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Conceptualizing a Public Health Prevention Intervention for Bridging the 30 Million Word Gap

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Abstract Early childhood experience is a social determinant of children's health and well-being. The well-being of young children is founded on their relationships and interactions with parents and family members in the home, caregivers, and teachers in early education, and friends and families in the greater community. Unfortunately, the early language experience of infants and toddlers from low-income families is typically vastly different than children from middle- and higher-income families. Hart and Risley (Meaningful differences in the everyday experience of young American children. Brookes, Baltimore, 1995) described a "30 Million Word Gap" experienced by age four for children from poor families compared to economically advantaged families as measured by the number of words delivered by adults in the home to their children. This discrepancy between groups is associated with a deficit in vocabulary growth over time (Hart and Risley in Meaningful differences in the everyday experience of young American children. Brookes, Baltimore, 1995; in The social world of children learning to talk. Brookes, Baltimore, MD, 1999; in Am Educ (Spring), 1–9. http://isites.harvard.edu/fs/docs/icb.topic1317532.files/09-10/Hart-Risley-2003.pdf, 2003), and readiness when they enter preschool and kindergarten compared to their more advantaged classmates. The purpose of this paper is to conceptualize a population-level public health prevention approach to research addressing the harmful impacts of the Word Gap. The approach includes use of evidence-based practices to improve children's language environments to foster their early language and literacy learning in early childhood. After a brief review of the Word Gap, we discuss four aspects: a conceptual framework, a community leadership team as driver of the local intervention, evidence-based language interventions for reducing the gap and promoting child language, and the measurements needed. Implications are discussed.

Keywords Word Gap · Vocabulary · Language environment · Multicomponent prevention intervention · Infants/toddlers

Early childhood experience is a social determinant of children's health and well-being (Irwin et al. 2007). We know that the most rapid period in human development occurs in the first 3 years of life (Shonkoff and Phillips 2000). Early childhood development is facilitated by positive environmental conditions, wherein stable, responsive caregiving by parents, family members, and other caregivers in the home and community settings supports physical, social-emotional, and cognitive development. Nurturing conditions supportive of a child's stable and interactive relationships with adults are most likely to occur in safe, caring neighborhoods and communities that are sustained and reinforced by favorable local and national policies and resources. Such conditions are supportive of quality child care, preschool, and educational opportunities.

Conversely, adverse care, low stimulation, and neglect lead to poor language, cognitive, and health outcomes with

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possible intergenerational transmission. Poverty is an associated risk factor. Children who live in poverty are less likely to live in communities that foster language, pre-literacy, school readiness, and grade-level academic achievement. There is a long-recognized relationship between children from low-income backgrounds and delays in learning to read (Knudsen et al. 2006; Shonkoff and Phillips 2000). Some measures indicate that 5-year-old lower-SES children score 2 years or more behind higher-SES children on standardized tests by the time they enter school.

Reading is a keystone skill with competence needed at high levels well beyond basic literacy skills for success in our post-industrial society (Warren 2015). Delays in learning to read put children at risk for not achieving expected language, literacy, and social-emotional outcomes (Shonkoff and Phillips 2000; Zill and Resnick 2006). Poor academic preparedness leads to later achievement delays and school failure, ultimately resulting in lifelong social and economic costs (Aram and Hall 1989; Shonkoff and Phillips 2000). Poor outcomes for individuals in low-income communities compound and persist, and are associated with higher rates of health problems, crime, violence, and limited job opportunities (Heckman 2006).

The Disparity in Early Vocabulary Learning

A recent discovery demonstrated that the precursors of reading, early literacy, and oral language begin before kindergarten and extend into the early childhood period. Hart and Risley (1995) reported that by age three, the spoken vocabularies of children growing up in economically disadvantaged families versus those more advantaged were vastly different; 525 versus 749 versus 1116 words for children in welfare, white collar, and professional families, respectively (Hart and Risley 2003). By age three, the average vocabularies of children in professional families were reported to be nearly twice that of children in welfare families. This finding has been widely reported in the USA (e.g., Farkas and Beron 2004) and as a wealth gradient in young children's cognitive development internationally (Schady et al. 2015).

The negative impact of poverty on children's English language learning can be identified as early as 18 months and is pronounced by 24 months between lower versus higher-SES children (Fernald et al. 2013). By age 24 months, there was a 6-month gap between SES groups in processing skills critical to language development. This effect also has been reported in low-SES Spanish-learning infants (Hurtado et al. 2008). At 18 months, children who received higher input had greater processing efficiency, knew more vocabulary, and at 24 months had faster word recognition than children receiving lower input. Similar findings in another low-SES Spanish-learning sample (Weislede and Fernald 2013) indicated that vocabulary growth was facilitated by child-directed input and not speech overheard.

As early as 30 months of age, we can predict literacy and school success from children's rate of vocabulary acquisition (Rowe et al. 2012). The gap continues to widen, affecting literacy skills into the elementary years. For example, we know the vocabularies of children in first grade can vary from 2000 to 10,000 words (Dickinson et al. 2010). Follow-up of Hart and Risley's (1995) participants found that children from lower-income families with smaller vocabularies at 3 years had significantly lower academic achievement in the elementary grades than their more advantaged peers (Walker et al. 1994).

What is significant here is the strong and lasting relationship between oral language and later literacy and academic achievement (Hoff 2013). A large body of research points to the fact that children's literacy development and academic trajectories can be traced to early differences in oral language (Morrison et al. 2005; NICHD Early Child Care Research Network 2005; Snow et al. 1998). Furthermore, literacy skills are directly linked to later life outcomes; for example, the likelihood of completing high school (Durham et al. 2007). The social significance of this early disparity is critical when 16 million (22%) of American children are living below the federal poverty rate (Child Trends 2014; Kneebone and Holmes 2016; National Center for Children in Poverty, n.d.).

The Associated Language Input Disparity

Hart and Risley (1995) also linked children's vocabulary learning to their home language environment. They reported that children who lived in poverty with smaller vocabularies were more likely to have families who talked to them significantly less often. Hart and Risley reported that this cumulative difference was as large as 30 million words by age four (Hart and Risley 1995, 1999, 2003). Moreover, the words heard by children in low-income families were more often negative, such as words of discouragement. Conversely, in more advantaged families, children were more likely to hear words of encouragement. It is important to note that these were proportional differences such that "negative words and phrases" accounted for a substantially larger part of a small total amount of words addressed to the child in low-income homes, thus creating an environment potentially motivating a child to avoid interacting with the parent (Warren 2015). Hart and Risley reported that 86% to 98% of the words used by each child by the age of three were derived from their parents'

vocabularies (Hart and Risley 2003). The average number of words utilized, the duration of conversations, and the overall speech patterns were all similar to their adult caregivers suggesting that adult input is a mechanism in children's learning.

Findings for bilingual families also have linked the quantity and quality of language heard at home to infants' later language growth (Garcia-Sierra et al. 2011). For example, the amount of talk children are exposed in each language predicts their rates of development in each language (DeHouwer 2009; Hoff et al. 2011). Because children hearing two languages in their homes are also hearing less English overall than monolingual English speakers, they typically show some delay in English proficiency compared to children raised in monolingual English households (Hoff 2013). However, children from bilingual homes who receive their English input from multiple sources are likely to have stronger language growth than those with more limited sources of exposure (Place and Hoff 2011).

Rowe (2008) reported that higher-SES mothers compared to low-SES mothers reported talking more to their children because they knew or believed it was beneficial for child development. SES has been linked to mothers' knowledge of child development, and self-efficacy beliefs contributing to lower-SES parents being less likely to believe that they have influence over their child's outcomes (Elder et al. 1995). Thus, the amount of child-directed speech may be mediated by maternal knowledge of child development and rearing practices. Consequently, maternal knowledge and its relationship to adult–child language may provide a leverage point for promoting a combination of intervention strategies (e.g., multimodal messaging, well-child exam promotion, employee wellness programs) through messaging campaigns as part of a multicomponent intervention effort. These differences in language input and child outcomes also may be mediated by the mother's vocabulary knowledge (Hindman et al. 2016), offering another potential pathway for improving children's vocabulary.

In summary, Hart and Risley and others identified a disparity in child's vocabulary that was associated with an unresponsive, taciturn parenting style in families living in poverty. While groundbreaking, these findings are correlational and not experimental-causal evidence. These findings alone are not sufficient to base a large-scale prevention effort.

Evidence that the Gap is Malleable

Evidence from controlled intervention research supports the beneficial effects of two major principles of effective early language learning adult–child interaction: (a) following a child's lead and creating joint attention and (b) recasting child vocalizations to enhance vocabulary and language complexity throughout the varied contexts of the day (Warren 2015). Following a child's lead has the effect of increasing the frequency of child initiations to the adult, while recasting by the adult enables following up with additional conversational turns. Together, this interaction style becomes highly responsive and engaging and it can be readily taught to and used by parents, caregivers, home visitors, and other child development specialists working with the family. This interaction style can also be promoted using messaging, materials, talking tips, video, and data-based feedback (see Table 1).

With pre-linguistic children, Warren et al. (2008) reported significant gains in children's intentional communication using gestures and vocalizations compared to control children resulting from a package of following the child's attentional lead, building social play routines, and using prompts and models with natural consequences to teach requesting and commenting combined with adult responsivity education (Warren et al. 2008). These strategies produced more frequent and complex non-verbal communications in very young children (Warren et al. 1993, 2008).

With children learning to talk, studies report improved communication was attained by following a child's lead, repeating a child's statement, using time delay and natural consequences, and encouraging more elaborate responding (Adamson et al. 2015; Charlop-Christy and Carpenter 2000; Kaiser and Roberts 2011). For example, using a natural consequence such as providing a child access to a favorite toy—given a child's request—reinforces the child's request, encourages more elaborate responses, and responsive interactions (Trent et al. 2007). Another example, using time delay—a child's talk may be evoked by simply inserting a natural pause in the conversation as an opportunity for the child to fill in the blank (Halle et al. 1979).

A meta-analysis of 18 randomized trials examining the effectiveness of parent-implemented language interventions combining a number of these strategies resulted in strong, positive impacts on receptive and expressive language skills of children with language impairments (Roberts and Kaiser 2011). Similar findings for parents trained to use the strategies were reported by Hancock et al. (2002). These strategies were reported effective when used by low-SES parents (Alpert and Kaiser 1992; Kong and Carta 2013; Peterson et al. 2005) and by early educators (Goldstein et al. 1992).

The dosage of these strategies on children's language growth is extended by using them across daily contexts and routines, such as bathing, play, and mealtime (Hart and Rogers-Warren 1978; Hemmeter and Kaiser 1994; Kaiser

Table 1 Multicomponent intervention prevention program for bridging the word gap

Level	Ecological setting (s)	Program/strategy type	Program name	Procedures and supporting evidence	
				Evidence-based components	Supporting evidence
Population	National media outlets	National media campaigns	Too Small to Fail's Community Tool Kit	1. Risk information 2. Practical strategies and tips for prevention 3. Approaches to measuring progress	Ending the tobacco problem (Institute of Medicine 2007); Safe-to-Sleep campaign http://www.nichd.nih.gov/sts/Pages/default.aspx
	Well-child visits	Video interaction coaching	BELLE/VIP Project	1. One-on-one interaction with a child development specialist providing an individualized relationship-based intervention 2. Videotaped interactions of mom and child interacting with modeling and reinforcing feedback; tape taken home for guidance 3. Interaction promoting materials 4. Pamphlet with interaction tips for verbal interactions, shared reading, and routines	Mendelsohn et al. (2011)
Community	Local media outlets	Local media campaign with web-based flyer	Talk, read, play KC	Recommends the PC TALK^{TM} strategies (see below)	Williams (2013, February 18)
	Neighborhoods	Community leadership team	Community tool box	1. Understanding community context (e.g., assessing community assets and needs) 2. Collaborative planning (e.g., developing a vision, mission, objectives, strategies, and action plans) 3. Developing leadership and enhancing participation (e.g., building relationships, recruiting participants) 4. Community action and intervention (e.g., designing interventions, advocacy) 5. Evaluating community initiatives (e.g., program evaluation, documentation of community and system change) 6. Promoting and sustaining the initiative (e.g., social marketing, obtaining grants)	Collie-Akers et al. (2013), Fawcett et al. (2010, 2013)
Community	Child Care, Home Visiting, Churches, Libraries, Museums, Coalitions	Language-promoting strategies	PC TALK	1. Following the child's lead 2. Commenting and labeling 3. Imitating and expanding 4. Asking open-ended questions 5. Giving praise and positive attention 6. Providing choices 7. Time delay/fill in the blank	Kaiser and Roberts (2011), Walker et al. (2008)

Table 1 continued

Level	Ecological setting (s)	Program/strategy type	Program name	Procedures and supporting evidence	
				Evidence-based components	Supporting evidence
Child/family	Home	Quantitative linguistic feedback to adults	LENA Online™	Data-based feedback to the adult from day-long audio recording of the home language environment	Providence Talks (2015), Suskind et al. (2013a, b)
				1. Adult Word Count	Warren (2015)
				2. Conversational Turns	Stile and Ortiz (1999)
				3. TV/Electronic Media	
				4. Parent reading frequency	
				5. Progress monitoring and child language skills	
		Language-promoting strategies	PC TALK	Parents and family members are taught (learn) to provide a more engaging and responsive parent style using the training procedures associated with the intervention programs below	
				Warren (2015)	
		Father engagement		A model for getting fathers and others in the family involved:	
				1. Early social interaction	
				2. Reading books	
				3. Pre-literacy activities	
				4. School involvement	

et al. 2000; Woods et al. 2004), and shared book reading (Lonigan and Whitehurst 1998). Used widely across a child's day, the resulting additional interactions strengthen the language learning environment (home or child care) (Kaiser and Roberts 2011; Trent et al. 2007; Warren et al. 2008). In summary, considerable evidence from experimental intervention research supports the effectiveness of this adult conversational style in terms of promoting children's social communication and vocabulary learning. Evidence strongly supports the prospect of a prevention intervention to bridge the Word Gap.

The Word Gap as a Health Issue

There is increasing evidence that the early stimulation gained from babies' communicative interactions with caregivers is not only a driver of language but also of brain development and cognitive function. The notion that early environment may affect the structure and function of the brain, and that this influence is pronounced during early life, is strongly supported in research based on animal models (Bailey et al. 2001; Bornstein 1989; Colombo 1982). Studies of human infant brain development also report that early experiences appear to be key drivers in language and cognitive development (Center on the Developing Child at Harvard University 2010; Kuhl 2004). For example, Kuhl and Rivera-Gaxiola (2008) reported that early brain measures in response to sounds, words, or sentences not only show structural and functional brain growth as language progresses, but also predict future language abilities. Raizada et al. (2008) reported that SES was a strong predictor of 5-year-olds' function in brain areas related to language and literacy. Even though research on the effects of the early language environment on brain development is not yet definitive, observational and intervention studies strongly suggest that early environments can have profound effects on children's development, both in terms of the positive effect of enhanced environments (Roberts and Kaiser 2011) and the negative effect of depriving environments (Hart and Risley 1995).

Summary

The discovery of the Word Gap and the evidence of its adverse impacts on early language learning, school readiness, health, and social equity point to a significant national health crisis (Cates et al. 2016; Crow and O'Leary 2015; Irwin et al. 2007). When children's early experiences are disrupted by the Word Gap, those missed opportunities for language learning can set in motion a cascade of negative life events previously noted: the inability to read (or read well), engaging in unhealthy behaviors, adoption of risky behaviors as young adults, and reduced life expectancy

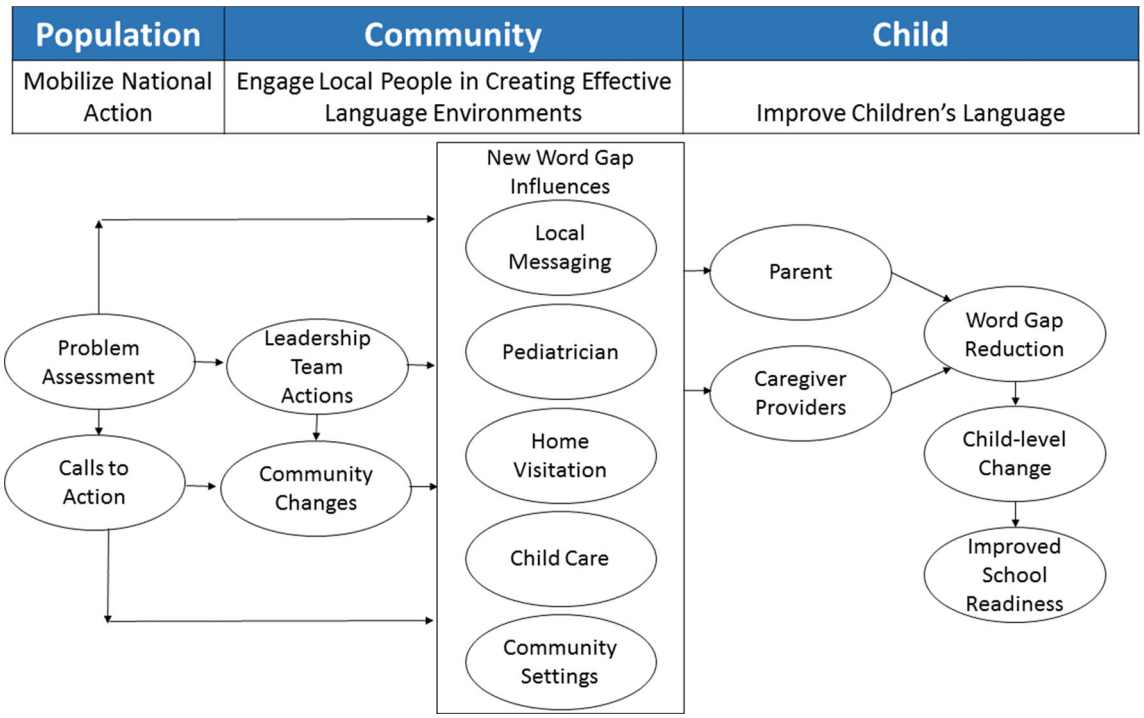

Fig. 1 Public health multilevel intervention framework for bridging the Word Gap

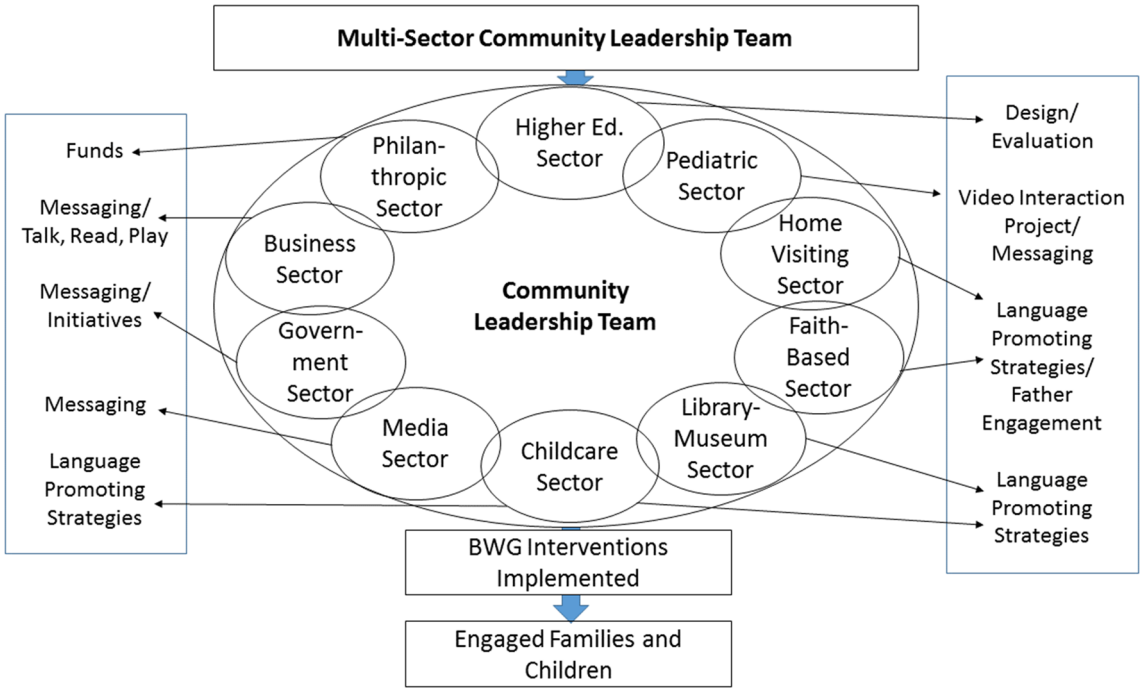

Fig. 2 Multi-sector community leadership team and implementation of the multilevel intervention to bridge the Word Gap—ensuring wherever the child is in the community, their language will be nurtured

(Felitti et al. 1998). Considering the strong causal evidence from experimental research of malleability through changes made and sustained in a child's language environment, a compelling reason exists for a population-based prevention effort. Economists suggest that investments in early childhood are one of the most substantial to yield a return on investment during the life course (Irwin et al. 2007). We stand at a critical point in the knowledge that the future of a child in poverty is not fixed, because language environments are alterable by parents at home and teachers in child care (Crow and O'Leary 2015). The good news is that the reviewed evidence suggests that the disparity may be prevented given that the *talking to infants* message is taken to heart by policymakers, funders, communities, professional groups, and practitioners (Irwin et al. 2007). Consequently, we are facing an unprecedented window of opportunity to prevent the problem through an aligned, coordinated effort across national-, community-, and child–family-level systems. Thus, the purpose of this research is to investigate a population-level impact solution to the Word Gap. We are calling for a decade-long, multicomponent prevention intervention research effort. In this effort, we intend to address the following research questions:

1. Can the multicomponent prevention intervention be well implemented?
2. Do the intermediate measures show progress in facilitating community change in policies, programs, and practices supporting bridging the Word Gap?
3. Are improvements in child- and community-level language impacts demonstrated?
4. Are there moderators of children's language learning?
5. Are there distal population-level impacts on children's school readiness and reading achievement at follow-up?

Theory of Change

The Institute of Medicine's (2003) Framework for Collaborative Public Health Action will guide the proposed research. The framework focuses on enhancing the capacity of multisectoral partnerships to facilitate assessment and planned action with the aim of implementing changes in the community system to support improvements in targeted population-level health and behavioral outcomes (Fawcett et al. 2010). The institute's framework is supported by a variety of conceptual models including Communities that Care (CTC) (Hawkins et al. 2008), PROSPER (Spoth et al. 2007), Getting to Outcomes (Wandersman et al. 2000), Strategic Prevention Framework (Anderson-Carpenter et al. 2016), PRECEDE–PROCEED Model (Green and Kreuter 2005), and the Interactive Systems Framework (Florin et al. 2012). Most of these

approaches support community processes such as assessment, planning, and evaluation as model components to address population outcomes.

Evidence indicates support for the Institute's framework (Collie-Akers et al. 2009, 2013; Watson-Thompson et al. 2008). For example, the framework has supported improvements in targeted behavioral outcomes related to teen pregnancy (Paine-Andrews et al. 2002) and adolescent substance use (Fawcett et al. 1997). Translating the framework to address bridging the Word Gap, we conceptualized a multicomponent prevention intervention set of influences leading to population outcomes (see Fig. 1). Central coordination is designed to occur at the community level through a collaborating partnership described as a Community Leadership Team (CLT) (Fig. 2). The work of the CLT will be guided and supported by community change process that is the Community Tool Box (Holt et al. 2013).

The theory of change behind this framework is ecological, providing multiple interventions at the population, community, and child levels designed to facilitate changes in policies, programs, and practices within and across the settings in which children live, learn, and play (Fawcett et al. 2010, 2013). The theory is responsive to recent developments in prevention science by (a) changing environmental structures that influence an individual's behavior, and (b) using the synergy of multilevel interventions rather than any one intervention in isolation (Biglan, 2016; Biglan et al. 2012; Charlebois et al. 2012). At the heart of this approach is creation of an improved language environment in a child's life by enhancing conversational interactions between parents/caregivers and children both at home, in child care, and out in the community (e.g., church, grocery store).

The primary constructs in the theory of change (from left to right) are: (a) Mobilizing National Action leading to (b) Engaging Local People in Creating Effective Language Environments, leading to (c) Improving Children's Language. Stepping through the framework (left to right), national action is mobilized around Hart and Risley (1995) report of the 30 million Word Gap, leading to calls to action around the country. Calls to action result in community mobilization where local leaders in neighborhoods and communities establish a leadership team with a mission and goal of collaboration in support of new Word Gap influences (see Fig. 1).

Collaborative actions at the community level lead to community changes in existing policies, programs, and practices that can be measured by the Community Check Box (Work Group for Community Health and Development 2016a). Key in community change is the aligned actions of multiple sectors. For example, efforts of a Community Leadership Team (CLT) could be local messaging sponsored by the business sector, early treatment of young children and referral to services by local pediatricians, interventions supported by church leaders, school officials, parent groups, local library programs, local childcare providers, and home visitors, to name a few collaborating partners. These changes support new language intervention services delivered to children's families and child care providers. Empowering adults to talk to their babies is expected to thereby improve the language environment to reduce the Word Gap at home, in child care, and in other community settings as measured. Consequently, based on what we know from the literature, the Word Gap can be reduced for children individually at home, broadly throughout a community, and collectively in the population over time. The results will be greater numbers of children ready for preschool and kindergarten, greater success in school, high school graduation, higher education, and lifelong positive outcomes for individuals, communities, and the nation.

The Multicomponent Prevention Intervention

Population-Level Intervention and Delivery System

We define a population-level intervention as one that has universal scope and the potential for nation-wide reach. Examples include (a) multimedia information campaigns (i.e., billboards, radio, and TV advertising), (b) the Internet to support messaging and information campaigns, and (c) universal childcare programs such as pediatric well-child visits.

Evidence Base

National information campaigns are carried out to warn of health problems and provide therapeutic health information designed to encourage behavioral change. The reach afforded by the media (including the internet) allows organizations to put messages out in the form of news stories via radio and TV reports, as well as online. Information campaigns may contain evidence-based strategies in response to warnings and risk information, strategies for prevention, and approaches to measuring progress, among others.

Two of the most effective examples of information campaigns have been the Surgeon General's program of warnings related to the harm of tobacco (U.S. Department of Health and Human Services 2014) and the CDC's successful Safe-to-Sleep campaign to prevent Sudden Infant Death Syndrome (Eunice Kennedy Shriver National Institute of Child Health and Human Development, n.d.) (see Table 1). Both have produced significant population-level

reductions in deaths from smoking and infant side/stomach sleeping position. Both used media to link specific behaviors with an immediate negative social outcome to reduce problem behaviors in messaging campaigns (Embry 2011).

One can cite numerous newspaper (e.g., Rich 2014, March 25) and magazine articles (e.g., Starr 2002, August 26) discussing the Word Gap. Media and web-based campaigns have targeted the Word Gap, including a coordinated effort from the White House (Shankar 2014) as well as efforts on behalf of many other entities and organizations (Bridging the Word Gap National Research Network, n.d.; Too Small to Fail, n.d.). Books on the subject have also recently emerged (Suskind et al. 2015).

In contrast to information campaigns, child healthcare delivery systems with national scale can provide a platform for a population-level Word Gap intervention (Radesky et al. 2016). Pediatric well-child services are a nearly universal platform by which parents can receive information, support, and interventions concerning bridging the Word Gap. One evidence-based program targeting the Word Gap during pediatric well-child visits is the BELLE/Video Interaction Project (BELLE/VIP) (Mendelsohn et al. 2011). Based on Reach Out and Read, an earlier intervention in pediatric clinics (Reach Out and Read, n.d.), BELLE/VIP teaches parents how to converse with their child.

The BELLE/VIP program is comprised of several evidence-based strategies. For example, families meet one-on-one with a child development specialist who provided an individualized relationship-based intervention focused on positive interactions, verbal engagement, cognitive stimulation, and emergent literacy (see Table 1). The focus is on play and shared reading with role modeling and parent feedback. A video is made of a mother–child interaction by the child development specialist, and then, parents are coached on the day of their primary care visits. Results from a randomized trial reported statistically significant impacts of the intervention on increased parent–child interactions and time engaged in shared-reading activities (Mendelsohn et al. 2011).

Practices to be Used

At the population level, we will use media–Internet campaigns to convey our messaging regarding Word Gap. Fashioned after the smoking cessation and SIDS campaigns, we will craft an aligned information campaign and also join those of existing campaigns of our partners in the Bridging the Word Gap Research Network. We also will disseminate our message directly through the professional organizations of the pediatric health community (Radesky et al. 2016).

Community-Level Intervention and Delivery System

Community-level interventions are multicomponent interventions that generally combine individual and environmental change strategies across multiple settings and sectors to prevent dysfunction and promote well-being among population groups in a defined local community (Wandersman and Florin 2003).

Evidence Base

A number of evidence-based multicomponent community interventions have been reported for mobilizing communities to support actions that improve and sustain a variety of desired community health and prevention outcomes (e.g., Spoth and Greenberg 2011). For community interventions focused on the well-being and development of children and youth, many have addressed adolescent obesity (Cruz et al. 2016; Heath et al. 2012; Hendrie et al. 2012) and adolescent substance abuse prevention (Anderson-Carpenter et al. 2016; Wandersman and Florin 2003) using interrupted time-series designs.

Biglan and Hinds (2009) reported that multicomponent community interventions produced significant improvements in outcomes using RCTs and quasi-experimental designs. These included Project Northland (Perry et al. 2002), Communities Mobilizing for Change on Alcohol (Wagenaar et al. 2000), and Communities that Care (CTC) (Hawkins et al. 2008), and PROSPER (Spoth et al. 2007). At the country level of scale ($N = 18$), the Positive Parenting Program (Triple P) multicomponent community intervention was supported in an RCT (Prinz and Sanders 2007).

There have been effective multicomponent community interventions making improvements in the physical activity and nutrition outcomes of preschool children. For instance, preschool and home-based multicomponent interventions to increase physical activity among minority preschool children were effective in a stratified cluster RCT (Cruz et al. 2016). Also, advancements in what we have learned about multicomponent community intervention have come from school-based research (including preschools) that included a home and/or family component (e.g., Hendrie et al. 2012; Scherr et al. 2014; Silva-Sanigorski et al. 2010). Community partnerships are often based on the known effects of making public commitment by signing up or pledging to engage in specific behaviors (Biglan et al. 2012; Embry and Biglan 2008), for example, on becoming a collaborative partner.

It was concluded that community-level physical activity interventions had a modest to substantial effect on physical activity behaviors based on a review of over 100 studies (Heath et al. 2012). Over 50% of these interventions were

multicomponent interventions across settings. Other sectors wherein the physical activity interventions occurred were the school, workplace, clinical and primary care settings as well as, the broader community (Heath et al. 2012). Common components used in the physical activity intervention studies were media campaigns and information combined with behavior management (e.g., social supports), skill development, and environmental change approaches.

Given these advances, there is still limited knowledge of multicomponent community intervention strategies. Seeking greater knowledge of community interventions addressing childhood obesity, the NIH Healthy Communities Study is currently examining the implementation of community interventions and related health behavior outcomes in 130 communities across the USA (Fawcett et al. 2015). As a part of this national study, community and systems changes (i.e., community policy and program changes) are a key community-level implementation measure.

To date, however, the overall effectiveness of population-level community interventions in both the prevention and public health literature has been mixed (Biglan and Hinds 2009; Hendrie et al. 2012; Roussos and Fawcett 2000; Wandersman and Florin 2003). For example, Roussos and Fawcett (2000) reviewed 34 studies that reported 252 multicomponent partnerships. Anderson et al. (2015) reviewed 58 community coalition/partnership studies. Many of these included scientific partners in combination with evidence-based practices to reduce health disparities. Both reviews reported mixed/equivocal findings even for the most rigorous studies.

Some of the reported methodological weakness in the reviews included the shortness of efforts, typically less than 4 years, and the need for longitudinal studies of sufficient duration (at least 10 or more years) to manifest improvements (Pittman 2010; Roussos and Fawcett 2000). Another was the time required to develop the capacity of multisector community partners and organizations prior to implementing intervention components (Roussos and Fawcett 2000). Additionally, there often are other uncontrolled conditions and factors (i.e., leadership, action planning, and sustainability) that may influence the effectiveness of multicomponent interventions (Pittman 2010; Roussos and Fawcett 2000). Thus, there is a need for additional studies that further examine the implementation of community interventions, as well as identify factors that contribute to differential effects.

Practices to be Used

We propose using Community Leadership Teams (CLTs) made up of individual community members and leaders representing the multiple sectors of interest needed to plan and implement community and system changes in new or modified, policies, programs, and practices. These changes will be identified as a part of the initial planning process. The Community Tool Box (CTB) (Work Group for Community Health and Development 2016b) provides several online tools and supports that will be used to assist the Community Leadership Team plan, implement, and evaluate the multicomponent intervention.

The Community Tool Box (www.ctb.ku.edu) was developed by the Work Group for Community Health and Development at the University of Kansas (a World Health Organization Collaborating Centre') as an online system that provides toolkits to build the individual skills and group capacity needed to facilitate change and improvement in population-level outcomes (Holt et al. 2013; Work Group for Community Health and Development 2016b). The vision behind the Community Tool Box is that people—locally and globally—are better prepared to work together to change conditions that affect their lives. It is currently available in three languages including English, Spanish and Arabic with users in over 230 countries. The KU Workgroup coordinates development and technical supports for the Community Tool Box.

The Community Tool Box has been used to support a variety of community-level public health interventions for building multisector partnerships for population health and health equity (Fawcett and Schultz 2008). In a two-year randomized pre/post-test study, the CTB resources were used to support training and technical assistance intervention with seven prevention coalitions, in which an increase in coalition capacity to support community change was observed (Watson-Thompson et al. 2013). Additionally, the CTB was used to provide training and technical resources for the Latino Health for All Coalition in a low-income area in Kansas City, KS, during a four-year effort to establish community policies, programs, and practices designed to promote improved nutrition and physical activity outcomes (Collie-Akers et al. 2013). The CLT will receive training and technical assistance on the use of the CTB online resources particularly related to community change action planning and multisector partnership development (Fawcett et al. 2010). Additionally, the Community Check Box Evaluation System (CCB), also supported by the Work Group for Community Health and Development, will be used to document and measure the community changes facilitated by the CLT and evaluate the progress of the BWG initiative.

The responsibility of the CLT will be to define its mission and priority goals for bridging the Word Gap, identify its sector members, create the plan with tasks and procedures, arrange for needed trainings, monitor progress, and adapt as needed to reach the goal of implementing the

multilevel intervention. The responsibility of individual sector leaders will be to work within their membership to achieve the sector's contribution to the overall effort of changing policies, programs, and practices to support bridging the Word Gap (see Figs. 1, 2).

Thus, we expect the CLT will use local media to produce messaging and create and reinforce information campaigns that promote knowledge and awareness of the Word Gap in the community (see Fig. 2; Table 1). This is designed to improve parents' and care providers' knowledge of the Word Gap and the importance of talking to their baby. For example, the Talk Read Play™ (TRP) campaign by The Family Conservancy in Kansas City is one such campaign focused on what parents and local organizations can do to bridge the Word Gap (https://www.thefamilyconservancy.org/parenting-resources/talk-read-play; see Table 1).

Similarly, the CLT will engage the pediatric, home visiting, and childcare sectors to adopt and be trained in using evidence-based strategies that help parents learn and use the conversation-based strategies previously discussed to nurture their child's language learning (see Fig. 2). The CLT will engage the philanthropic sector to fund local efforts and sustain them over the long run. The CLT will engage Higher Education/Research partners to assist achieve its goals, monitor short-term progress, and evaluate impact.

Child-Level Interventions and Delivery System

Children living in low-SES families in low-SES communities will be recruited and enrolled in the study. Low SES will be defined by current federal policy guidelines. Families in the study will be those referred from local pediatrician partners and who will be served by a home visitation program partners such as Parents as Teachers and/or Early Head Start. Parents as Teachers (PAT) are home visitation programs typically affiliated with the public schools programs. Early Head Start (EHS) enrolls children and families that meet low-income eligibility requirements, many serve children using a home visitation model.

The child-level interventions are those designed to influence change in each individual child's communication and vocabulary skills as previously discussed. The delivery system here is the parent and adult caregiver in the home and child care/preschool who will be trained to do so.

Adult-Level Education, Training, and Motivation Interventions

(i) *Evidence base*. With respect to teaching adults how to use the new conversational strategies with a child, research evidence supports a combination of brief education, coaching, and performance-based feedback (Embry and Biglan 2008). Strategies are available for coaching parents who are facing risks to interacting with young children to promote their language (Bigelow and Walker 2016; Carta et al. 2013; Suskind et al. 2016). Use of these procedures has been promising in making changes in adults' conversation style (Suskind et al. 2013a, b, 2016; Zhang et al. 2015). Additionally, modeling of the desired conversational behaviors by trainers, coaches, home visitors, or video is an effective component (Embry, 2011), as are performance-contingent feedback and verbal praise (Biglan et al. 2012; Embry and Biglan 2008) (see Table 1). The BELLE/VIP procedures used in pediatric practice previously reviewed included use of video-based coaching and modeling for parents during well-child visits.

(ii) *Practices to be used*. We will employ these strategies to teach local pediatricians, home visitors, childcare providers, parents, and caregivers. They will be provided education, training, and support arranged and sponsored by the CLT and its sector partners. The specific adults to use the evidence-based language-promoting conversation strategies to be taught will include those in the *BELLE/VIP* procedures for pediatric practice and *Promoting Communications (PC-TALK)* for parents and early educators.

Child-Level Interventions

(i) *Evidence base*. The child-level evidence-based interventions will be those supporting the conversational style of following the child's lead and recasting as previously discussed. *PC TALK* is one program containing these strategies with a record of use and testing in childcare settings (Walker and Bigelow 2012; Walker et al. 2008) and in early intervention home-visiting programs (Bigelow and Walker 2016; Buzhardt et al. 2011) (see also http://www.talk.ku.edu/).

(ii) *Practices to be used*. Seven of the evidence-based conversational strategies are contained in the *PC TALK* program and each is designed to contribute uniquely to promoting a child's language learning (see Table 1). Parents, adult relatives and caregivers, and childcare teachers will employ *PC TALK* strategies with the child.

Design

Reported weakness in syntheses of the literature (previously reported) shaped the design choice for the proposed multicomponent prevention intervention study (Roussos and Fawcett 2000). Additional influences on the design include the challenge of finding equivalent communities for randomization to treatment with few good alternatives. Others are the lack of comparative outcomes measured

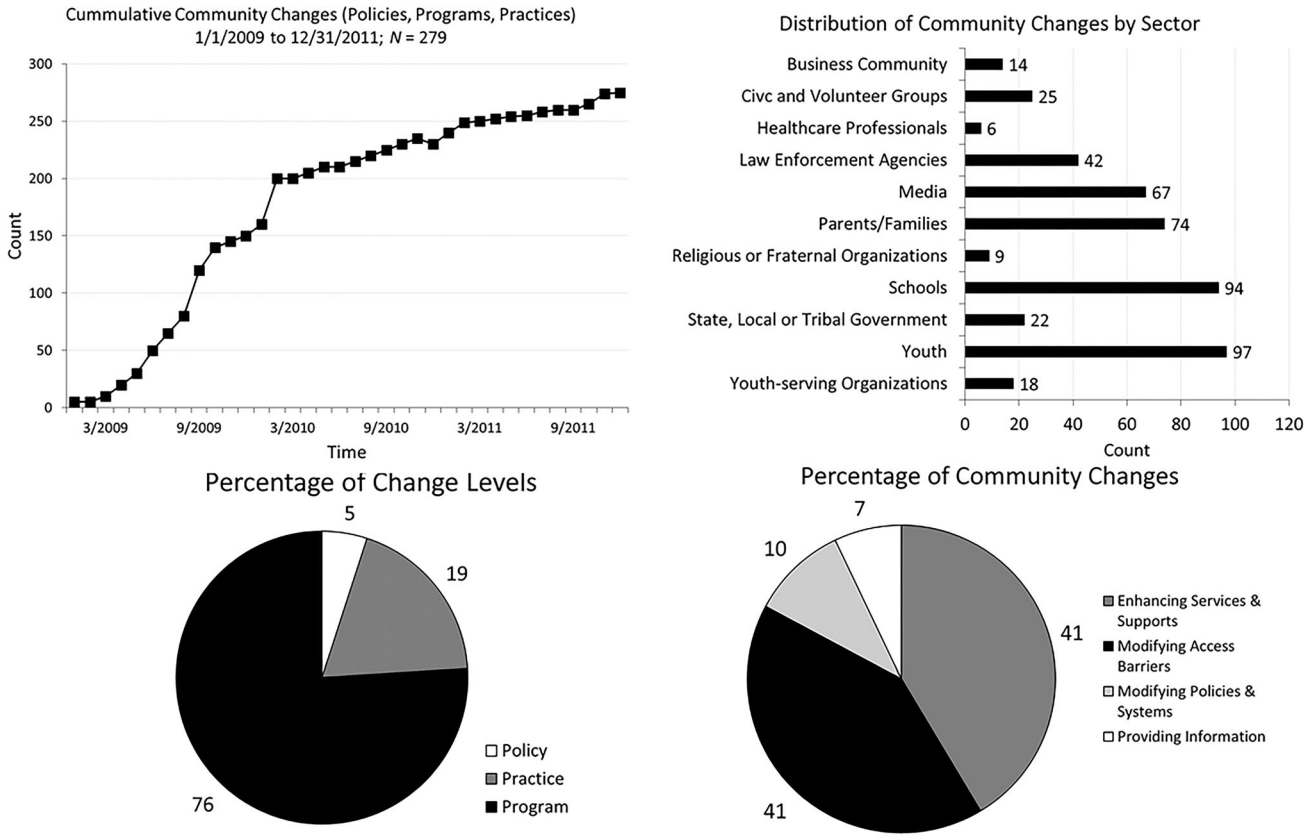

Fig. 3 Illustrative data analytic views from the online Community Check Box

before, during, and following the intervention; failure to empirically test a theory of change; use of evidence-based component practices; and fidelity of intervention needed to support estimating dose–response relationships.

Consequently, to evaluate the effectiveness of the multicomponent BWG prevention intervention, we are proposing a 10-year study duration using a multiple baseline experimental interrupted time-series design approach at the community level. We will use it to test our theory of change. To develop generalizability, we will replicate the study design in 10 geographically diverse, low-SES communities in the USA.

Advantages of the multiple baseline design for this purpose are several (Biglan et al. 2000; Roussos and Fawcett 2000). All consenting communities participate and receive the evidence-based intervention unlike the randomized trial. Measurement before (baseline) and during (treatment), and following along to gauge intermediate effects followed by sustainability and population outcomes over time are available for comparative purposes. Specific options for the design include an interrupted time series with switching replication (with randomization of the time), or equivalent comparison group interrupted time-series design. Moderation effects/hypotheses (i.e., fidelity, dosage, maternal knowledge and vocabulary) can be tested among others using analytics such as multilevel modeling (Little et al. 2000; Snijders and Bosker 2012). Positive findings from this research could then justify investment in a national RCT.

Measurement Needed to Test the Word Gap Prevention Intervention Theory of Change

Given the theory of change and the planned prevention intervention, multiple measures are needed to empirically test the theory of change at multiple levels over time. We discuss the specific measures linked to each research question. The measures will be either developed by the researchers or off-the-shelf purchased assessments and tests.

RQ 1. Can the multicomponent prevention intervention be implemented?

Measures of intervention fidelity A major weakness in past research community partnership/coalition research has been lack of information on the implementation of intervention (Roussos and Fawcett 2000). We propose researcher-developed measures to document the population, community, and child levels of intervention. An allied focus will be at the child level where source and receipt of

these interventions can be used to examine dose–response questions (Roussos and Fawcett 2000).

RQ 2. Do the intermediate measures show progress changing community policies, programs, and practices to bridge the Word Gap?

The intermediate measures provide important feedback to decision makers by monitoring short-term progress at the community and child–family levels over time. These data will be used to inform adults on the progress and to adjust what they are doing when needed to continue and/or improve the rate of progress toward achieving goals and making desired change (Mrazek et al. 2004).

Community-level Progress: The Community Checkbox (CCB) Examining the implementation of community change (defined as policy, program, and practice changes) is a key intermediary measure of how a child's community environment is being modified to support the goals of the Word Gap prevention intervention. The community changes are necessary as precursors to obtaining community- and child-level impacts. The lack of progress monitoring poses a major challenge to achieving successful change (Charlebois et al. 2012; Collie-Akers et al. 2013; Mrazek et al. 2004), where many similar efforts have failed in the absence of data-informed feedback (Roussos and Fawcett 2000). The ability to make corrective decisions at the community level based on cumulative progress promotes the quality of implementation (Collie-Akers et al. 2013).

Using the CCB, we will systematically document what is happening in communities seeking to bridge the Word Gap and what is accomplished over time and across individual community partners (Fawcett and Schultz 2008). The CCB is an online community-level measurement system for recording progress toward goal and objectives related to the attainment of prioritized outcomes (Fawcett and Schultz 2008; Work Group for Community Health and Development 2016a). The community-level data can be used to update goals, plans, revision, and reporting of outcomes over time. Implementation of interventions across socioecological levels can be documented at the child, community, and population levels.

The CCB provides data forms and capabilities to: (a) log or record the occurrence of a reported activity implemented by the CLT or collaborative partners; (b) code the activity as a key type of measure (e.g., community action, community change, service); (c) characterize the activity to understand how the Word Gap initiative is saturating (e.g., activity duration, strategy type) and penetrating the community (e.g., sector, reach); and (d) communicate the work through the use of automated system-generated summary reports and graphs (Work Group for Community Health and Development 2009). The CCB provides automated graphs of the data in a number of useful ways (see Fig. 3) as well as customized reports. For example, one may produce a trajectory of cumulative progress over time (upper left panel), as a distribution of community changes by sector (upper right panel), type of changes made (lower left panel), and kind of nature of the changes implemented (lower right panel).

The reported inter-coder reliability of the CCB has ranged 96% and higher (Collie-Akers et al. 2009, 2013) across individual community-wide change projects. The coding system is currently in use in 125 communities as part of the Healthy Communities Study focused on reducing childhood obesity (Fawcett et al. 2015).

RQ 3. Are the desired child-level and community-level language impacts demonstrated?

Intermediary outcome measures are needed for children as they grow older to indicate whether or not early progress and change has led to new impacts on language and reading during follow-along or follow-up research (Fig. 1), and ultimately whether children and communities are reaching desired population outcome goals (e.g., increased graduation rates, etc.).

Child-level Language ENvironment Analysis (LENA) Only recently has it become possible to provide objective data-based feedback to parents and adult caregivers on the changes they are actually making in talking to their baby. The *LENA* (LENA Research Foundation, n.d.) is a digital system designed to quantify the adult and child talk occurring in the home or child care modeled on the Hart and Risley research. LENA Online™ is a cloud-based system designed to support using LENA data in scaled-up social change projects like we are proposing involving multiple users (parents, home visitors, program Directors, etc.). Providence Talks uses the LENA online system (Providence Talks 2015).

LENA uses a digital recorder to record the talk that the child hears during the day. Speech recognition software analyzes the audio recording producing frequency counts and percentile score benchmarks. LENA's three meaningful talk indicators are: Adult Word Count, Conversational Turns, and Child Word Count. *Adult word count* (AWC) is an estimate of the number of clear adult words spoken near the child wearing the LENA recorder, estimated nominally to occur within a 10-foot radius. Proximity is important to AWC because of the greater likelihood of communication between the dyad occurring. The *child vocalization count* (CVC) reflects the number of expressive, speech-related vocalizations produced by the child as identified by the automated system. *Conversational turn* (CT) counts are the number of alternations between clear adult and key child vocalizations. A conversation is defined as a sequence of vocalizations bounded by at least 5 s of non-vocal material, based on rules suggested by Hart and Risley (1995). Eight

other categories also are automatically identified: female versus male adult, child wearing the recorder versus other children, overlapping human speech, TV, noise, and silence.

These outcomes are primarily intended to track the progress of adults seeking to use the conversational parenting style, as described above. An example of a single-page sample LENA Feedback Report to a parent is shown in Fig. 4. This can be presented as feedback, discussed with the parent by a home visitor or printed online by the parent, or automatically delivered to the parent via a text message in LENA Online™. Entire day LENA scores for AWC, CT, and TV/Electronic sound are presented on the left and hourly data on the right side of the chart. Stars on the charted bars are earned when parents reach goals for words, turns, or shared book reading.

The reported accuracy of LENA's automated detection in terms of agreement with human identification is 82, 76, 71, and 76% for adult, child, TV, and other speech (Xu et al. 2008a, b, 2009). The automatic Child Word Count (CWC) is highly, positively correlated with a child's chronological age, and with expressive language scores on standardized, norm-referenced language measures (Richards et al. 2008). Yoder et al. (2013) reported that a single day-long recording was able produce a stable estimate for a measure of vocal development highly related to a measure of expressive spoken language.

Community-Level LENA

Another indicator of community-level change is available. The LENA online data management system has the ability to capture and display data aggregating up from the individual dyad, to home visitor caseloads, to all participating families in the community (Providence Talks 2015). Data can be aggregated to provide actionable feedback to project directors, researchers, program managers, home visitors, and parent coaches.

Early Communication Indicator (ECI)

The ECI (Greenwood et al. 2010; Walker et al. 2008) is a 6-min observational measure of a child's growth in

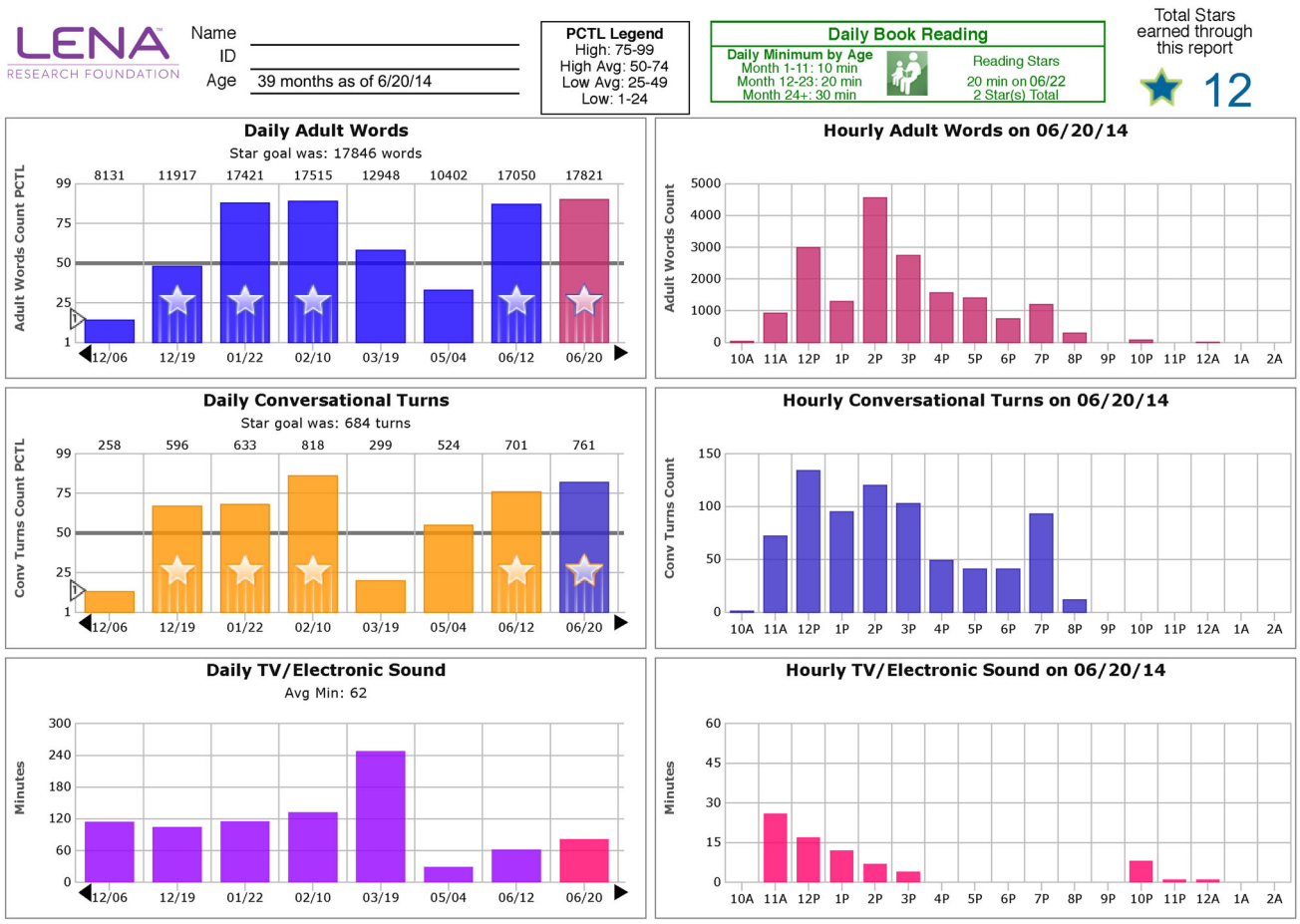

Fig. 4 LENA's individual family progress report

communication (i.e., gestures, vocalization, single words, and multiple words) with a familiar adult during a standard play session for children 6–36 months of age. The ECI is a universal screening and progress monitoring measure with age-based benchmarks (Greenwood et al. 2010, 2011).

The ECI is administered by a familiar adult who acts as a play partner with the child during the session (Walker and Buzhardt 2010). Two standard toy sets are used, the Fisher Price House and Barn™, as the play context for each administration. The House and Barn serve as alternate forms and are used on alternate measurement occasions. The play partner is taught to adopt a play strategy that follows the child's lead, is responsive to the child but is non-directive or overly prompting. The goal is to evoke the child's best communicative performance during the brief session. The child's communicative behavior is recorded either live or from video tape by a certified, reliable coder (i.e., home visitor) as are the frequency of a child's gestures, vocalizations, single words, and multiple words. Each assessment is scored by a trained adult.

The frequency of each skill is entered into a secure online data system for automated scoring and graphing of individual child- and program-level data (www.igdi.ku.edu). ECI scores are calculated as rate per minute where the counts are for four key skills: gestures, vocalization, single words, and multiple words are each divided by the 6-min duration. A total communication score is also calculated based on a composite of the counts for these four skills where single word counts are weighted by 2 and multiple word counts are weighted by 3. Gestures and vocalizations are not weighted. The weighted total composite score is also divided by 6 min converting it to rate per minute.

An inter-observer agreement index of .90, test–retest reliability of .89 for mean level, .62 for slope, alternate forms reliability of .72, and criterion validity of $r = .62$ referenced to the *Preschool Language Scale* (Zimmerman et al. 1992) are the psychometrics reported for the ECI. The construct validity of the ECI's continuum of key skills trajectories over time was established in a large sample of low-SES children (Greenwood et al. 2013b). The equivalence (invariance) of the ECI's measurement properties was demonstrated in two time-displaced samples of ECI data collected by practitioners (Greenwood et al. 2013a).

Developmental Snapshot

The Developmental Snapshot is an online measure of a child's expressive communication that is completed by the child's parent (Gilkerson et al. 2016). The Snapshot is a monthly progress monitoring tool that enables parents to better recognize language milestones and offer professionals prompt information to fine-tune intervention strategies. Initial items were piloted by 15 families; refinement and further development of the instrument was conducted with parents of 308 typically developing children. Reliability and criterion validity metrics were examined on subsets of approximately 60 children who completed the Snapshot on a monthly basis and were evaluated on standardized assessments. Divergent validity was also examined for samples of children diagnosed with language delays related to ASD ($n = 77$) or not ($n = 49$). Results supported the criterion validity ($r = .67$–$.97$) and test–retest reliability claims of the Snapshot ($r = .95$). Sensitivity and specificity for language delay detection were good at 87%.

Preschool Language Scale (PLS)

The PLS (Zimmerman et al. 2012) is a widely used standardized measure of a child for children ages birth through 6 years. Norms are based on a nationally representative sample of 1500 children, including children with disabilities and ethnic minorities. A Spanish version of the test is available. Test–retest reliabilities are in the .90 range, and the inter-rater reliability correlation was .95. The validity of this version 5 was established using the *Preschool Language Scale* (Zimmerman et al. 2002) and the *Denver Development Screening Test* (Frankenburg and Dodds 1990).

RQ 4. Are there moderators of children's language learning?

In addition to detecting primary effects of the intervention prevention, we intend to address questions of moderation. Of particular interest will be the moderating effects of maternal knowledge/beliefs about children development and talking to one's baby. Additional maternal impacts of attained education level, and vocabulary are of interest. Lastly, we intend to examine the dose–response relationship between fidelity and children's language development.

Maternal Education Level, Family SES, and Maternal Vocabulary

We will develop an online survey to assess family SES and ethnic status based on the literature and past research. Maternal and paternal education levels will be assessed in addition to family income. We will use the most recent US census categories for assessing race/ethnicity. To assess maternal vocabulary, we will use one of the existing web-based vocabulary size estimating tools following a review and analysis of their psychometric properties.

Parent Knowledge/Belief

Data on parent beliefs and behaviors will provide information on the extent to which national and local messaging is penetrating the population about the Word Gap and the knowledge that talking to one's baby is important. Several annual national health surveys on parent beliefs and behaviors exist including the Behavioral Risk Factors Surveillance System (Centers for Disease Control and Prevention) and the National Health Interview Survey (Centers for Disease Control and Prevention, n.d.-b). However, none include information related to bridging the Word Gap. Thus, we intend to develop our own online survey regarding the importance of talking, reading, and playing with one's child as well as "following the child's lead," and recasting strategies to build language complexity could provide needed information.

RQ 5. Are there distal population-level impacts on children's school readiness and reading achievement at follow-up?

Because a public health approach is concerned with the outcomes of entire populations, indicators of population-level impact are needed to evaluate the ultimate success of prevention interventions (Mrazek et al. 2004). Because our community focus is linked to elementary schools and local school districts, we will tap data on school readiness and reading achievement.

School Readiness/Reading Achievement

There is broad agreement on the language and early literacy skills acquired in early childhood (Shanahan and Lonigan 2008; Spencer et al. 2013). However, universally agreed upon measures or assessment systems are not in place at the national level. Reading achievement is tracked nationally in the National Assessment of Educational Progress (NAEP) (National Center for Educational Statistics, n.d.), but this does not include early childhood outcomes. Early childhood achievement is reflected in the National Household Education Surveys Program (NHES) (National Center of Educational Statistics, n.d.). Estimates are that about half the states have measures of school readiness (Garber et al. 2007).

A number of language and early literacy measures with large, national databases exist that can be used. The measures are supported by online websites and are administered by teachers, early educators, and home visitors. For grades K-3, the Dynamic Indicators of Basic Early Literacy Skills (*DIBELS*) assessment provides information on indicators of vocabulary, phonemic awareness, alphabetic principle, accuracy and fluency with connected text, and reading comprehension (Good et al. 2010). *My IGDIs* (Individual Growth and Development Indicators) are similar measures of language (vocabulary) and early literacy (phonological awareness) skills for pre-schoolers, children ages 3–5 (McConnell et al. 2014). We will also utilize schools' archival reading achievement data.

Census-Based Social Change Indicators

Socioeconomic indicators represent the most distal of community- and population-level outcomes. We intend to use US census information (i.e., graduation rates, income, and health) that are associated with bridging the Word Gap (Mrazek et al. 2004).

Discussion

The purpose of this paper was to propose a population-based, multicomponent prevention intervention approach to research addressing the harmful effects of the Word Gap. The problem we face is a disparity in vocabulary learning that is associated with comparatively less language input provided by low-SES parents/adults. The evidence behind the disparity is strong and growing, and the evidence demonstrating that positive effects can be made by changes in adults' conversational style is compelling. Recent developments in evidence-based practices have provided new language-promoting strategies and program intervention strategies. Advances in tools for measuring progress in community-level collaborative action and in child/adult language environments supported by Internet and computer technology are available for conducting rigorous research at scale. The cumulative impact of recent national Word Gap messaging has piqued the interest of many, such that a window of opportunity is open for developing a program of research to prevent the Word Gap.

We have proposed a public health approach using and evaluating the effects of a multicomponent prevention intervention for population impact. Interventions addressing the Word Gap were selected based on moderate to strong evidence of effectiveness from each level (i.e., population, community, and child). The desired outcome is population-level prevention of the Word Gap in low-SES children and families, through the onset of new policies, programs and practices known to change the prevailing social determinants of the Word Gap. Our goal is to do a vastly better job at scale of teaching and motivating adults to adopt a conversational parenting style, one that follows a child's interests and recasts conversation, thereby accelerating child vocabulary development. While no research has yet examined effects of the proposed interventions at all levels, study of the strategies as proposed will provide needed new knowledge and advance prevention research overall.

Strengths of the proposed research are many. The research takes advantage of current knowledge of the Word Gap and uses evidence-based interventions at the child level to bridge the gap. The research extends our knowledge of prevention by scaling up combinations of interventions and examining the combined effects across multiple levels, including the individual and community levels. We propose to experimentally test of our multicomponent theory of change as well as examine moderation hypotheses also overcoming past weaknesses. Because prevention effects require significant time to manifest (Roussos and Fawcett 2000), our plans address demonstrating the short-term child–family outcomes needed to produce long-term community- and population-level outcomes. Plans include population-level measures to evaluate the ultimate success of the approach. We are leveraging internet and computer technology to support widespread use of new interventions and progress monitoring measurement. Doing so supports use of novel data that can be used to improve implementation of interventions, and add to a developing digital data infrastructure for future research.

A weakness in the proposed research can be noted. While the face validity behind all the strategies in the multilevel package is strong, evidence of effectiveness varies. Case in point, syntheses of community coalition/partnerships models have reported mixed, weak, and equivocal findings (Anderson et al. 2015; Roussos and Fawcett 2000). Consequently, our plan seeks to overcome many of these concerns. For example, using the Community Tool Box coupled with its online progress monitoring measurement has demonstrated promise and scalability (Collie-Akers et al. 2009, 2013). The current work will extend the strength of evidence behind these procedures.

In conclusion, the public health prevention intervention described in this paper is a step toward advancing plans for guiding future research to reduce the Word Gap (Bridging the Word Gap National Research Agenda 2015) where it has yet to be addressed. The prevention intervention is consistent with other successful approaches to health promotion that apply combinations of interventions at each level to address social determinants. The results envisioned in the multicomponent approach are that parents and others in the community will learn and use the evidence-based conversational talk strategies, so that anywhere a child goes in the community, his or her language is promoted. Positive later life impacts on children's school readiness and success learning to read by third grade are predicted. The prospect of preventing the Word Gap problem impacting millions of children living in poverty is intriguing and made urgent given the current window of opportunity existing among policy makers, community leaders, funders, and early learning professionals. Realization of the promise awaits the outcome of future research and demonstration.

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Compliance with Ethical Standards

Conflict of interest Dr. Walker has an intellectual property interest in PC Talks, the Promoting Communications Intervention described in the paper. Dr. Gilkerson is an employee of the LENA Research Foundation with an interest in the LENA system described in the paper. Dr. Watson-Thompson is a member of the KU Work Group on Community Health and Development, developers of the Community Tool Box and Community Check Box both described in the paper. Dr. Carta is the PI, Drs. Greenwood and Walker are CoPIs of the Bridging the Word Gap Research Network. Drs. Gilkerson and Watson-Thompson are voluntary members of the Bridging the Word Gap Research Network. No other conflicts are noted.

Research Involving Human Participants and/or Animals No human or animal participants were involved in this work.

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