. The Hamilton Integrated Research Ethics Board at McMaster University (Hamilton, Ontario, Canada) approved the use of anonymized data for this investigation.

Participants

Assessment and demographic data were available for 80 413 children. We applied three exclusion criteria to ensure the relevant children remained in our data set. We removed data for 1673 children who did not have outcome scores recorded; 2026 who were outside the ages for which measurement tools were validated or outside the ages typically serviced by the PSLP; and 29 842 who had accessed specialized services other than the PSLP. This left us with data for 46 872 children, and all available data were included in the analysis. This non-probability sample represented all children who accessed PSLP services between 1 October 2012 and 1 May 2016 for whom outcomes data were collected. Families reported speaking 66 different languages at home (90% English; 2.7% French; 1% Spanish; 0.8% Arabic). We believe most assessments were completed in English, but have no way of knowing this for certain.

Outcome measures

The Focus on Communication Outcomes Under Six (FOCUS) is a valid and reliable 50-item parent-report measure that evaluates changes in children's communicative participation skills.[17–19] FOCUS scores range from a low of 50 to a top value of 350.[17–19] It has been validated for use with children from 18 months to 6 years of age.[18] The Communication Function Classification System (CFCS) is a valid discriminative classification tool, typically completed by a speech-language pathologist. It categorizes children's skills into five levels of function based on how they communicate daily.[20,21] 'CFCS levels vary by familiarity of the communication partner, the child's successful sending and receiving of messages, and the pace of communicative interactions. Children in Level I function best and those in Level V function least well'.[21] More detailed descriptions of the five levels can be found at http://cfcs.us/.

Statistical analysis

Data were analyzed using version 13 of Stata Data Analysis and Statistical Software (College Station, TX, USA). The population of children under investigation was described using counts, percentages, means, and SDs. Analysis of variance was used to examine differences in how children functioned at baseline in each of the five CFCS levels with respect to age and FOCUS scores.

Mixed effects modeling was used to develop average growth curves for children in each CFCS level. Mixed effects models are flexible, allowing for analysis of data sets with (1) missing data; (2) an unequal number of assessments per child; and (3) an unequal number of months between assessments from child to child.[22]

The data used for this work were collected for program evaluation, not specifically for the purposes of health services research. As such, there was variability in when children entered and left the program as well as the points at which assessments were completed. Although our inclusion criteria required that children be between 18 months and 67 months of age, not all children were first assessed at 18 months of age. Similarly, children remained in the program for varying periods of time, so some had multiple assessments, while others were seen only once. Finally, the PSLP requested assessments at 6-month intervals for all children, but logistically this was not always possible, meaning not all assessments were equally spaced for all children.

Average change in FOCUS scores was modeled within CFCS levels. Age (primary predictor of change) was centered at 18 months (centered age ranged from 0–48mo), and both centered age and the square of centered age were included as predictors. The mixed effects models account for (1) average FOCUS score at 18 months; (2) rate of change in FOCUS scores per month of age; and (3) the deceleration (or acceleration) of FOCUS scores with increasing age. This can be represented with the following equation: predicted FOCUS score=average FOCUS score at 18 months+Age (centered at 18mo)+Age(centered).[2]

Allowing for random intercept and slopes, we estimated the between-child variability in both the predicted starting score (intercept) and estimated rate of growth (coefficients of age and age squared terms in the model).[22]

A likelihood ratio test and the Bayesian Information Criterion[22] favored models in which the rate of development is expected to change over time and in which all three developmental parameters are allowed to vary randomly among children: (1) intercept (average FOCUS score at 18mo); (2) slope (rate of growth in FOCUS score per month of age); and (3) slope squared (acceleration/deceleration in FOCUS scores per month of age). The degree of individual variation around the average line is estimated as variances in the random effects for each change parameter. Except for children in CFCS Level IV, the covariance matrix of the random effects included estimates of the covariance among developmental parameters, consistent with the possibility that a child's FOCUS score at 18 months might be predictive of subsequent change. The data for CFCS Level IV did not allow for estimating these covariances, but the model was otherwise similar to models for the other levels.

RESULTS

Data for 46 872 children were included in this analysis. Average age at the time of first assessment differed significantly among children in the five CFCS levels ($F(4, 46, 867)=2137.49$, $p<0.001$), with the youngest children (on average) in Level V and the oldest (on average) in Level I (Table I). Children in CFCS Levels I to III differed in age from each other and from children in Levels IV and V, who did not differ from each other. Initial FOCUS scores also differed significantly among children in the five CFCS levels ($F(4, 46, 865)=7491.94$, $p<0.001$), with children in the lowest levels (V) receiving the lowest FOCUS scores. FOCUS scores in each of the CFCS levels differed significantly from FOCUS scores in each of the other CFCS levels (Table I). The range of scores in each of the CFCS levels suggests that SLPs may still not be classifying children correctly in all cases, an issue previously reported within the PSLP.[23] Total FOCUS scores also differed significantly by age ($F(49, 46, 820)=384.32$, $p<0.001$), with older children achieving higher FOCUS scores than younger children. Finally, there was a significant interaction between age and CFCS level for FOCUS scores. This interaction occurred between CFCS Levels IV and V when children were approximately 50 months of age.

Children were grouped into the five CFCS levels based on how they were classified at the point of first assessment. The 46 872 children had a total of 84 495 assessments; on average, children received 1.8 assessments (range 1–10

Table I: Participant characteristics by Communication Function Classification System (CFCS) level at the point of first assessment

	CFCS Level I	CFCS Level II	CFCS Level III	CFCS Level IV	CFCS Level V	All levels combined
N (%) of children	7991 (17)	9442 (20)	11 646 (25)	14 825 (32)	2968 (6)	46 872
N of children by sex (%)[a]	Male=4389 (61) Female=2768 (39)	Male=5478 (66) Female=2819 (34)	Male=6798 (66) Female=3440 (34)	Male=9007 (71) Female=3743 (29)	Male=1847 (73) Female=686 (27)	Male=27 519 (67) Female=13 456 (33)
Mean (SD) age in mo	46.94 (10.88)	43.02 (11.46)	37.74 (11.78)	34.20 (11.10)	33.75 (11.53)	39.0 (12.32)
Mean (SD) FOCUS score	266.62 (47.33)	236.89 (53.00)	203.83 (54.02)	164.98 (52.28)	125.86 (57.20)	203.97 (67.07)
N of assessments	10 692	15 730	22 353	29 786	5934	84 495
Mean *n* of assessments (range)	1.3 (1–7)	1.7 (1–7)	1.9 (1–8)	2.0 (1–10)	2.0 (1–7)	1.8 (1–10)

[a]The total number for sex is slightly lower than the number of children in the total sample because sex was not reported for all children in the sample. FOCUS, Focus on the Outcomes of Communication Under Six.

Table II: Estimates of coefficients for the development of communicative participation skills

	CFCS Level I	CFCS Level II	CFCS Level III	CFCS Level IV	CFCS Level V
Fixed effects					
Predicted FOCUS score at 18mo (95% CI)	190.56 (185.49–195.62)	156.50 (153.29–159.71)	139.90 (137.88–141.92)	120.46 (118.89–122.04)	101.25 (98.34–104.17)
Estimated rate of change in FOCUS score per mo of age (95% CI)	4.32 (3.96–4.67)	4.97 (4.71–5.22)	4.77 (4.58–4.97)	3.79 (3.62–3.95)	1.65 (1.3–2.0)
Estimated acceleration/ deceleration in FOCUS score per mo of age (95% CI)	−0.05 (−0.06 to −0.04)	−0.05 (−0.05 to −0.05)	−0.05 (−0.05 to −0.04)	−0.02 (−0.03 to −0.02)	0.01 (0.003–0.02)
Random effects					
SD estimated rate of change (SE)	3.30 (0.37)	3.32 (2.57)	2.49 (0.18)	1.49 (0.25)	3.77 (0.28)
SD estimated acceleration/ deceleration (SE)	0.05 (0.008)	0.06 (0.006)	0.06 (0.004)	2.23e-11 (4.70e-12)	0.06 (0.009)
Corr. rate of change/predicted score at 18mo (SE)	−0.72 (0.45)	−0.44 (0.07)	−0.29 (0.06)		−0.18 (0.14)
Corr. rate of change/ acceleration/deceleration (SE)	−0.94 (0.02)	−0.90 (0.02)	−0.90 (0.01)		−0.84 (0.03)
Corr. acceleration/deceleration/ predicted score at 18mo (SE)	0.48 (0.11)	0.04 (0.14)	−0.12 (0.12)		−0.28 (0.30)
SD predicted score at 18mo (SE)	60.74 (3.32)	44.67 (2.30)	34.61 (1.46)	32.21 (0.49)	23.29 (2.49)

CFCS, Communication Function Classification System; FOCUS, Focus on the Outcomes of Communication Under Six.

observations) (Table I). Estimates of the parameters for the average (fixed effects) and individual (random effects) development of communicative participation skills for children in each CFCS level are presented in Table II. Figure 1 provides a visual representation of the population average growth curves for children's FOCUS scores in each CFCS level (the solid line) as well as individual variation in the growth shown by the dashed lines (one SD above/below average).

The predicted intercepts for the fixed effects (i.e. predicted FOCUS score at 18mo) increased as the CFCS levels increased (i.e. predicted intercepts were highest in CFCS Level I and lowest in CFCS Level V) (Table II). The 95% CI for the intercepts in the five CFCS levels did not overlap, suggesting that the average growth curves differ in each of the CFCS levels; however, this was not tested statistically. Predicted average slopes were initially rapid, but leveled off for all children but those in CFCS Level V, whose rate of growth was slower, but continuous (Table II).

The coefficients for the random effects indicate the degree to which individual children are expected to vary around the average curve (Table II). The SD of the intercept (predicted FOCUS score at 18mo) indicates the variability of initial FOCUS scores. The SD slope terms indicate individual variability in rates of growth. The correlations between intercept and slope indicate the degree to which a child's FOCUS score at 18 months is associated with their rate of growth in FOCUS scores. Initial rate of growth at 18 months was negatively related to subsequent change (thus the negative coefficient for age squared in the model – see Table II), meaning children starting with higher FOCUS scores are expected to have less rapid growth, whereas the opposite is expected for children starting with lower FOCUS scores.

DISCUSSION

We used a non-probability sample of a cohort of preschool children with identified speech-language impairments to create five growth curves based on children's levels of communicative function beginning at 18 months of age. To our knowledge this is the first time the development of communicative participation skills has been modeled longitudinally. The models estimate average growth, while also accounting for individual variability. Predicted average FOCUS scores at 18 months increased with CFCS levels. Estimated growth was initially rapid, but leveled off as children got older for all children except those in the lowest level of function.

It should be noted that our data show a trend for children with lower levels of functional communication to enter the PSLP earlier. For instance, children in CFCS Level V had the youngest average age and the lowest average FOCUS score at the point of first assessment. As shown in Table I, children in the lowest levels of function also had more assessments on average than those in the higher levels, which suggests they participated in the PSLP

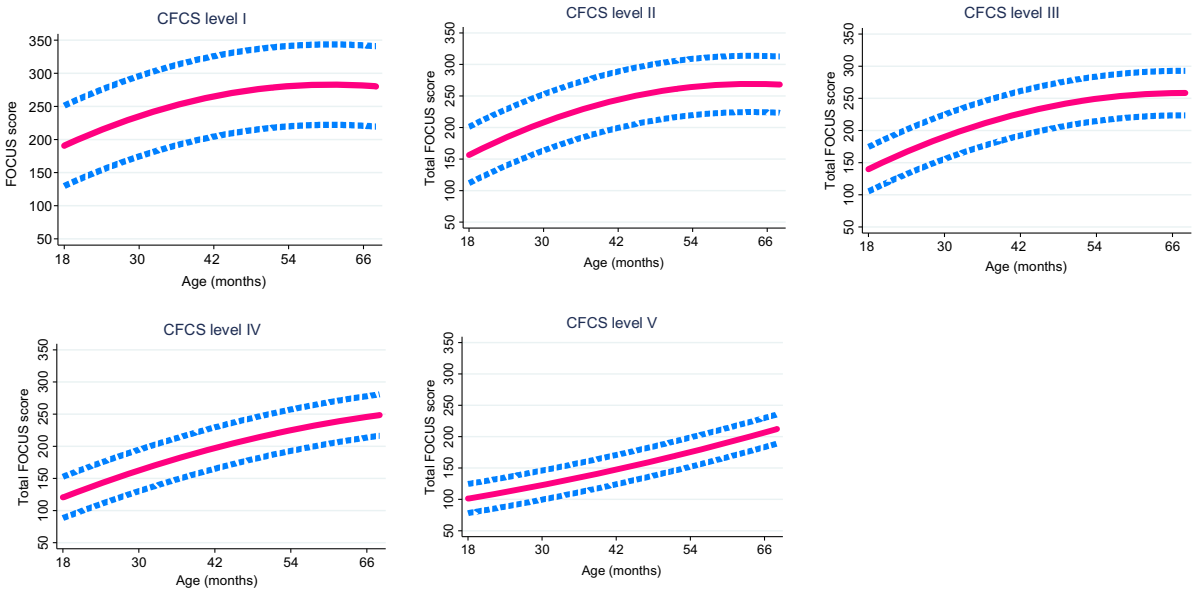

Figure 1: Predicted FOCUS scores in each of the five CFCS levels as they were assigned at the point of first assessment. The curved solid lines indicate the predicted population FOCUS scores. The dotted lines above/below the solid line indicate the standard deviation of the predicted line (individual variation in FOCUS). CFCS, Communication Function Classification System; FOCUS, Focus on the Outcomes of Communication Under Six. [Colour figure can be viewed at wileyonlinelibrary.com].

for longer periods of time and likely received more assessment and intervention services.

The growth curves show that children at all levels of function can make meaningful changes in their communicative participation skills. In the past, children with speech and language impairments have been assessed using impairment-focused measures that evaluate changes in skills such as articulation of consonant sounds, use of grammatical markers, and speech fluency.[24] With this approach, children may not make measurable change (e.g. they achieve the same standard score), but parents often report important functional changes (e.g. that other people can now understand their child). As such, it may appear as if children's skills are not improving. Using communicative participation as the primary outcome, we can capture meaningful changes in how children use communication to function in their everyday lives, separate from impairment-based changes.

Clinically these growth curves can be used as a broad estimate of prognosis when a speech-language impairment is identified. We use the term 'broad estimate' because while the curves present important information about patterns of change, they do not yet consider other individual child and family factors (e.g. socioeconomic status, parental education, additional diagnoses) that are likely to alter the growth trajectories. Nevertheless, a clinician could theoretically use a child's raw FOCUS score and CFCS level to see whether they are following a trajectory similar to other age- and CFCS-matched peers. When a child is first identified with a speech-language impairment, parents often wonder what the long-term prognosis is for their child. Considering the child's present level of function, clinicians will be better positioned to discuss prognosis with families based on how children use their communication functionally.

Administrators and policy makers may be interested in development of communicative participation skills for the purposes of service delivery planning and funding. In the past, researchers have predicted which children will benefit most from speech-language interventions, suggesting that therapy may be more/less warranted for different groups of children. These curves show that children at all ages and levels of communicative function can make meaningful communicative changes.

Study limitations

Our growth curves were developed using a non-probability sample of preschool children participating in a publically funded community service. Convenience samples such as this are subject to bias in that the individuals included may be fundamentally different from those who did not participate, which may limit generalizability of study findings. We believe that our study population was somewhat different in that PSLP services are available freely to all families who need them. This eliminates financial inequities to a point, but we acknowledge that there may still have been families with personal or social constraints that made PSLP services inaccessible to them. As such, we are cautious in generalizing findings beyond preschool children who typically access these types of services.

A second limitation lies in the SLPs' use of the CFCS. After visualizing the raw data (i.e. the range of FOCUS scores in each CFCS level), it does appear that SLPs may have misclassified some children in each CFCS level (e.g. children classified as CFCS Level I, but have a low reported FOCUS score). We did not remove the suspected outliers as there was no way to be certain they were misclassifications.

Third, we were unable to explore the environmental factors to which children were exposed over time, or the nature of the children's impairments. Some of the children included in the model were participating in active speech-language therapies, while others received only assessments. As such, the curves do not yet consider factors that might influence development of communicative participation skills. Next steps for our group will be to identify relevant variables within the PSLP data set that may be predictive of communicative participation skill development, and add them to our models. Of specific interest will be the child's intervention status (i.e. whether they were receiving active intervention). Additionally, we suspect that development may look different by type of impairment. At present, information about children's impairments is not collected. Another next step for us is to develop a tool clinicians can use together with the FOCUS and CFCS to identify impairments quickly and reliably at assessment. A limitation of our data set is that we do not have access to information about many of the factors that might influence the development of communicative participation skills. We plan to collaborate with the PSLP to improve data collection to be better able to identify the important factors that facilitate the best outcomes for children and families.

CONCLUSIONS

These growth curves can help us to look beyond impairment-based thinking, and to focus on function and participation for children with speech and language impairments. From the perspective of participation, children at all levels of function make meaningful changes in their communication skills over time. This information can be used for identification, prognostication, and counseling with families, as well as for service delivery planning. Future work in this research program will investigate factors that predict the development of communicative participation skills, which will have important implications for clinicians and those who fund and plan service delivery.

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