A Text-Based Intervention to Promote Literacy: An RCT

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abstract

BACKGROUND AND OBJECTIVES: Children entering kindergarten ready to learn are more likely to thrive. Inequitable access to high-quality, early educational settings creates early educational disparities. TipsByText, a text-message–based program for caregivers of young children, improves literacy of children in preschool, but efficacy for families without access to early childhood education was unknown.

METHODS: We conducted a randomized controlled trial with caregivers of 3- and 4-year-olds in 2 public pediatric clinics. Intervention caregivers received TipsByText 3 times a week for 7 months. At pre- and postintervention, we measured child literacy using the Phonological Awareness Literacy Screening Tool (PALS-PreK) and caregiver involvement using the Parent Child Interactivity Scale (PCI). We estimated effects on PALS-PreK and PCI using multivariable linear regression.

RESULTS: We enrolled 644 families, excluding 263 because of preschool participation. Compared with excluded children, those included in the study had parents with lower income and educational attainment and who were more likely to be Spanish speaking. Three-quarters of enrollees completed pre- and postintervention assessments. Postintervention PALS-PreK scores revealed an unadjusted treatment effect of 0.260 ($P = .040$); adjusting for preintervention score, child age, and caregiver language, treatment effect was 0.209 ($P = .016$), equating to ~3 months of literacy gains. Effects were greater for firstborn children (0.282 vs 0.178), children in 2-parent families (0.262 vs 0.063), and 4-year-olds (0.436 vs 0.107). The overall effect on PCI was not significant (1.221, $P = .124$).

CONCLUSIONS: The health sector has unique access to difficult-to-reach young children. With this clinic-based texting intervention, we reached underresourced families and increased child literacy levels.

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Drs Chamberlain and Loeb conceptualized and designed the study, contributed to the analytic plan, drafted the initial manuscript, reviewed and revised the manuscript, and critically reviewed the manuscript for important intellectual content; Dr Bruce conceptualized and designed the study, drafted the initial manuscript, reviewed and revised the manuscript, and critically reviewed the manuscript for important intellectual content; Dr Steinberg, Ms De La Cruz, and Mx Bruguera designed the data collection instruments, collected data, summarized data, and reviewed and revised the manuscript; Ms Ordaz and Ms Connelly collected data and reviewed and revised the manuscript; Dr Peterson contributed to the study's conception and design and reviewed and revised the manuscript for important intellectual content; Dr Huffman conducted the initial analyses and contributed to the interpretation of data and reviewed and revised the manuscript for important intellectual content; Drs Gardner and He contributed to the analytic plan, conducted the analyses, and critically reviewed and revised the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

WHAT'S KNOWN ON THE SUBJECT: Not all children are ready to start kindergarten: low-income families have limited access to preschool and other supports that promote school readiness. Nearly all these families engage with the medical sector repeatedly in the first 5 years of life.

WHAT THIS STUDY ADDS: Interventions that are deployed via the medical sector can reach the most underresourced families and reduce educational disparities. Using a literacy-based texting program, we effectively promoted literacy in a group of children with high likelihood of not being school-ready.

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Early childhood education (ECE) and adult health are substantially linked[1–5] because children entering kindergarten ready to learn are well positioned for academic success. Conversely, poor education is a key social driver of intergenerational poverty.[6] Early childhood adversity, including poverty, can impede a child's development and long-term educational outcomes.[7–13] The effect of poverty on life outcomes is mediated through many mechanisms, including fewer books in the home,[14–16] lower maternal education levels,[17] more single-parent households,[17] limited access to ECE,[18–20] and numerous financial and informational barriers,[7,21,22] all of which contribute to kindergarten readiness. National studies reveal less than one-half of low-income children are ready to start kindergarten.[23–27] Northern California mirrors the nation: in our county, 38% of low-income children score "ready" at school entry, and, in our public clinic, only 13% of low-income, immigrant children aged 5 years were "kinder-ready."[22,28]

Pediatrics has unique, near-universal, regular access to children aged <5 years[29] and enjoys high levels of trust: families report that, outside their own immediate family, the pediatrician is the most trusted voice.[30–33] Increasingly, the American Academy of Pediatrics is issuing guidelines for pediatricians to screen for psychosocial risks and developmental delays[34] and to use evidence-based interventions and programs to promote school readiness.[35,36] Although health clinics provide books to families[37] and initiatives to mitigate the developmental impacts of poverty,[38] school readiness disparities persist.

The ubiquity of the electronic health record makes texting patients a novel, scalable way to reach large patient populations. Texting has empowered adult behavior change, from weight loss[39] to smoking cessation[40] to college enrollment for high school graduates.[41,42] Many texting programs have emerged for parents, but only 1, TipsByText (TbT), formally known as Ready4K, has revealed positive effects on child literacy development and parent-reported behaviors for children enrolled in preschool[43] and has expanded to many states. However, TbT has not been tested in the clinical setting.

Pediatricians have access to the hardest-to-reach children, enjoy high levels of trust, and now have the ability to text families. This transdisciplinary study tests the hypothesis that pediatric clinics can use TbT to improve literacy in young children detached from the ECE system. Secondarily, we sought to determine the feasibility of pediatricians connecting caregivers to an early childhood literacy intervention via texting.

STUDY DESIGN AND METHODS

Subjects

We screened electronic charts of patients aged 3–4 years with appointments between October 2017 and August 2019 in 2 large, county-based clinics. Children were ineligible if they had developmental delay, if the family language was not English or Spanish, if there were more patients than the research assistant (RA) could get to, or if the child was deemed too ill. Eligible families were approached for enrollment, and those who consented completed a demographic survey assessing child age and birth order, household structure (single or 2-parent), primary caretaker's age, role (mother, father), highest education level, race and ethnicity, preferred language, household income, preschool enrollment, and child's insurance type. Children in preschool or transitional kindergarten were then excluded. Remaining families were randomly assigned through block randomization stratified by parent language and child baseline age.

Outcomes and Instruments

We measured early child literacy with the Phonological Awareness Literacy Screening Tool (PALS-PreK), which the University of Virginia developed and validated for a diverse child population.[44] The PALS-PreK measures preschoolers' knowledge of literacy fundamentals: name writing, alphabet knowledge, sound awareness, print and word awareness, rhyme awareness, and nursery rhyme awareness (Supplemental Table 5). PALS-PreK has revealed reliability, with strong internal consistency measured by Cronbach's α (0.75–0.93) and similar Guttman split-half scores (0.71–0.94).[44]

We calculated composite PALS-PreK scores for Spanish and English separately by summing individual items. Because the 2 PALS-PreK versions slightly differ in content, we standardized composite scores for pre- and postscores by language. Additionally, pre- and postintervention scores were standardized, allowing for comparison, creating the possibility of negative preintervention scores. As in previous research,[45] we did not include letter sounds and lowercase letters questions in the composite score because children must score well on previous sections to be given these items, and most did not qualify.

Parent–child language exchanges were measured using the Parent Child Interactivity Scale (PCI), which uses parent self-assessment and has been validated in similar populations.[43] The PCI uses a 4-point Likert scale for 5 items assessing reading, such as "Looked at pictures together in a book," and

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10 items assessing other literacy activities, such as "Practiced rhyming words." (Supplemental Table 6) The PCI has revealed internal consistency in English (Cronbach's $\alpha = 0.83$) and Spanish (Cronbach's $\alpha = 0.84$).[45] We calculated reading (PCI Read), other activities (PCI Activities), and a composite score (PCI Total).

Data Collection

The research team conducted weekly check-ins to monitor data collection. Improvement procedures included standardized protocols and monitoring of interrater reliability over 9 months (May 2018 to February 2019).[46] We conducted interrater reliability for 17 PALS-PreK assessments (5% of assessments) across 4 independent raters (1 primary, 3 secondary). The interclass correlation coefficient ranged from 0.97 to 1.0 across raters with no change over time. Bilingual RAs administered the PALS Pre-K, and the vast majority of RA assessments were blinded. Unblinding occurred when families mentioned receiving texts or when an RA had to cover a different team role; sensitivity analyses indicated no impact on results.

Intervention

Intervention caregivers received texts supporting literacy promotion 3 times a week for 7 months.[43] The texts were designed by educational professionals as a 2-generation, caregiver empowerment model drawing on family strengths. Texts were structured to build on one another and delivered in small bits, delivering a light cognitive load to the caregiver. Each week, adults received 3 texts about an academic skill or set of skills: a "FACT" text designed to inform and motivate caregivers; a "TIP" text to minimize the cognitive, emotional, and time burdens of high-quality parenting by providing caregivers with specific activities building on existing family routines; and a "GROWTH" text to provide encouragement and reinforcement. (Supplemental Table 7) Each text began with "Doc Says" to convey the pediatrician's support. The control group did not receive texts.

Statistical Analysis

We used descriptive statistics to summarize baseline child, caregiver, and household characteristics. We implemented univariate analyses using χ^2 tests and Fisher's exact tests for categorical data and t tests for continuous data to determine if excluded and included participants differed. We similarly assessed differences between control and intervention groups to test whether randomization was effectively matched.

For PALS-PreK and PCI, we calculated summary statistics at baseline (preintervention) and at follow-up 7 months later (postintervention). We used multivariable regression to compare postintervention scores between control and intervention participants and calculated 95% confidence intervals for estimated effect sizes. For each outcome, we ran 3 models: model 1 was used to estimate the bivariate relationship between treatment and outcome (unadjusted), model 2 was adjusted for baseline score, and model 3 was adjusted for baseline score, age in months, and caregiver language. We further conducted subgroup analyses to assess the heterogeneity of effects, examining child birth order (firstborn, not firstborn), family structure (single-parent family, not single-parent family), caregiver language (English, Spanish), caregiver education (less than high school, high school, some college or more), and child baseline age ($\geq$48 months, $<$48 months). Because of the skewed distribution of the standardized PALS-PreK score, asymptotic normality may not hold, given finite samples.[47,48] Therefore, we calculated the standard errors of our model estimates using bootstrapping for valid inference.[49] Statistical analysis were conducted by using R version 3.6.2 (R Foundation, Vienna, Austria).[50] All statistical tests were 2-sided and performed at .05 significance level.

The Stanford University Human Subjects Review Board and the Santa Clara Valley Medical Center Research and Human Subjects Committee approved the study.

RESULTS

We screened medical records for 1968 upcoming clinic appointments, identifying 914 potential participants (Fig 1). The majority of ineligible appointments were excluded because of developmental delay (n = 554, 53%). Of the 914 eligible participants, 270 declined, most for the reason of "not enough time on appointment date" (n = 153, 57%). Of eligible participants, 644 completed the demographic survey, after which we excluded an additional 263 (41%) because of preschool or transitional kindergarten enrollment. We randomly assigned 381 participants to the intervention or control group, and 10 caregivers opted out of receiving texts. At the postintervention time, 275 (74%) completed the postintervention assessment, 29 (8%) declined to participate, and 67 (18%) could not be reached. Those who did and did not participate at postintervention (n = 106 lost to follow-up) were similar in terms of sibling order, total children, caregiver age and race and ethnicity, household income, and insurance type (Supplemental Table 8). The groups differed in some respects: those lost to follow-up had slightly older

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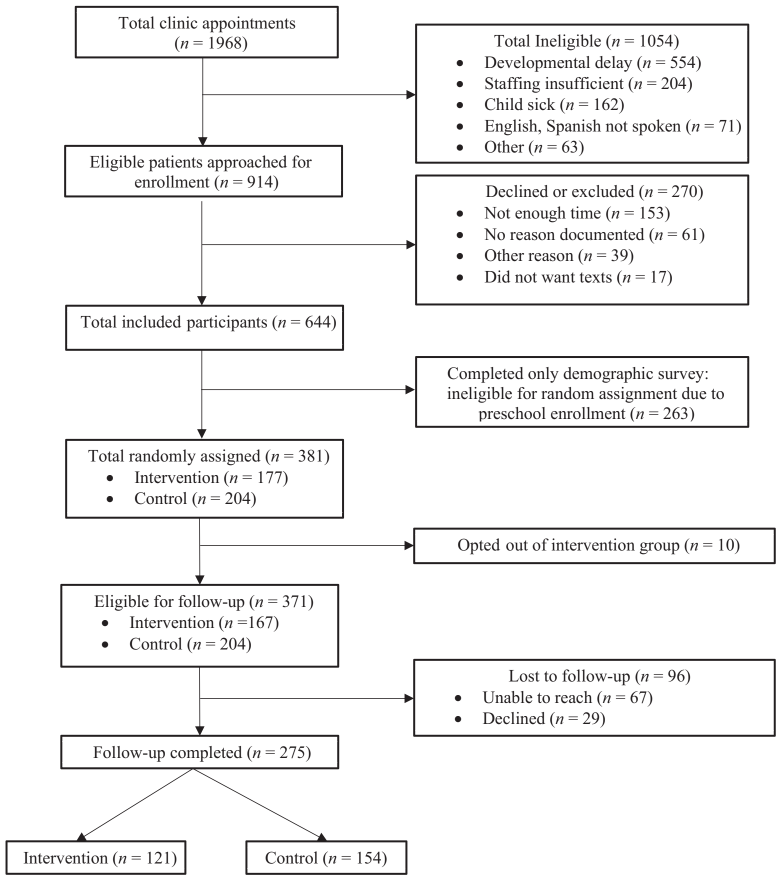

FIGURE 1
TbT randomized trial subject enrollment, October 2017–July 2019.

children (43 vs 45 months) with more caregivers who were fathers, spoke English, and attended college. We found no evidence of difference in attrition between intervention and control groups in the proportion leaving or in the characteristics of those who left.

Included participants and those ineligible largely because of preschool enrollment were similar in family structure and caregiver age but differed across several sociodemographic characteristics (Table 1). Eligible participants came from families with lower income and lower educational attainment (65% vs 83% with a high school education or greater). They were slightly younger and more likely to have a Spanish-speaking caregiver (46% vs 29%).

The intervention and control groups had similar demographic backgrounds, family composition, and socioeconomic status (Table 1). Children were an average of 44 months old, and 89% attended clinic with their mothers (average age 33 years). Participants were predominantly Hispanic (73%) with a minority identifying as non-Hispanic white (6%), Black or African American (5%), Asian American (7%), multiracial or ethnic (6%), or other (4%). Almost one-half of participants indicated Spanish was their preferred language. Participants came largely from low-income, 2-parent families (64% with a family income <\$36 001; 71% from a 2-parent family) with Medicaid insurance (88.7%). Baseline standardized PALS-PreK scores were similar for control and intervention groups on average (−0.38 [SD = 0.76] vs −0.32 [SD = 0.83]), as were total PCI scores (24.40 [SD = 9.68] vs 24.08 [SD = 9.97]). Postintervention, standardized PALS-PreK scores were, on average, 0.36 (SD = 0.98) for the control group compared with 0.62 (SD = 1.08) for the intervention group. Total PCI scores were 25.96 (SD = 10.0) for the control, versus 28.34 (SD = 9.15) for the intervention group.

TbT's impact on the children's literacy development is revealed in the intervention's estimated effect on follow-up PALS Pre-K scores (Table 2). Model 1 gives the unadjusted overall intervention effect of 0.260 (95% CI: 0.121 to 0.507, $P = .040$). Model 2 is adjusted for the baseline PALS-PreK score, with estimated effect of 0.202 (CI: 0.031 to 0.372, $P = .021$). Model 3 is adjusted for baseline PALS-PreK score, baseline child age, and caregiver language, with an estimated effect size of 0.209 (CI: 0.038 to 0.378, $P = .016$). Including the additional controls had little effect on the point estimates but reduced the standard errors and, as a result, made the estimates more precise. In Model 3, although caregiver language being Spanish was not associated with postintervention PALS-PreK score (−0.053, CI: −0.219 to −0.113, $P = .532$), child age did have an independent contribution (0.029, CI: 0.014 to 0.043, $P < .001$), as did baseline PALS-PreK score (0.813, CI: 0.702 to 0.923, $P < .001$).

To provide real-world context for TbT effects, we compared them to typical learning rates. When we estimate the relationship between child age and postintervention PALS-PreK scores for those in the control group, the estimate is 0.066 (CI: 0.043 to 0.089, $P < .001$). Thus, in a normal routine, children in our

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TABLE 1 Baseline Sociodemographic Characteristics of Ineligible Due to Preschool Enrollment and Included Study Participants

Characteristics	Overall	Ineligible	Included	P[a]	Included: Control	Included: Intervention	P[b]
Total	644	263	381		204	177	
Child age, mean (SD), mo	46 (7.08)	48 (6.63)	44 (6.85)	<.001	44 (6.90)	44 (6.81)	.71
Child age ≥48 mo, *n* (%)	263 (46)	127 (66)	136 (36)	<.001	76 (37)	60 (34)	.59
Child birth order, mean (SD)	2 (1.16)	2 (1.04)	2 (1.23)	.05	2 (1.26)	2 (1.19)	.70
Family child number, mean (SD)	2 (1.21)	2 (1.10)	2 (1.28)	.13	2 (1.31)	2 (1.25)	.36
Family structure, *n* (%)							
2-parent family	455 (73)	193 (74)	262 (71)	.61	130 (67)	132 (76)	.12
Single-parent family	153 (24)	61 (24)	92 (25)	—	53 (27)	39 (22)	—
Other	9 (1)	2 (0.8)	7 (2)	—	5 (3)	2 (1)	—
Prefer not to answer	11 (2)	4 (2)	7 (2)	—	6 (3)	1 (0.6)	—
Caregiver age, mean (SD), y	33 (6.69)	33 (6.01)	33 (7.09)	.71	33 (7.34)	32 (6.82)	.68
Caregiver role, *n* (%)				.05			.42
Father	76 (12)	41 (16)	35 (9)	—	20 (10)	15 (9)	—
Mother	556 (87)	218 (83)	338 (89)	—	177 (88)	161 (91)	—
Other	8 (1)	3 (1)	5 (1)	—	4 (2)	1 (0.6)	—
Caregiver education, *n* (%)				<.001			.55
Less than high school	168 (27)	42 (17)	126 (35)	—	71 (37)	55 (32)	—
High school	180 (29)	66 (26)	114 (31)	—	61 (32)	53 (31)	—
Some college	180 (29)	92 (37)	88 (24)	—	41 (21)	47 (28)	—
College+	88 (14)	52 (21)	36 (10)	—	20 (10)	16 (10)	—
Caregiver race and ethnicity, *n* (%)				<.001			.71
Hispanic	415 (66)	145 (55)	270 (73)	—	149 (75)	121 (70)	—
White	55 (9)	33 (13)	22 (6)	—	10 (5)	12 (7)	—
Black or African American	40 (6)	23 (9)	17 (5)	—	10 (5)	7 (4)	—
Asian American	61 (10)	37 (14)	24 (7)	—	12 (6)	12 (7)	—
Multiple races or ethnicities	39 (6)	17 (7)	22 (6)	—	11 (6)	11 (6)	—
Other	23 (4)	7 (3)	16 (4)	—	6 (3)	10 (6)	—
Caregiver language Spanish, *n* (%)	252 (40)	76 (29)	176 (46)	<.001	97 (48)	79 (45)	.64
Household income, *n* (%)				.005			.77
<$12 000	65 (10)	20 (8)	45 (12)	—	25 (13)	20 (11)	—
$12 001–$24 000	172 (27)	53 (21)	119 (32)	—	57 (29)	62 (35)	—
$24 001–$36 000	137 (22)	61 (24)	76 (20)	—	43 (22)	33 (19)	—
$36 001–$48 000	74 (12)	35 (14)	39 (10)	—	20 (10)	19 (11)	—
>$48 000	90 (14)	46 (18)	44 (12)	—	24 (12)	20 (11)	—
Decline to respond	94 (15)	43 (17)	51 (14)	—	30 (15)	21 (12)	—
Insurance type, *n* (%)							.65
Medicaid	336 (89)	—	336 (89)	—	176 (87)	160 (90)	—
Commercial	37 (10)	—	37 (10)	—	22 (11)	15 (9)	—
Other (private)	6 (1)	—	6 (1)	—	4 (2)	2 (1)	—

Percentages are rounded to whole numbers. —, not applicable.
[a] Test between ineligible and included groups.
[b] Test between control and intervention group.

sample would have gained 0.066 points on the PALS-PreK assessment per month. Those in the intervention group gained an additional 0.202 to 0.260 depending on the model, which translates to 3 months of learning. Thus, the intervention effect on literacy scores equates to 3 months of literacy gains for children.

We examined the heterogeneity in the TbT effects on postintervention PALS-PreK score by calculating the estimated effect for subgroups.(Table 3) The intervention effect was evident for firstborn children (0.282, CI: 0.021 to 0.542, *P* = .034), 2-parent families (0.262, CI: 0.063 to 0.461, *P* = .010), English-speaking caregivers (0.238, CI: 0.003 to 0.473, *P* = .047), and children aged ≥48 months (0.436, CI: 0.116 to 0.755, *P* = .008). We found no difference by caregiver level of education.

The PCI scale was used to assess caregivers' self-reported literacy interactions with their children (Table 4). The reading and total PCI scores did not reveal a significant change across unadjusted or adjusted analyses. The unadjusted intervention effect on postintervention PCI literacy activities was significant (1.96, CI: 0.167 to 3.76, *P* = .033); however, the intervention effect was not statistically significant when

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TABLE 2 Estimated Effect and 95% CIs of TbT Intervention on Child Follow-up PALS-PreK Score

	Model 1	Model 2	Model 3
TbT intervention	0.260	0.202	0.209
CI	0.012 to 0.507	0.031 to 0.372	0.039 to 0.378
P	.040	.021	.016
Baseline PALS-PreK score	—	0.921	0.813
CI	—	0.825 to 0.372	0.702 to 0.923
P	—	<0.001	<0.001
Baseline child age, mo	—	—	0.029
CI	—	—	0.014 to 0.043
P	—	—	<.001
Assessment language, Spanish	—	—	−0.053
CI	—	—	−0.219 to 0.113
P	—	—	.532

Model 1: overall treatment effect (n = 275). Model 2: adjusts for baseline PALS-PreK score (n = 275). Model 3: adjusts for baseline PALS-PreK score, baseline child age, and assessment language (n = 275). —, not applicable.

adjusted in Model 2 (1.25, CI: −0.329 to 2.83, P = .122) or Model 3 (1.22, CI: −0.328 to 2.77, P = .124).

DISCUSSION

Profound educational disparities are evident across socioeconomic groups at kindergarten entry. With this literacy-promoting texting program, we leveraged a pediatric care setting and increased literacy levels for a group of underresourced children by an average of 3 months. The effects varied across subgroups: firstborn and older children revealed more gains. These differential effects within our sample are not intended to guide clinical application. These findings are shared so that they may inform the design of future research into the effects of this program and parenting programs more generally. Overall, this is not one size fits all intervention.

Young children in the United States have greater access to health care than to early education because health care for young children is near universal. The Early and Periodic Screening, Diagnostic and Treatment benefit of Medicaid ensures all children (aged <18–21, state depending) are entitled to routine preventive services and medical treatment. Overall 49% of children aged 3–4 years are enrolled in preschool, with lower enrollment rates for those with parents who have lower educational levels,[51] nearly 99% of children were hospital born,[52] and, at 5 years of age, 94% have received required immunizations for school entry.[53] As we have revealed, this cohort of low-income, publicly insured children represents a heterogeneous population. In our sample, those not in preschool had caregivers with significantly lower education and income and were more likely to identify as Hispanic and to speak Spanish at home. Educational interventions deployed from clinic can reach a distinct, more underresourced subset of families; this finding adds to our knowledge about the unique contribution the health sector can make toward addressing school readiness. More evidence-based, scalable programs are needed for younger and older children, as well as for those enrolled in preschool, to narrow ECE inequities.

TbT has the potential to move pediatrics to a higher level of impact. Past experience that scaled texting programs for parents

TABLE 3 Heterogeneity in TbT Intervention Effects on Literacy

	n	Estimated Effect	95% CI	*P*
Full sample	275	0.209	0.039 to 0.378	.016
Child birth order				
Firstborn	95	0.282	0.021 to 0.542	.034
Not firstborn	164	0.178	−0.053 to 0.408	.131
Family structure				
Single-parent family	60	0.063	−0.257 to 0.383	.700
Not single-parent family	199	0.262	0.063 to 0.461	.010
Caregiver language				
English	127	0.238	0.003 to 0.473	.047
Spanish	148	0.188	−0.048 to 0.423	.119
Caregiver education				
Less than high school	95	0.184	−0.113 to 0.480	.225
High school	90	0.186	−0.108 to 0.479	.215
Some college or more	77	0.221	−0.083 to 0.525	.154
Child baseline age, category				
≥48 mo	86	0.436	0.116 to 0.755	.008
<48 mo	189	0.107	−0.088 to 0.302	.283

Each row represents an individual model estimating the effect of the intervention on PALS-PreK standardized score, stratified by each of the groups listed above. All models are adjusted for baseline PALS-PreK score, child baseline age, and caregiver language.

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TABLE 4 Estimated Effect and 95% CIs of TbT Intervention on Follow-up PCI Literacy Activities And Reading; Summaries of Pre- and Postintervention PCI Scores Stratified by Group

	Model 1	Model 2	Model 3
PCI activities	1.96	1.25	1.22
CI	0.167 to 3.70	−0.329 to 2.83	−0.328 to 2.77
P	.033	.122	.124
PCI Reading	0.510	0.248	0.242
CI	−0.542 to 1.60	−0.822 to 1.32	−0.839 to 1.32
P	.346	.650	0.661
Preintervention	Overall	Control	Intervention
PCI total score[a]	24.26 (9.80)	24.40 (9.68)	24.08 (9.97)
PCI reading	8.09 (4.03)	8.21 (3.98)	7.94 (4.10)
PCI activities	15.40 (7.10)	15.37 (7.09)	15.45 (7.14)
Postintervention	Overall	Control	Intervention
PCI total score	27.02 (9.68)	25.96 (10.00)	28.34 (9.15)
PCI reading	8.58 (3.99)	8.36 (4.17)	8.87 (3.75)
PCI activities	16.92 (7.40)	16.05 (7.41)	18.02 (7.26)

Model 1: overall intervention effect (n = 261 for activities, n = 219 for reading). Model 2: adjusts for baseline PCI score (n = 251, n = 188). Model 3: adjusts for baseline PCI score, baseline child age, and caregiver language (n = 251, n = 188).
[a] Mean and SD are shown for each score.

through the education sector is informative. Within a few years after completing initial studies among preschool families in the San Francisco Unified School District, this program scaled quickly. The original research team has sent >40 million parenting texts to families in public preschools through the school districts in Florida, Georgia, New Jersey, Pennsylvania, Texas, and Wisconsin, among others. Large scale and rapid uptake were facilitated by the transformative ubiquity of personal cell phones, texting as a well-received modality of parent communication, and the intervention being inexpensive and scalable by design. However, although school districts have been instrumental in reaching families with children in preschool, they do not reach families with younger children or those not attending preschool. Health clinics can provide access to these families, but evidence of clear benefits for families and children are needed to justify moving to scale.

We used the PCI to assess program effects on parent self-reported behaviors and to better understand literacy improvement. The study was designed to measure the primary outcome of child literacy gains using PALS, rendering it underpowered to detect differences measured by PCI parent self-report. This choice was acceptable to investigators because early studies in preschools using teacher and parent reports detected positive impact on parenting behavior, as measured by PCI and teacher surveys, establishing the TbT causal mechanism.[45] Of note, at baseline, caregivers reported high reading levels, indicating that messaging to read to children may be reaching saturation, a fact to celebrate. However, caregivers who have heard they should be reading to their children may overreport reading, suggesting parent reports might not be accurate, given strong societal pressures. Tools that measure language directly by recording and counting number of words spoken[54] may better assess parental behavior.

TbT's structure and scaffolding are based on extensive theoretical models that address caregiver challenges of low-resourced communities, including economic stress that requires adults to focus on short-term over long-term outcomes. For instance, a focus on having food for the week would displace a caregiver's attention on longer term educational outcomes. TbT is designed to address these barriers, to break down educational processes into bite-size components that come via small doses every other day over a long period of time. As other nontexting clinic-based interventions emerge, such as individualized parent coaching,[55,56] library referrals,[57] electronic preschool enrollment,[58] or community referral coordinators,[59] sustained attention to caregiver needs and their day-to-day barriers will likely be important to overcoming the persistent differences in school readiness across groups.

The medical sector is increasingly motivated to address issues of poverty and its antecedent factors.[36,60] New advances in ECE are needed to address social-emotional learning, numeracy, literacy, and ways to support the development of newborn-to-3-year-olds. It requires humility to acknowledge that medical training does not prepare us to build effective ECE interventions. The role of convergence science,[61] founded on trusting, transdisciplinary

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partnerships with schools of education, holds promise for transformative advances.

Limitations

This study has a number of limitations. Northern California is racially diverse, with a significant Hispanic population, limiting generalizability. It remains to be seen whether rural families or urban, African American families would respond similarly, although early findings show promise.[45] Demographic data could not be gathered from those declining participation, so how they vary from participants is unknown. The PCI tool relied on parent self-report, which may have been impacted by social desirability bias and a ceiling effect, particularly for reading. Fidelity concerns are always warranted, but treatment fidelity is unusually strong in a text-message program. The caregivers we texted may have changed caregiving responsibilities or allowed others to use their phone. A final limitation is that the study is based on 1 measure of child development, and TbT can affect many aspects of child development beyond what PALS-PreK assesses.

CONCLUSIONS

This study revealed that a texting intervention sent from a clinical setting could reach a underresourced population of families, resulting in 3 months of literacy gains for young children. Further studies of clinic-based texting interventions exploring the causal factors linked to child outcomes are warranted. Leveraging the health sector's unparalleled access to young children presents an opportunity to narrow educational disparities.

ABBREVIATIONS

ECE: early childhood education
PALS-PreK: Phonological Awareness Literacy Screening Tool
PCI: Parent Child Interactivity Scale
RA: research assistant
TbT: TipsByText

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