Women's and Children's Health Policy Center
Johns Hopkins University

Strengthen the Evidence for Maternal and Child Health Programs

National Performance Measure 6
Developmental Screening
Evidence Review

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EXECUTIVE SUMMARY

Developmental screening is one of fifteen Maternal and Child Health National Performance Measures (NPMs) for the State Title V Maternal and Child Health (MCH) Services Block Grant program. The goal of NPM 6 is to increase the percentage of children, ages 9 through 35 months, who received developmental screening using a parent-completed screening tool in the past year. The purpose of this evidence review is to identify evidence-based strategies that State Title V programs might consider implementing to address NPM 6.

Thirteen peer-reviewed publications and four gray literature sources met study inclusion criteria and informed the review. These sources described interventions targeting parents, health care providers, health care practices, states, and payers. Systems-level interventions engage diverse stakeholders and may involve public-private partnerships. Examples of each intervention and its evidence rating are shown below.

Target Audience	**Intervention**	**Example(s)**	**Evidence Rating**
Parents	Home Visiting	Routine developmental screening and parent education by home visitors	—
Health Care Providers	Health Care Provider Training Only	Learning module implemented in pediatric practices	—
Health Care Practices	Quality Improvement in Health Care Settings	Statewide learning collaborative for primary care practices	Moderate Evidence
Systems	Systems-level Approaches with Quality Improvement	Statewide learning collaborative for primary care practices with enhanced reimbursement for developmental screening and collaboration with local agencies	Moderate Evidence

— indicates insufficient number of studies to assign evidence rating

Three key findings emerged regarding uptake of parent-reported developmental screens**:**

1. Quality improvement in health care settings appears to be effective.
2. Systems-level approaches with quality improvement interventions appears to be effective.
3. Health care provider training and home visiting programs may be effective; however, further evidence is needed to fully assess.

The evidence review categorized developmental screening interventions along a continuum from *Evidence Against* (least favorable) to *Scientifically Rigorous* (most favorable). "Quality Improvement in Health Care Settings" and "Systems-level Approaches with Quality Improvement" interventions were found to have *Moderate Evidence*. "Home Visiting" and "Health Care Provider Training Only" were not assigned evidence ratings due to the limited number of studies assessing these strategies.

Findings from this review should be considered in the context of multiple national efforts intending to improve the delivery of services crucial to early childhood development. While only two strategies were deemed to have sufficient evidence to be rated on the evidence continuum, both quality improvement and systems-level initiatives with quality improvement support the use of multiple strategies across an array of stakeholders and service sectors. As evaluations of multiple national initiatives continue, it is likely that additional evidence-based strategies to increase developmental screening will emerge. Sustained investment in evaluations of systems-level approaches is essential for expanding the evidence base of strategies to improve developmental screening.

ACKNOWLEDGEMENTS

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INTRODUCTION*

Strengthen the Evidence Base for Maternal and Child Health Programs is a Health Resources and Services Administration (HRSA)-funded initiative that aims to support states in their development of strategies to promote the health and well-being of maternal and child health (MCH) populations in the United States. This initiative, carried out through a partnership among Johns Hopkins Women's and Children's Health Policy Center, the Association of Maternal and Child Health Programs, and Welch Library at Johns Hopkins, was undertaken to facilitate implementation of the transformed Title V MCH Services Block Grant Program.

One goal of the Strengthen the Evidence project is to conduct reviews that provide evidence of the effectiveness of possible strategies to address the National Performance Measures (NPMs) selected for the 5-year cycle of the Title V MCH Services Block Grant Program, beginning in fiscal year 2016. States are charged to select eight NPMs and incorporate evidence-based or evidence-informed strategies to achieve improvement for each NPM selected.

BACKGROUND

Developmental screening is one of the fifteen maternal and child health (MCH) National Performance Measures (NPMs). Forty-one states and jurisdictions selected NPM 6 Developmental Screening. These states and jurisdictions include Alaska, Alabama, American Samoa, Arizona, California, Colorado, Connecticut, District of Columbia, Delaware, Federated States of Micronesia, Georgia, Hawaii, Iowa, Illinois, Kansas, Louisiana, Maryland, Maine, Marshall Islands, Michigan, Minnesota, Missouri, Northern Mariana Islands, Mississippi, North Carolina, New Hampshire, New Jersey, New Mexico, Nevada, New York, Ohio, South Carolina,

* The language used in the Introduction section was crafted by the Strengthen the Evidence team and is consistent across all evidence reviews within this project

South Dakota, Tennessee, Texas, Utah, Virgin Islands, Vermont, Washington, Wisconsin, and Wyoming.[1] The goal of NPM 6 is to increase the percentage of children ages 9 through 35 months who received a developmental screening using a parent-completed screening tool in the past year.[2]

According to the 2016 National Survey of Children's Health (NSCH), only 30.4% of children ages 9 through 35 months received a parent-completed standardized developmental screening.[3] Percentages for developmental screening varied considerably across states (ranging from 17.2% in Mississippi to 58.8% in Oregon).[4] Furthermore, receipt of developmental screening varied by child's race/ethnicity, household income, and parental education. Among white, non-Hispanic children, 34.4% of parents completed a developmental screening compared to 24.8% of parents of black, non-Hispanic children and 18.4% of parents of Asian, non-Hispanic children. Children growing up in poverty also were less likely to have parents who completed developmental screens (23.6% for children living in households earning less than 100% of the federal poverty level (FPL) vs 35% of children in households with incomes of greater than or equal to 400% FPL). Children living in households with adults with higher education were also more likely to receive screening (37.7% of children in households with adult with college degree or higher vs 16% of children in households with all adults with less than high school education).[3]

Delayed or disordered development may indicate an increased risk of developmental or behavioral disorders or another medical condition.[5] The National Health Interview Survey reported that nearly 7% of children ages 3-17 in 2016 had ever been diagnosed with a developmental disability.[6] Furthermore, identification and treatment of developmental disorders have been shown to be most effective when occurring during a child's earliest years of life.[7]

Developmental surveillance and screening are essential functions to ensure early identification of developmental disorders in children. The American Academy of Pediatrics (AAP) recommends that developmental surveillance be integrated into each well-child visit.[5] Surveillance, also referred to as developmental monitoring, is an ongoing process by which a healthcare professional observes and documents a child's development while also addressing parental concerns.[8] Health care professionals are expected to follow up any observed problems with developmental screening. Developmental screening uses a standardized tool to help identify whether a child is at risk of developmental problems. This screening often occurs at well-child visits, but can also take place in other health care, community, or early care and education/school settings. The AAP recommends that all children receive a general developmental screen at the 9, 18, and 30 (or 24) month well-child visit.[5] In addition, children should be screened for autism spectrum disorder at the 18 and 24 month well-child visit.[9] Various guidelines and standards provide support for this NPM, including: *Bright Futures Guidelines for Health Supervision*,[10] led by the AAP and supported, in part, by HRSA/MCHB; *Standards for Systems of Care for Children and Youth with Special Health Care Needs,*[11] produced by the Association of Maternal and Child Health Programs (AMCHP) and supported by the Lucile Packard Foundation for Children's Health; and the *National Health and Safety Performance Standards: Guidelines for Early Care and Education Programs,* produced by the AAP, the American Public Health Association, and the National Resource Center for Health and Safety in Child Care and Early Education and supported by HRSA/MCHB.[12]

There are several compilations of state strategies and federal initiatives to support developmental screening. A 2017 compilation prepared by AMCHP and the National Insitute for Children's Health Quality (NICHQ)[13] identified five main categories of state efforts: policy

research, development and implementation; data collection, measurement and existing landscape; technical assistance and training; and education, engagement and resource development. Additionally, a 2014 publication by the Center for Law and Social Policy[14] highlighted the role of both privately and federally funded national initiatives, in addition to state child care policies, in expanding access to developmental screening. Head Start programs, for example, require developmental screening for all children within 45 days of entry and also require that enrolled children receive preventive health care.[15]

A prior systematic review assessed the evidence of health care practice-based interventions to improve screening.[16] The review focused on primary care interventions to increase the quality and uptake of recommended screenings for children, one of which was developmental screening. To our knowledge, the current review is the first to assess interventions to increase developmental screening across an array of early childhood settings.

METHODS

Studies were identified for review by searching through the PubMed, Cochrane Library, and CINAHL Plus databases. Search strategies varied depending on the database due to differences in controlled vocabulary, indexing, and syntax. Table 1 provides detailed search strategies used for each database. There were five concepts that informed search strategies in each database: child/infant, development, screening/intervention, evaluation, and screener/tools. A library specialist (informationist) at Welch Medical Library informed the selection of databases and ensured the adequacy of the search strategies. Dates of publication were restricted to January 1, 1994 through January 30, 2017. The following inclusion criteria for peer-reviewed literature were used:

1. The study was empirical and assessed interventions aimed at increasing uptake of

developmental screening in a wide range of settings.

2. The study described interventions that fall within the scope of Title V.
3. The study's intervention components and results were clearly described.
4. The study included:
    a. A control and intervention group design, a pretest-posttest design or a quality improvement design (with baseline and follow up assessments) to assess intervention effectiveness. Control groups were limited to those with no intervention, standard of care, or an intervention unrelated to the outcome (e.g. diabetes education).
    b. Screening tools, which are either well-established instruments or instruments for which the authors provide reliability and validity data.
    c. Screenings completed by health care providers, paraprofessionals and/or parents.
5. The study was conducted in the United States or in another high-resource country that is a member of the Organization for Economic Cooperation and Development
6. The study was published between 01/01/1994 and 1/30/2017.
7. The study was published in English.
8. The study sample included children between the ages of 9 through 35 months.[†] Initial searches included children up to age 10 years.
9. The study was published in a peer-reviewed journal.

[†] Age range reflects revised measure in the Appendix of Supporting Documents for the eighth edition of the Title V MCH Services Block Grant to States Program: Guidance and Forms for the Title V Application/Annual Report for fiscal year 2019-2021

Duplicate articles were removed before beginning title screening. Each title was reviewed and if it appeared related to developmental screening, the abstract was then screened. The full text was reviewed for articles for which information in the abstract indicated that the study initially met the inclusion criteria or when the abstract was unavailable. All articles remaining after title and abstract screening were retrieved for detailed full-text review to assess their eligibility for inclusion in the review. Furthermore, reference lists of relevant previously published review articles were reviewed to identify potential articles to be included in the review.[16-19]

In addition to peer-reviewed literature, four gray literature sources informed the review: 1) *Improving Health Outcomes for Children (IHOC) First STEPS Phase II Initiative: Improving Developmental, Autism, and Lead Screening for Children Final Evaluation Report,*[20] published in 2013 by the University of Southern Maine Muskie School of Public Service as part of a CHIPRA Quality Demonstration; 2) *Final Report: Developmental & Autism Screening in Primary Care,*[21] released in 2012 by the Vermont Child Health Improvement Program (VCHIP); 3) a 2016 Home Visiting Collaborative Improvement and Innovation network (HV CoIIN) webinar [22] and supplemental 2015 article by Mackrain et al.[23]; and 4) *CHIPRA Mandated Evaluation of the Children's Health Insurance Program: Final Findings*, released in 2014 by Mathematica Policy Research (Mathematica) and the Urban Institute.[24] Data for sample size and study results were obtained with permission from a 2013 memo sent by Mathematica to the Office of the Assistant Secretary for Planning and Evaluation.[25]

The authors (EB, SG) extracted data pertaining to the study characteristics (setting, sample, and design); intervention (components, implementation, data collection); data sources and outcome measures for evaluating developmental screening; and results. The study team met

regularly to review interim extractions and resolve items in question**.** Interventions were characterized by target audience: Studies were categorized into four groups based on their primary intervention: "Home Visiting," "Health Care Provider Training Only," "Quality Improvement in Health Care Settings," "Systems-level Approaches with Quality Improvement," and "Other".

An evidence continuum was created to assess evidence-informed strategies, along with criteria for each category along the continuum. The Robert Wood Johnson Foundation's What Works for Health evidence ratings were adapted to create an evidence continuum tailored toward the Strengthen the Evidence project.[26] The evidence rating categories include: Evidence Against, Mixed Evidence, Emerging Evidence, Expert Opinion, Moderate Evidence, and Scientifically Rigorous. Strategies that are characterized by Emerging Evidence or more favorable ratings are considered evidence-informed. Table 2 shows the detailed evidence rating criteria for both study types and study results for each rating.

Interventions identified through assessment of both peer-reviewed and gray literature were placed along the evidence continuum. Assignment to the continuum required that interventions or intervention categories be evaluated in four or more peer-reviewed studies or in the gray literature selected for the evidence review. Interventions or intervention categories that were evaluated in three peer-reviewed studies without expert opinion from gray literature were not assigned an evidence rating, nor placed on the evidence continuum. A team of two project members independently assigned ratings to the interventions or intervention categories. The members then compared their assessments and discrepancies were discussed by the full project team until a consensus was reached.

RESULTS

Search Results

Searches in the PubMed, Cochrane Library, and CINAHL Plus databases were performed in February 2017. In total, the systematic search identified 13,963 records (Figure 1). The search in PubMed, Cochrane Library, and CINAHL Plus yielded 8451, 852, and 4660 records respectively. A total of 51 records were also identified from searching through previously published review articles[16-19] prior to duplicate removal.

Title and abstract screening was conducted for 10,850 records after 3,164 duplicates were removed from the total 14,014 records. During title and abstract review, 10,790 were excluded due to failure to meet inclusion criteria. The most common reason for not meeting the inclusion criteria was that studies were not relevant to the purpose of this review. Full-text articles were assessed for eligibility for 60 records, and 47 were excluded due to failure to meet all inclusion criteria. Major reasons for excluding studies included: not evaluations of interventions; did not measure the outcome of interest; did not include an appropriate comparison group; and did not describe results clearly. A total of 17 sources were included in this review after combining 13 peer-reviewed studies with four sources of gray literature. Figure 1 displays the flow chart for the study selection process.

Characteristics of Studies Reviewed

The 17 sources (13 peer-reviewed and 4 gray literature) included in this review varied by study setting and design, intervention type, and data source. The detailed characteristics of the studies are reported in Table 3. Twelve of the 17 studies were quasi-experimental studies (QE) (8 pretest-posttest design[20,21,27-32]; 2 pretest-posttest non-equivalent control group[33,34]; 1 non-equivalent control group[24]; and 1 interrupted time-series design[35]); 2 were randomized controlled trial (RCT) designs[36,37]; 1 had a quality improvement time series design[23]; 1 was an observational

pretest-posttest design[38]; and 1 study incorporated both RCT and QE pretest-posttest non-equivalent control group designs.[39]

While all 17 studies took place within the United States, the locations of each study differed. Some studies involved single practices,[28,32] while others involved multiple sites within a single state,[20,21,27,29,31,33,36-38] and some were implemented in multiple states.[23,24,30,34,35,39] While all studies assessed receipt of a developmental screening as an outcome, they differed in the type of screening tool used, the age at which the developmental screening took place, and other characteristics. Most studies used the child's medical record as the primary data source,[20,21,27-30,32-36,39] but additional sources included the Promoting Healthy Development Survey,[21] telephone surveys with parents,[24,37] Medicaid data,[20,33,38] and local team data registries.[23] Table 4 outlines data sources and outcome measures for each study.

Intervention Components

Table 5 describes the intervention implemented in each study. Most of the included studies do not incorporate an external comparison group due to the nature of the intervention and study design.[20,21,23,27-32,35,38]

Table 6 identifies the components of the intervention for each study, grouped by intervention categorization. "Home Visiting," "Health Care Provider Training Only," "Quality Improvement in Health Care Settings," "Systems-level Approaches with Quality Improvement," and "Other" encompassed 2, 3, 4, 4, and 4 studies, respectively.

Studies implementing "Home Visiting" evaluated the impact of evidence-based home visiting on outcomes related to child development and family well-being.[23,37] One study used quality improvement to promote shared learning and measure progress across multiple home

visiting sites.[23] The other study assessed the effects of a home visiting program focused on parent education, individualized family issues, and healthy child development.[37]

Studies categorized as "Health Care Provider Training Only" evaluated interventions that provided training to health care providers and practices on child development.[27,28,33] Two studies also provided training on specific screening tools[27,33], one of which conducted chart audits that accounted for a screening tool included in the training curriculum.[33]

Studies were considered "Quality Improvement in Health Care Settings" if they stated a quality improvement model (e.g., Plan-Do-Study-Act cycles) was used and/or included routine auditing/monitoring. Quality Improvement studies all included education on child development, while a majority also included the use of resource toolkits and written materials[31,32,35]; email- and phone-based expert support[31,32,34,35]; the creation of quality improvement practice teams[31,34,35]; data collection training for staff at the practice site and chart audits as a part of the intervention[31,34,35]; and subsequent expert feedback using the Plan-Do-Study-Act tool.[31,34] Other quality improvement intervention components included education on screening tools[31,35]; web-based resources[32]; participation incentives[31,35]; screening tool implementation training[32,35]; office systems assessments and implementation training[34]; and collaboration with local agencies.[31]

Studies that described quality improvement initiatives with at least one of the following additional components were determined to be "Systems-level Approaches with Quality Improvement": collaboration with other sectors (e.g., health department, clinician professional organization) [20,21,29,30]; a change in coding or payment with commercial or public insurers[20,21,29]; engagement with payers (e.g., supplemental funds to support care management, enhanced reimbursement for developmental screening)[20,21,29]; or involvement with a broader systems-change initiative (e.g., CHIPRA demonstration grant, improvement partnership).[20,21,29] These

studies mainly took place in a single state, with one study using a national sample of primary care practices.[30] While it is likely that other quality improvement studies had systems-level components, this review was limited to the information described in each article.

Of the four studies classified as "Other", one was a statewide intervention put in place following a court ruling in which providers were educated on child development and given associated resources and data collection training.[38] Another study was an evaluation of the Healthy Steps for Young Children program, an enhancement of primary medical care.[39] The components included well child visits with the physician and child development specialist, home visits, telephone support, developmental assessments, written materials, parent support groups, and referrals to community resources. The third study assessed the effectiveness of a computerized clinical decision support system module that included universal screening, surveillance, reassessment, and recommended physician prompts.[36] The last source in the "Other" category was the 2014 *CHIPRA Mandated Evaluation of the Children's Health Insurance Program: Final Findings,* which evaluated the impact of the Children's Health Insurance Program (CHIP) on access to preventive care and healthcare utilization.[24]

Summary of Study Results

Detailed descriptions of study results are shown in Table 7 and the summarized study findings are presented in Table 8. Both tables present the studies organized by intervention category. Sixteen of the seventeen sources demonstrated favorable findings with regard to the percentages of children for whom developmental screening was reported.

"Quality Improvement in Health Care Settings" interventions appear effective in increasing receipt of developmental screens, as demonstrated by consistently favorable results across studies. All four peer-reviewed studies reported favorable findings. With support from the

gray literature, "Systems-level Approaches with Quality Improvement" initiatives also appear to be effective. The two peer-reviewed studies in this category had favorable results. Furthermore, both gray literature sources reported that systems-level quality improvement initiatives favorably impacted rates of developmental screening. The VCHIP report, *Final Report: Developmental and Autism Screening in Primary Care*, showed an increase in the percentage of children with developmental screens at recommended well-child visits following implementation of a statewide quality improvement program[21] and *Improving Health Outcomes for Children (IHOC) First STEPS Phase II Initiative: Improving Developmental, Autism, and Lead Screening for Children Final Evaluation Report* reported increases in both the average percentage of documented developmental screens and the rate of developmental screening based on state Medicaid claims.[20]

"Health Care Provider Training Only" and "Home Visiting" contained three and two studies respectively. Gray literature from the HV CoIIN demonstrated improvement in the percentage of children screened in participating sites from baseline to follow-up.[22] Due to the limited number of studies focusing on these interventions, conclusions cannot be drawn for either intervention.

Evidence Rating and Evidence Continuum

Evidence rating designations stemmed from the composite of the results of the 17 included studies (Tables 7 and 8). "Health Care Provider Training Only" contained only three peer-reviewed studies, while "Home Visiting" contained two studies. Therefore, they were neither given an evidence rating nor placed on the continuum. Based on the evidence rating criteria (Table 2), *Moderate Evidence* was assigned for "Quality Improvement in Health Care

Settings" and "Systems-level Approaches with Quality Improvement" interventions. Figure 2 shows the evidence-informed interventions with the evidence continuum for NPM 6.

IMPLICATIONS

A majority of the states and jurisdictions in the United States chose the Developmental Screening National Performance Measure as a programmatic focus for the current 5-year cycle of the Title V MCH Services Block Grant initiated in the 2016 fiscal year. The purpose of this review was to identify evidence-based and evidence-informed interventions aimed at increasing the percentage of children, ages 9 through 35 months, who received developmental screening using a parent-completed screening tool.

Based on the evidence in this review, quality improvement in health care settings and systems-level initiatives including quality improvement efforts appear to be effective in increasing the percentage of children who receive developmental screens using a parent-reported screening tool. It was not possible to draw conclusions about home visiting programs and health care provider training due to a minimal number of studies.

The primary strength of this evidence review is that the scope included multiple early childhood settings. However, except for the studies on home visiting, the majority of the literature was conducted in health care settings. An additional strength of this review is the inclusion of gray literature sources[20,21] that provide detailed descriptions of interventions and evaluations. While peer-reviewed manuscripts may not include detailed information due to length restrictions, this information is essential to support replication and scale-up. The evidence review also has several limitations. As seen from the small number of studies that met inclusion criteria (13 peer reviewed and four gray literature sources), the conclusions drawn may be narrow. Among the 17 studies qualifying for the review, only 6 evaluated interventions taking

place in multiple states, thus limiting generalizability across diverse settings. Search results were screened by one reviewer; however, a consistent protocol was followed and issues that emerged throughout the process were discussed with the research team. Comparing and synthesizing studies was also limited due to variations in study setting, sample, and design. Lastly, given that 16 of 17 studies reported favorable results, the limited number of articles or technical reports reporting negative or null findings may reflect publication bias in the literature on interventions to increase developmental screening.

Findings from this review should be considered in the context of multiple national efforts intending to improve the delivery of services crucial to early childhood development. The Commonwealth Fund's Assuring Better Child Development (ABCD) Program, in partnership with the National Academy for State Health Policy, led three learning collaboratives to improve service delivery and financing through Medicaid-led public/private coalitions from 2000 – 2012.[40] Earls & Hay highlighted the success of North Carolina's ABCD program, a statewide quality improvement approach to increase developmental screening and promote changes in Medicaid policy.[29] Other innovations included as part of the ABCD program also focused on systems changes and included enhanced capacity of state Medicaid programs to support children's mental health diagnoses and referral,[41] and improved care coordination between primary care providers and other providers serving children and families (e.g., Early Intervention, mental health, WIC).[42]

An ongoing national initiative, the HRSA/MCHB-funded Early Childhood Comprehensive Systems Collaborative Improvement and Innovation Network (ECCS CoIIN), led by NICHQ, supports 12 state grantee communities in working toward a 25% increase in developmental skills among 3-year-old children.[13] Developmental health promotion including

developmental screening, referral and follow-up is a key driver in this systems work. Grantees identify up to five communities within their states to participate in the ECCS CoIIN, and at least one of the communities also must receive services as part of the Maternal Infant and Early Childhood Home Visiting Program (MIECHV). MIECHV grantees focus on developmental screening as one the performance indicators for the benchmark area of school readiness and achievement.[43] Ongoing state and tribal MIECHV evaluations are likely to yield additional strategies within home visiting to promote developmental screening.

The Pediatric Quality Measures Initiative (PQMP), another ongoing national initiative, is sponsored by the Agency for Healthcare Research and Quality (AHRQ) and the Centers for Medicare and Medicaid (CMS).[44] It has supported the development, implementation and dissemination of pediatric quality measures. In addition to the developmental screening measure included in the 2009 Child Core Set of quality measures, the PQMP is developing an expanded set of measures focused on follow up and referral following developmental screening.[44,45]

Systems efforts as part of the Substance Abuse and Mental Health Services Administration supported initiative Project LAUNCH (Linking Actions for Unmet Needs in Children's Health) also promote use of developmental screening.[46] LAUNCH supports use of developmental screening across an array of settings including child care, primary care, early childhood education, and mental health and substance use programs serving families with young children. Activities implemented by Project LAUNCH grantees include: parent education on developmental milestones and the importance of screening; provider training on screening and assessment using validated tools; systems efforts to support consistent and shared screening information across early childhood providers and systems; and alignment with ongoing initiatives such as Help Me Grow, Birth to 5: Watch Me Thrive, and MIECHV.[46]

In 2016, regulatory changes to the Child Care Development Block Grant, recommended an array of policies to promote developmental screening.[47] These included: engaging families and child care providers to use tools and resources developed as part of Centers for Disease Control and Prevention (CDC)'s Learn the Signs, Act Early initiative and the Race to the Top - Early Learning Challenge; building workforce capacity in child care settings through credentialing and professional development opportunities; and strengthening quality rating improvement systems in child care settings to address developmental screening.

A broad array of strategies intend to support developmental screening within the early childhood system of care. This review finds sufficient literature to identify quality improvement in health care settings and systems-level initiatives with quality improvement as effective in increasing the percentage of children with developmental screening. As evaluations of multiple national initiatives continue, it is likely that additional evidence based strategies will emerge. A commitment to and funding of rigorous evaluations and dissemination of these findings is essential to growing the evidence base of strategies to support continued improvements of this NPM.

FIGURES AND TABLES

Figure 1. Flow Chart of the Review Process and Results

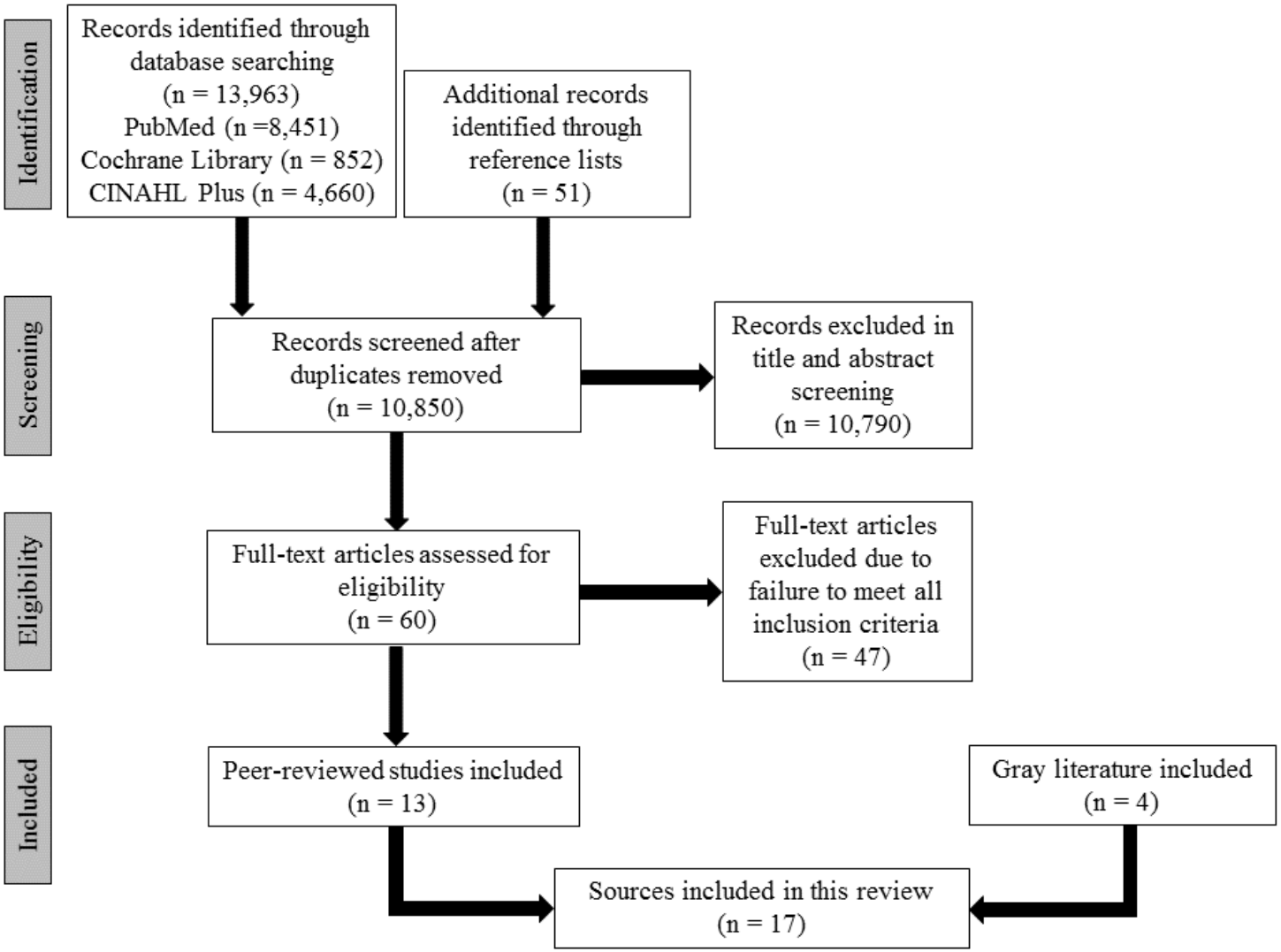

Figure 2. Evidence Continuum

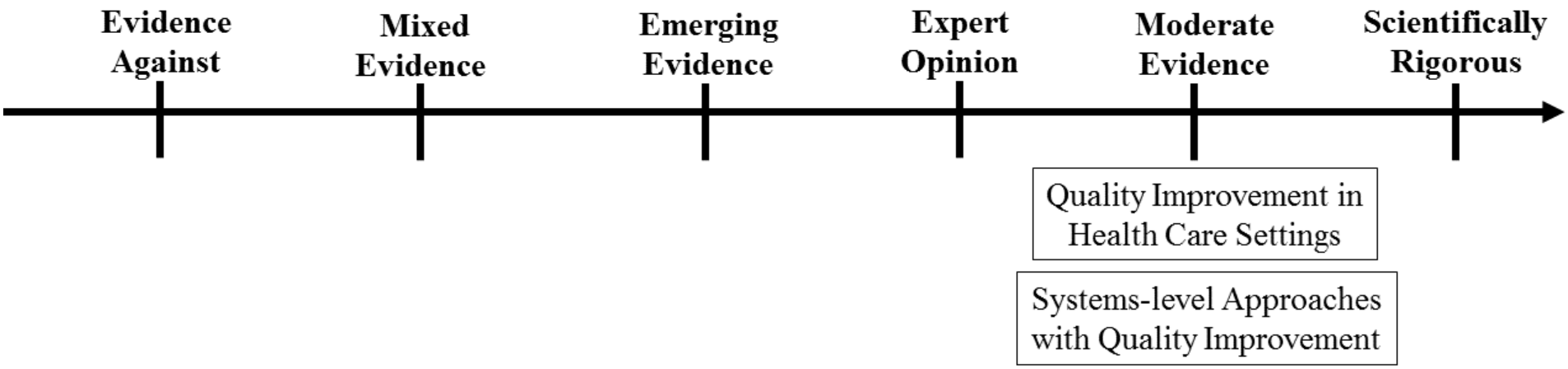

Table 1. Detailed Search Strategies.

Database		Search Strategies
PubMed	#1	"Infant"[mesh] OR infant*[tw] OR infanc*[tw] OR "baby"[tw] OR "babies"[tw] OR "child"[mesh] OR child*[tw] OR toddler*[tw] OR "Pediatrics"[Mesh] OR pediatric*[tw] OR preschool*[tw] OR pre school*[tw] OR "under 5"[tw] OR under five*[tw] OR "less than five"[tw]
	#2	"Child Development"[Mesh] OR "Developmental Disabilities"[Mesh] OR "Child Behavior"[Mesh] OR "Child Behavior Disorders"[Mesh] OR "Child Development Disorders, Pervasive"[Mesh] OR Child development*[tw] OR child's development[tw] OR children's development[tw] OR Developmental Disabilit*[tw] OR Development Disorder*[tw] OR Developmental Delay*[tw] OR Development Deviation*[tw] OR developmental*[tw] OR autism[tw] OR autistic[tw] OR social development*[tw] OR emotional development*[tw] OR physical development*[tw] OR cognitive development*[tw] OR language development*[tw]
	#3	"Mass Screening"[Mesh] OR "Preventive Health Services"[Mesh:NoExp] OR "Early Medical Intervention"[Mesh] OR screening*[tw] OR preventive[tw] OR referral*[tw] OR consultation*[tw] OR intervention*[tw] OR "early prevention"[tw] OR prevention[tiab]
	#4	"Program Evaluation"[Mesh] OR "Quality of Health Care"[Mesh:NoExp] OR "Quality Improvement"[Mesh] OR "Quality Assurance, Health Care"[Mesh:NoExp] OR "Utilization Review"[Mesh] OR "Evaluation Studies as Topic"[Mesh] OR "Evaluation Studies" [Publication Type] OR "Evidence-Based Medicine"[Mesh] OR "Guideline Adherence"[Mesh] OR "Guidelines as Topic"[Mesh] OR "Surveys and Questionnaires"[Mesh:NoExp] OR evaluat*[tw] OR evidence based[tw] OR assessment*[tw] OR effectiveness[tw] OR campaign*[tw] OR strateg*[tw]
	#5	"Family"[Mesh] OR family[tw] OR families[tw] OR parent*[tw] OR father* OR mother* OR caregiver* OR care giver*[tw] OR "Practice Patterns, Physicians"'[Mesh] OR "Physicians, Primary Care"[Mesh] OR "Pediatricians"[Mesh] OR "Physicians, Family"[Mesh] OR "Primary Health Care"[Mesh] OR "well child"[tw] OR well visit*[tw] OR Physician*[tiab] OR "Child Health Services"[Mesh:NoExp]
	#6	#1 AND #2 AND #3 AND #4 AND #5
	#7	(animals[mh] NOT humans[mh])
	#8	#6 NOT #7
Cochrane Library	#1	MeSH descriptor: [Child] explode all trees
	#2	MeSH descriptor: [Infant] explode all trees
	#3	(pediatric*) OR (preschool*) OR (pre NEXT school*) OR ("under NEXT 5") OR ("less NEXT than NEXT five") OR (child*) OR (toddler) OR (infant*) OR (infanc*) OR (baby) OR (babies)
	#4	#1 OR #2 OR #3
	#5	MeSH descriptor: [Child Development] explode all trees
	#6	MeSH descriptor: [Developmental Disabilities] explode all trees
	#7	MeSH descriptor: [Child Behavior] explode all trees
	#8	MeSH descriptor: [Child Behavior Disorders] explode all trees
	#9	MeSH descriptor: [Child Development Disorders, Pervasive] explode all trees
	#10	(development NEXT disorder*) OR (developmental NEXT delay*) OR (development NEXT deviation*) OR developmental*OR autism OR autistic OR (social NEXT development*) OR (emotional NEXT development*) OR (physical NEXT development*) OR (cognitive

		NEXT development*) OR (language NEXT development*) OR (child NEXT development*) OR (child's NEXT development) OR (children's NEXT development) OR (developmental NEXT disabilit*)
	#11	or #5-#10
	#12	MeSH descriptor: [Mass Screening] explode all trees
	#13	MeSH descriptor: [Preventive Health Services] this term only
	#14	MeSH descriptor: [Early Medical Intervention] explode all trees
	#15	screening* or preventive or referral* or consultation* or intervention* or (early next prevention*) or prevention
	#16	#12 or #13 or #14 or #15
	#17	MeSH descriptor: [Program Evaluation] explode all trees
	#18	MeSH descriptor: [Quality of Health Care] this term only
	#19	MeSH descriptor: [Quality Improvement] explode all trees
	#20	MeSH descriptor: [Quality Assurance, Health Care] this term only
	#21	MeSH descriptor: [Utilization Review] explode all trees
	#22	MeSH descriptor: [Evaluation Studies as Topic] explode all trees
	#23	MeSH descriptor: [Evaluation Studies] explode all trees
	#24	MeSH descriptor: [Evidence-Based Medicine] explode all trees
	#25	MeSH descriptor: [Guideline Adherence] explode all trees
	#26	MeSH descriptor: [Guidelines as Topic] explode all trees
	#27	MeSH descriptor: [Surveys and Questionnaires] this term only
	#28	evaluat* or (evidence next based) or assessment* or effectiveness or campaign* or strateg*
	#29	or #17-#28
	#30	MeSH descriptor: [Family] explode all trees
	#31	MeSH descriptor: [Practice Patterns, Physicians'] explode all trees
	#32	MeSH descriptor: [Physicians, Primary Care] explode all trees
	#33	MeSH descriptor: [Physicians, Family] explode all trees
	#34	MeSH descriptor: [Primary Health Care] explode all trees
	#35	MeSH descriptor: [Child Health Services] this term only
	#36	(well next child) or (well next visit*) or Physician*
	#37	or #30-#36
	#38	#4 and #11 and #16 and #29 and #37
	#39	#38 Publication Year from 1994
CINAHL Plus	S1	(MH "Infant+") OR (MH "Child+") OR (MH "Child, Preschool") OR (MH "Pediatrics") OR infant* OR infanc* OR baby OR babies OR child* OR toddler* OR pediatric* OR preschool* OR (“pre school*”) OR ("under 5") OR “under five*” OR "less than five" OR (ZG "child, preschool: 2-5 years") OR (ZG "infant: 1-23 months")
	S2	(MH "Child Behavior") OR (MH "Child Behavior Disorders") OR (MH "Child Development Disorders, Pervasive") OR (MH "Child Development") OR "emotional development" OR “social development” OR “cognitive development” OR “physical development” OR “language development” OR “developmental delay” OR (MH "Developmental Disabilities") OR “Child development*”OR “child's

		development” OR “children's development” OR “Developmental Disabilit*” OR “Development Disorder*” OR “Developmental Delay*” OR “Development Deviation*” OR developmental* OR autism OR autistic
	S3	(MH "Mass Screening") OR (MH "Preventive Health Care") OR (MH "Early Medical Intervention") OR referral* OR consultation* OR screening* OR intervention* OR preventive* OR TI(prevention) OR AB(prevention) OR “early prevention”
	S4	(MH "Program Evaluation") OR (MH "Quality of Health Care") OR (MH "Quality Improvement") OR (MH "Quality Assurance") OR (MH "Evaluation Research") OR (MH "Utilization Review") OR (MH "Medical Practice, Evidence-Based") OR (MH "Guideline Adherence") OR strateg* OR campaign* OR (MH "Surveys") OR (MH "Questionnaires”) OR evaluat* OR “evidence based” OR assessment* OR effectiveness
	S5	family OR families OR parent* OR father* OR mother* OR caregiver* OR “care giver*” OR "well child" OR “well visit*” OR TI(Physician) OR AB(Physician) OR (MH "Family") OR (MH "Practice Patterns") OR (MH "Physicians, Family") OR (MH "Pediatricians") OR (MH "Primary Health Care") OR (MH "Child Health Services")
	S6	S1 AND S2 AND S3 AND S4 AND S5

Table 2. Evidence Rating Criteria

Evidence Rating	Evidence Criteria: Type	Evidence Criteria: Study Results
Scientifically Rigorous	• Peer-reviewed study results are drawn only from: o Randomized controlled trials, and/ or o Quasi-experimental studies with pre-post measures and control groups	• Preponderance of studies have statistically significant favorable findings
Moderate Evidence	• Peer-reviewed study results are drawn from a mix of: o Randomized controlled trials o Quasi-experimental studies with pre-post measures and control groups o Quasi-experimental studies with pre-post measures without control groups o Time trend analyses	• Preponderance of studies have statistically significant favorable findings
Expert Opinion	• Gray literature	• Experts deem the intervention as favorable based on scientific review
Emerging Evidence	• Peer-reviewed study results are drawn from a mix of: o Randomized controlled trials o Quasi-experimental studies with pre-post measures and control groups o Quasi-experimental studies with pre-post measures without control groups o Time trend analyses o Cohort studies	• Studies with a close-to-evenly distributed mix of statistically significant favorable and non-significant findings • Only cohort studies with preponderance of statistically significant favorable findings
	• Gray literature	• Experts deem the intervention as favorable
Mixed Evidence	• Peer-reviewed study results are drawn from a mix of: o Randomized controlled trials o Quasi-experimental studies with pre-post measures and control groups o Quasi-experimental studies with pre-post measures without control groups o Time trend analyses o Cohort studies	• Studies with a close-to-evenly distributed mix of statistically significant favorable, unfavorable, and non-significant findings
	• Gray literature	• Experts deem the intervention as having mixed evidence
Evidence Against	• Peer-reviewed study results are drawn from a mix of: o Randomized controlled trials o Quasi-experimental studies with pre-post measures and control groups o Quasi-experimental studies with pre-post measures without control groups o Time trend analyses o Cohort studies	• Preponderance of studies have statistically significant unfavorable or non-significant findings
	• Gray literature	• Experts deem the intervention as being ineffective or unfavorable

Table 3. Study Characteristics. [1]

Study	Country	Setting	Study Sample		Study Design
			Target Sample	**Sample Size**	
Allen et al. (2010)	US	Primary care medical homes (federally qualified health centers, residency training programs, private practices) primarily in Chicago, Illinois, metropolitan area	Children ages 4 to 24 months	Chart audits at 16 sites (n=25 per site)	QE: pretest-posttest
Barry et al. (2012)	US	Pediatric and family medicine practices in Vermont	Children up to age 3	Chart audits at 37 baseline and 35 follow-up sites (n=30 per site) Baseline charts (n=1381) - Children 19-23 months (n=697) - Children 31-35 months (n=684) Follow-up charts (n=1301) - Children 19-23 months (n=646) - Children 31-35 months (n=655)	QE: pretest-posttest
Bauer et al. (2009)	US	University of Chicago Pediatric Residency Program in Chicago, Illinois	Children ages 6 to 24 months	Chart audits - Baseline (n=27 of 50 selected) - Follow-up 1: (n=61 of 100 selected) - Follow-up 2: (n=82 of 100 selected) - Follow-up 3: (n=94 of 100 selected) - Follow-up 4: (n=74 of 100 selected)	QE: pretest-posttest
Carroll et al. (2014)	U.S.	Four primary care pediatric clinics in the Eskenazi Medical Group in Indianapolis, Indiana	Children younger than 66 months	Medical records - Intervention (n=180) - Control (n=180)	RCT

Study	Country	Setting	Study Sample		Study Design
			Target Sample	Sample Size	
Earls & Hay (2006)	US	Partnership for Health Management, a network within Community Care of North Carolina	Children ages 6 to 60 months receiving Early Periodic Screening, Diagnosis, and Treatment services	Unknown number of charts – screening rates tracked in 2 counties (>20,000 screens by 2004)	QE: pretest-posttest
Gray et al. (2013)	US	Pediatric and family practices serving children with MaineCoverage	Children ages 6 to 35 months	Unknown number of chart reviews from 9 practice sites completing follow-up	QE: pretest-posttest
Green et al. (2014)	US	Seven Health Families Oregon program sites in Oregon	First-born children from birth through 36 months of age	Telephone surveys (n=803 mothers) - Intervention (n=402) - Control (n=401)	RCT
Harrington & Kenney, et al. (2014)/Smith & Dye (2013)	US	Ten states: Alabama, California, Florida, Louisiana, Michigan, New York, Ohio, Texas, Utah, and Virginia	Children ages 0-5 enrolled in the Children's Health Insurance Program (CHIP) for at least 12 consecutive months	Telephone survey[2]: - Established enrollees (n≈800) - Uninsured (n≈188)	QE: non-equivalent control group
Honigfeld et al. (2011)	US	Pediatric and family medicine practice (5 intervention and 5 control) sites in Connecticut	Children at 18-month well-child visits	Baseline Chart Audits[3]: - Intervention (n=200) - Control (n=100) Follow-Up Chart Audits: - Intervention (n=196) - Control (n=100)	QE: pretest-posttest non-equivalent control group
King et al. (2009)	US	Sixteen pediatric primary care practices from 15 different states	Children ages 8 to 36 months at well-child visits	Chart audits: - Baseline and Follow-Up: (n=30) per practice in July 2006 and March 2007; total charts audited (n= 960) - Intervention period: (n=10) per practice per month for 7 months; total charts audited (n=1,120)	QE: interrupted time-series design
Kuhlthau et al. (2011)	US	Massachusetts	Children enrolled in Medicaid	Well-child visits - Baseline/first quarter 2008 (n=122,494)[4] - Follow-up/first quarter 2009 (n=118,573)[5]	Observational pretest-posttest design

Study	Country	Setting	Study Sample		Study Design
			Target Sample	Sample Size	
Lannon et al. (2008)	US	Primary care practices (15 at baseline, 8 at follow- up) throughout the US (9 states total), with most in the Midwest	Children from birth through 21 years of age	Unknown number of chart audits from 8 practice sites completing follow-up	QE: pretest-posttest
Mackrain et al. (2015)	US	Maternal, Infant, and Early Childhood Home Visiting Programs within 8 states and one Tribe: AR, MI, IN, NJ, GA, OH, PA, FL and White Earth Home Health Agency	Prenatal to age 5 children and families	• Phase I – 11 sites (n≈1019) • Phase II – 5 sites (n≈676) N=families per month	Quality improvement time series design
Malik et al. (2014)	US	Seven primary care practices in a large urban area and small regional community in New Mexico	Children ages 1 through 60 months	Total medical records reviewed at baseline and follow-up (n=1139)	QE: pretest-posttest
Margolis et al. (2008)	US	Pediatric and family primary care practices (17 collaborative education, 18 comparison practices) in Vermont and North Carolina	Children ages 0-48 months receiving well-child visits	Unknown number of chart audits	QE: pretest-posttest non-equivalent control group
Minkovitz et al. (2003)	US	Pediatric practices in 14 states (6 randomization sites: San Diego, CA; Iowa City, IA; Allentown, PA; Pittsburgh, PA; Florence, SC; Amarillo, TX. 9 QE sites: Birmingham, AL/Chapel Hill, NC; Grand Junction, CO/Montrose, CO; Chicago, IL; Kansas City, KS; Boston, MA; Detroit, MI; Kansas City, MO; New York, NY; Houston, TX/Richmond, TX)	Children ages 0-36 months	Randomization Sites: - Intervention (n=832) - Control (n=761) - Total (n=1593) Quasi-Experimental Sites: - Intervention (n=1189) - Control (n=955) - Total (n=2144) Total: - All families (n=3737) - Intervention: (n=2021) - Control (n=1716)	RCT and QE: non-equivalent control group

Study	Country	Setting	Study Sample		Study Design
			Target Sample	Sample Size	
Schonwald et al. (2009)	US	Boston Children's Hospital Primary Care Center (CHPCC) and Joseph Smith Community Health Center in Massachusetts	Children ages 2-3 years (20-40 months) receiving well-child visits	Medical charts reviewed[6]: - Baseline (n=338) o Children aged 2 years (n=169) o Children aged 3 years (n=169) - Follow-up (n=278) o Children aged 2 years (n=127) o Children aged 3 years (n=151) - Total charts (n=616)	QE: pretest-posttest

[1]Abbreviations used in this table: RCT (randomized controlled trial); QE (quasi-experimental study); AAP (American Academy of Pediatrics); CHIP (Children's Health Insurance Program)
[2] Calculation by authors (CM & SG)
[3] Calculation of total charts by author (EB)
[4] Calculation by author (EB) based on 20334 screens amounting to 16.6% of well-child visits in the first quarter of 2008
[5] Calculation by author (EB) based on 63,555 screens amounting to 53.6% of well-child visits in the first quarter of 2009
[6] Only medical charts from CHPCC were reviewed due to limited research staff availability

Table 4. Data Sources & Outcome Measures.[1]

Study	Data Source	Outcome Measure
Allen et al. (2010)	Child medical record	Percentage of practice sites meeting project objective of 85% screening by 12-month well-child visit with ASQ
	Child medical record	Percentage of practice sites meeting project objective of 85% screening by 18-month well-child visit with ASQ:SE
	Child medical record	Percentage of practice sites meeting project objective of 85% screening by 24-month well-child visit with ASQ
Barry et al. (2012)	Child medical record	Percentage of developmental screening with well-child visits (at 9-, 18-, 24-, 30-month visits)
	Child medical record	Percentage of autism screenings using M-CHAT at 18- and 24-month well-child visits
	ProPHDS Survey	Percentage of parents who report completing a standardized developmental screening tool for their child
Bauer et al. (2009)	Child medical record	Percentage of 12-; 24-month well-child visits with developmental screening using the ASQ screening tool
	Child medical record	Percentage of 18-month well-child visits with developmental screening using the ASQ:SE tool
Carroll et al. (2014)	Child medical record	Percentage of developmental screenings performed with a standardized screening tool (at 9-, 18-, and 30-month visits)
Earls & Hay (2006)	Child medical record	Percentage of ASQ screening at well-child care visits (at 12-, 24-, 36-, 48-, 60- months)
Gray et al. (2013)	Child medical record	Percentage of documented ASQ or PEDS screening at well-child care visits (12-, 24-, 36-months)
	MaineCare paid claims	Billing rates of ASQ or PEDS screening
Green et al. (2014)	Parent telephone survey	Percentage of children who received developmental screening by 12 months of age
Harrington & Kenney, et al. (2014)/Smith & Dye (2013)	2012 Congressionally Mandated Survey of CHIP and Medicaid Enrollees and Disenrollees	Percentage of children who received developmental screening
Honigfeld et al. (2011)	Child medical record	Percentage of autism screenings using M-CHAT at 18-month well-child visits
	Medicaid claims	Number of developmental screens billed to Medicaid with well-child visits for children <3 years
King et al. (2009)	Child medical record	Percentage of structured developmental screening at well-child visits for children 8- to 36-months of age
	Child medical record	Percentage of structured developmental screening at well-child visits for practices using PEDS vs ASQ
Kuhlthau et al. (2011)	Medicaid data prepared for *Rosie D. v Romney (Patrick)* court case	Percentage of Medicaid-enrolled children with screens at well-child care visits
Lannon et al. (2008)	Child medical record	Percentage of children up to age 5 with documented structured developmental assessment (PEDS or ASQ)
Mackrain et al. (2015)	Local team data registries	Percentage of children screened for developmental risk/delay within the last 6 months
Malik et al. (2014)	Child medical record	Percentage of developmental screenings performed with any screening tool during well-child visits
	Child medical record	Percentage of developmental screenings performed with a validated screening tool (>80% sensitivity and specificity) during well-child visits
Margolis et al. (2008)	Child medical record	Percentage of children aged 0-48 months with documented developmental and psychosocial screenings
Minkovitz et al. (2003)	Child medical record	Percentage of children who had developmental assessment
	Child medical record	Odds of children receiving timely well-child visits

	Child medical record	Percentage of children who received age-appropriate well-child care visits (1-, 2-, 4-, 6-, 12-, 24-months)
Schonwald et al. (2009)	Child medical record	Percentage of 2- and 3-year old children who were screened with the PEDS tool

[1] Abbreviations used in this table: ASQ (Ages and Stages Questionnaire); ASQ:SE (Ages and Stages Questionnaire: Social-Emotional); M-CHAT (Modified Checklist for Autism in Toddlers); PEDS (Parents' Evaluation of Developmental Skills); CHIP (Children's Health Insurance Program)

Table 5. Intervention Description.[1]

Study	Comparison Group[2]	Description of Intervention	Intervention Implementation	Data Collection
Allen et al. (2010)	N/A	Provider training using the Enhancing Developmentally Oriented Primary Care (EDOPC) curriculum from Healthy Steps National Curriculum - On-site training for primary care practices - Instruction on ASQ and ASQ:SE - Resource toolkits - E-mail and phone-based contact and teleconferences for technical assistance and practice change monitoring with experts	2005-2007	Baseline: before site training Follow-up: at least twice yearly after training
Barry et al. (2012)	N/A	Vermont Child Health Improvement Program's (VCHIP) Improving Developmental and Autism Screening in Primary Care QI project - Partnership between VCHIP, Vermont Agency of Human Services, Department of Vermont Health Access (DVHA), Vermont Department of Health, The AAP-Vermont Chapter, and the Vermont Academy of Family Physicians - Modified billing practices through DVHA prior to launch of project - Practice improvement using goal-setting, data evaluation, PDSA rapid-cycle change QI framework o Training on screening, QI methods; training eligible for Maintenance of Certification credits o Screening tool selection and implementation o Early screening and intervention resources o Community outreach, collaboration o Bimonthly educational conference calls; ongoing email, site visits, and phone-based support and feedback	Fall 2009 – Fall 2011	Baseline: Fall 2009 Follow-up: Approximately 18 months after baseline
Bauer et al. (2009)	N/A	Pediatric resident training on EDOPC curriculum - 11 on-site, 1-hour case-based didactic modules (video clip, and evidence-based recommendations) - Web-based resources	Jan – Jun 2006	Baseline: 2007 Follow-up: 2008-2009
Carroll et al. (2014)	Traditional CHICA system	Child Health Improvement through Computer Automation with Decision Support System (CHICA DSS) - Traditional CHICA system with additional components: o Universal screening: automatic printing of ASQ o Surveillance: patient screening form and, if issues identified, physician worksheet and standardized screening tool o Reassessment: automatic tracking for rescreening at	Jun 1, 2010 – Dec 31, 2012	Beginning 6 months after intervention implementation

Study	Comparison Group[2]	Description of Intervention	Intervention Implementation	Data Collection
		subsequent visits o Recommendations: prompts for physicians based on Bright Futures guidelines who screened children with positive screening results		
Earls & Hay (2006)	N/A	North Carolina Assuring Better Child Health and Development (ABCD) Project, QI initiative - Office improvement using PDSA cycle QI tool o Evaluate baseline office procedures o Identify physician to serve as ABCD advocate; facilitate site feedback o Mapping of office workflow, identify needed system support components o Staff orientation; child development and early intervention training o ASQ selection and implementation o Office and patient data collection, submission, and feedback to staff o Development and provision of resources o Continuing education sessions and materials - Outreach, marketing communication, and collaboration with local and state organizations and stakeholders - Supplemental Medicaid funds for provision of staff to support care management, reimbursement for process implementation expenses ($2.50 each per member per month) - Chart audits assessing ASQ use at 12-, 24-, 36-, 48-, and 60-month well-child visits began in 1 county with replication in 9 counties	Aug 2000 - 2004	Baseline: 1999 Follow-up: quarterly for 5 years following implementation
Gray et al. (2013)	N/A	First STEPS (Strengthening Together Early Prevention Services) Learning Initiative Phase II - Implemented as part of the Improving Health Outcomes for Children grant, in collaboration with the Maine Center for Disease Control, the Muskie School of Public Service at the University of Southern Maine, Vermont's Medicaid Program, and the University of Vermont - Piloted new MaineCare billing codes and modifiers for developmental screening and assessment procedures - Monthly coaching calls and two all day learning sessions - Office procedure changes	May – Dec 2012	Chart review data Baseline: May 2012 Follow-up: Nov 2012 MaineCare claims Baseline: May 2011-Apr 2012 Follow-up: May 2012-Apr 2013

Study	Comparison Group[2]	Description of Intervention	Intervention Implementation	Data Collection
		○ Incorporate screening tools into workflow ○ Improve referral tracking ○ Develop list of community and medical resources ○ Consider care coordination and care plans ○ Involve families in quality improvement efforts ○ Sharing of monthly reports across practices		
Green et al. (2014)	Families who did not receive the Healthy Families Oregon programming	Healthy Families Oregon home visiting program - Parent education, coaching, and support ○ Facilitate parent knowledge, skills, and education on child development using Parents as Teachers and/or Growing Great Kids curriculum - Address individualized family needs and provide resources - Provide social, cognitive, and health supports to children ○ Promotion of breastfeeding ○ Developmental screenings ○ Linking families to preventive health care services	Study enrollment: Feb 2010-Feb 2012	Telephone surveys: when child is 12 months of age
Harrington & Kenney, et al. (2014)/Smith & Dye (2013)	Children who were uninsured for 5-12 months prior to enrollment	Enrollment in the Children's Health Insurance Program (CHIP) for one year or more	2012	2012
Honigfeld et al. (2011)	Pediatric practices that did not receive the Educating Practices in the Community (EPIC) Autism Spectrum Disorder (ASD) Screening training module	EPIC provider training - ASD Screening module presented by trained pediatric primary care provider; emphasis on Modified Checklist for Autism in Toddlers (M-CHAT) at 18-, 24-month well-child visits - Developmental Monitoring module presented by four trained child development specialists; emphasis on use of ASQ or PEDS at 9-, 18-, 24- (or 30-) month well-child visits- - Chart audits assessing use of ASQ, M-CHAT, and PEDS at 18-month well-child visits	Connecticut Department of Social Services approval of Medicaid reimbursement for developmental screening occurring on the same day as a well-child visit: Oct 2008 EPIC ASD Screening module and surveys: Mar 2009 – Nov 2010 EPIC Developmental Monitoring module	Intervention: - Baseline: 20 charts of visits going backward sequentially pre-EPIC presentation; - Follow-up: post-EPIC presentation, 20 charts moving forward sequentially starting at least 3 months after EPIC presentation Control: sequentially from Aug 2009 (included visits that took place 5 months after initial EPIC ASD training presentation)

Study	Comparison Group[2]	Description of Intervention	Intervention Implementation	Data Collection
			and surveys: Jan 2009 – Aug 2010	
King et al. (2009)	N/A	QI initiative; assessment of sites' implementation of screening and referrals - Baseline submission by practices o Surveillance, screening, and referral methods o 3-member project team at each site o Screening instrument(s) included ASQ, PEDS, Prescreening Developmental Questionnaire (PDQ), and others - Site training o 1-day orientation session o Forms for standardized reporting o AAP staff monitored data reporting and answered related questions - Chart reviews and results of aggregate data submitted to the AAP - Practices participating in all study components received $1800	Jul 2006 – Mar 2007	Baseline: Jul 2006 Intervention period: Aug 2006 – Feb 2007 Follow-up: Mar 2007
Kuhlthau et al. (2011)	N/A	*Rosie D. v Romney (Rosie D. v Patrick)* class-action lawsuit led to regulations requiring primary care providers to screen for developmental and behavioral concerns at all well-child visits or at parent request for MassHealth patients younger than 21 years o Fee-for-service reimbursement for validated, standardized screening tests, evaluations, and management for positive screens - State outreach efforts to promote developmental screening o State-provided technical assistance and educational resources o Broadcast information through healthcare networks, local media, and notices to MassHealth organizations o Coordination of regional educational forums and phone consultations for providers on behavioral health screening	Screening mandatory Jan 2008 (regulations requiring well-child screening went into effect Dec 31, 2007)	Baseline: Jan 2008 Follow-up: Apr 2008 - Dec 2009
Lannon et al. (2008)	N/A	Bright Futures Training Intervention Project and QI initiative - Joint project between the AAP and the Center for Health Care Quality at Cincinnati Children's Hospital Medical Center - Provider team-based learning collaborative; 3- to 4-person practice teams	Nov 2005 – Nov 2006	Baseline: before first workshop Follow-up: 2 months following post-

Study	Comparison Group[2]	Description of Intervention	Intervention Implementation	Data Collection
		o Medical chart reviews with ASQ, PEDS, and Bright Futures Guidelines o 1-day workshops pre- and post-intervention period o Education on Model for Improvement; assessments of site changes using PDSA o Monthly conference calls (13 total) and email interactions - Monthly web-based feedback charts and resource toolkits to support practice improvement and use of structured developmental assessment - Provider 21-question office systems inventory (OSI) surveys, assessments, and implementation of OSI-related components following feedback o OSI included composite scores for recall/reminder systems and community linkages to increase referrals		intervention workshop
Mackrain et al. (2015)	N/A	Home Visiting Collaborative Improvement and Innovation Network Breastfeeding Initiation and Support project - Practice improvement using shared AIM, data evaluation, PDSA rapid-cycle change QI framework (Breakthrough series and Model for Improvement) o Training and ongoing coaching on QI methods o Driver diagram of recommended changes o Collaboration amongst sites o Monthly educational and peer-to-peer conference learning calls; three in-person learning sessions per phase; ongoing virtual support and feedback	Phase I: May 2014 – August 2015 Phase II: November 2015 – August 2016	Continuous throughout Phase I and Phase II
Malik et al. (2014)	N/A	QI project to promote use of standardized developmental screening tools among pediatrician and mid-level providers - Provider training and establishment of 2- to 5-person QI team at each site o In-person collaborative learning sessions (2- to 4-hour introductory training; at least 1 2-hour mid-study session involving state and local agencies) o Assessments of site changes using PDSA o Teleconference-based continuing education (2+ sessions) and support o Provision of ASQ and M-CHAT materials o Providers trained eligible to receive up to 35 Maintenance of	May 2009 – Nov 2010	Baseline: May - Oct 2009 Follow-up 1: Nov 2009 - Jan 2010 Follow-up 2: Feb - Mar 2010 Follow-up 3: Apr - May 2010 Follow-up 4: Jun - Jul 2010

Study	Comparison Group[2]	Description of Intervention	Intervention Implementation	Data Collection
		Certification credits - Performance reviews using data collected from site submissions of patient records o QI team training on data sampling and collection measures during site visit o Designation of practice team member responsible for medical record reviews; training for that designee by the Developmental Screening Initiative coordinator through the first review o Progress reports, feedback on data submissions (use of PDQ, ASQ, M-CHAT), and guidance for practices		
Margolis et al. (2008)	Sites' usual developmental screening recommendations and practices	12-month education and QI program using the Breakthrough Series Collaborative QI, PDSA model o Establishment of QI practice teams o Three 1-day, in-person, provider training sessions on QI strategies and clinical changes o Provider assessment and implementation of QI-based changes to developmental screening practices o Continuing education and feedback through conference calls - Data collection and reporting to measure implementation progress using Promoting Healthy Development Survey o Surveys of parents, practice staff, and collaborative teams collected by intervention sites each month o OSI check-list survey completion by each practice at baseline and follow-up o Intervention site training and implementation of medical record data collection	2004-2005	Intervention sites - Baseline: Jun - Aug 2004 - Intervention period: Sept 2004 – May 2005 - Follow-up: Jun - Dec 2005 Comparison sites: - Baseline: Sept 2004 - Mar 2005 - Follow-up: Jun - Nov 2005
Minkovitz et al. (2003)	Usual standard of pediatric care (at the randomization sites, from the same physicians as the intervention groups)	Healthy Steps program (caseload of 100 families per Healthy Steps Specialist) o Enhanced well-child visits with Healthy Steps Specialist o Up to 6 home visits during infant's first 3 years o Developmental support provided by telephone line staffed by Specialists o Developmental assessments o Written materials on preventive health o Parent-oriented, educational, support groups	Sept 1996 – Nov 2001	32 months following enrollment

Study	Comparison Group[2]	Description of Intervention	Intervention Implementation	Data Collection
		o Referrals to community resources - Training for key site personnel o 3 annual project training sessions o Training and program manuals o Technical assistance via biweekly teleconferences		
Schonwald et al. (2009)	N/A	QI initiative on implementation of routine screening - 29-question provider survey completed prior to training, repeated 4 months after implementation of routine screening - Provider training o 45- to 60-minute pre-implementation in-person training on use of PEDS o Development of and training on second-stage screening o In-person (only for first 2 weeks of implementation) and mobile access to trained staff able to answer questions o Implementation of PEDS in practices o Web-based continuing education resources o Resource notebooks and handouts provided decision-making support for referrals	Dec 2005 - Aug 2006	Baseline: Jul - Oct 2005 Follow-up: Apr - Jul 2006

[1] Abbreviations used in this table: QI (quality improvement); AAP (American Academy of Pediatrics); IHI (Institute of Healthcare Improvement); ASQ (Ages and Stages Questionnaire); ASQ:SE (Ages and Stages Questionnaire: Social-Emotional); EDOPC (Enhancing Developmentally Oriented Primary Care); CHIP (Children's Health Insurance Program); M-CHAT (Modified Checklist for Autism in Toddlers); OSI (office systems inventory); PDQ (Prescreening Developmental Questionnaire); PDSA (Plan-Do-Study-Act); PEDS (Parents' Evaluation of Developmental Skills)
[2] "N/A" (not applicable) refers to quasi-experimental studies with pretest-posttest designs.

Table 6. Intervention Components.

Study	Parents	Health Care Providers					Health Care Practices									State		
	Home Visiting	Education on child development	Education on screening tools	Resource toolkits and written materials	Expert support (email and phone-based)	Web-based resources	Participation incentives	QI practice teams	Modified billing practices	Data collection training for staff	Screening tool implementation training	Office systems assessments and implementation training	Chart audits	Expert feedback using the Plan-Do-Study-Act tool	Clinical decision support system	Collaboration with local agencies	Engagement with payers	Public insurance
Home Visiting (n=2)																		
Green et al. (2014)	X															X		
Mackrain et al. (2015)	X							X										
Health Care Provider Training Only (n=3)																		
Allen et al. (2010)		X	X	X	X													
Bauer et al. (2009)		X				X												
Honigfeld et al. (2011)		X	X										X					
Quality Improvement in Health Care Settings (n=4)																		
King et al. (2009)		X	X	X	X		X	X		X	X		X					
Malik et al. (2014)		X	X	X	X		X	X		X			X	X		X		
Margolis et al. (2008)		X			X			X		X		X	X	X				
Schonwald et al. (2009)		X		X	X	X					X							
Systems-level Approaches with Quality Improvement (n=4)																		
Barry et al. (2012)		X	X	X	X		X	X	X	X	X	X	X	X		X	X	
Earls & Hay (2006)		X	X	X			X		X	X	X	X	X	X		X	X	
Gray et al. (2013)			X		X				X		X	X	X	X		X	X	
Lannon et al. (2008)		X	X	X	X	X		X		X		X	X	X		X		
Other (n=4)																		
Carroll et al. (2014)															X			
Harrington & Kenney, et al. (2014)/Smith & Dye (2013)																		X[1]

Kuhlthau et al. (2011)		**X**		**X**	**X**		**X**			**X**								
Minkovitz et al. (2003)	**X**	**X**		**X**	**X**					**X**	**X**	**X**						

[1] CHIP is administered by states and funded jointly by states and the federal government.

Table 7. Study Results.[1]

Study	Results
Home Visiting (n=2)	
Green et al. (2014)	• Percentage of children who received developmental screening by age 12 months was 93.8% for intervention and 86.5% for control group (OR=0.41, P<.01)
HV CoIIN Webinar	• Percent of children screened for developmental risk/delay within the last six months had a shift in Phase II, from a Phase I baseline of 70% to a final Phase II mean of 88%
Health Care Provider Training Only (n=3)	
Allen et al. (2010)	• Percentage of sites screening 85% of children by 12-month well-child visit increased from 0% at baseline to 68.8% at follow-up o Sites not reaching 85% screening screened 48-83% of children at follow-up • Percentage of sites conducting social/emotional screening for 85% of children by 18-month well-child visit increased from 6% at baseline to 46.7% at follow-up o Sites not reaching 85% screening screened 5-81% of children at follow-up • Percentage of sites screening 85% of children by 24-month well-child visit increased from 0% at baseline to 68.8% at follow-up o Sites not reaching 85% screening screened 18-84% of children at follow-up
Bauer et al. (2009)	• Percentage of ASQ screening at 12-month well-child visits increased from 11% at baseline[2] to 100% at follow-up • Percentage of ASQ:SE screening at 18-month well-child visits increased from 0% at baseline[8] to 95% in June 2008 and declined to 58% at last follow-up in Jan 2009 • Percentage of ASQ screening at 24-month well-child visits increased from 0% at baseline[8] to 88% at follow-up
Honigfeld et al. (2011)	• Percentage of screening at 18-month well-child visits increased (P<.05) in all intervention practices o Average screening percentages were 70.8% for intervention practices, 46% for control practices o One intervention practice had a lower screening % than matched control practice (P=.37) • Number of screens performed on the same day as a well-child visit increased from 3,442 in 2008 to 12,533 in 2009
Quality Improvement in Health Care Settings (n=4)	
King et al. (2009)	• Percentage of screenings increased across all practices from 68% to 86% for 9, 18, 24/30-month well-child visits
Malik et al. (2014)	• Percentage of use of any screening tool increased from 62% at baseline to 92% at follow-up (P<.001) • Percentage use of validated screening tool[3] increased from 32% at baseline to 92% at follow-up (P<.001)
Margolis et al. (2008)	• Percentages of average developmental and psychosocial screening from baseline to follow-up increased from 78% to 88% (P<.001) and 22% to 29% (P=.002), respectively • Percentage of children whose parents reported high-quality care[4] increased from 40% to 52% (baseline to follow-up) among intervention practices, no change in comparison practices (37% to 37%)
Schonwald et al. (2009)	• 61.4% of 2-year-olds and 61.6% of 3-year-olds were screened with the PEDS in the postimplementation chart review[5]
Systems-level Approaches with Quality Improvement (n=4)	
Barry et al. (2012)	• Percentage of developmental screenings at 9-, 18-, 24-, and 30-months all increased from baseline to follow-up (P<.001) • Percentage of children screened using standardized developmental screening tool completed by parents increased from baseline to follow-up (11.6% to 32.4%; P<.001)
Earls & Hay (2006)	• Percentage of screenings using ASQ increased from 15.5% at baseline to 76% at last follow-up[6]

Gray et al. (2013)	• Average percentage of documented use of a developmental screening tool increased substantially from baseline to follow-up for all three age groups (46% to 97% for children under one; 22% to 71% for children 18-23 months; and 22% to 58% for children 24-35 months) • Rate of developmental screening based on MaineCare claims increased from the year prior to intervention implementation to the year after implementation for all three age groups (5.3% to 17.1% for children age one; 1.5% to 13.3% for children age two; and 1.2% to 3.3% for children age 3)
Lannon et al. (2008)	• Percentage of SDA use overall increased from 12.5% at baseline to 44.67% at follow-up • Among sites providing complete data, 6 sites with 0% SDA screening at baseline increased use of SDA to between 25-100% at follow-up[7]
Other (n=4)	
Carroll et al. (2014)	• Significant increase in percentage of children screened with a standardized screening tool at target visits (85% vs 24.4%, P<.001)
Harrington & Kenney, et al. (2014)/Smith & Dye (2013)	• No difference in percentage of children with developmental screening between CHIP enrollees and children uninsured for 5-12 months in the prior year (30.2% vs 27.7%)
Kuhlthau et al. (2011)	• Percentage of Medicaid well-child visits with screens increased from 16.6% at baseline to 53.6% follow-up
Minkovitz et al. (2003)	• Percentage of children with developmental assessments was 83.1% for intervention and 41.4% for control group (OR=8.00; 95% CI=6.69, 9.56; P<.001)

[1] Abbreviations used: ASQ (Ages and Stages Questionnaire); ASQ:SE (Ages and Stages Questionnaire: Social-Emotional); M-CHAT (Modified Checklist for Autism in Toddlers); PEDS (Parents' Evaluation of Developmental Status); SDA (structured developmental assessment)
[2] Bauer et al. report baseline percentages but not specific associated numbers
[3] Malik et al. define a validated screening tool as having >80% sensitivity and specificity
[4] Margolis et al. define high-quality care as the receipt of at least 3 components of developmental care visits
[5] Baseline data not available; no routine developmental screening practice prior to the study (A. Schonwald, MD, email communication, July 2017)
[6] Data reported by quarter; annual average calculated by author (EB)
[7] Baseline data for sites with complete datasets provided by C.M. Lannon, MD, MPH (email communication, June 2017)

Table 8. Summary of Study Results. [1]

Study	Developmental Screening
Home Visiting (n=2)	
Green et al. (2014)	+
HV CoIIN Webinar	(+)
Health Care Provider Training Only (n=3)	
Allen et al. (2010)	(+)
Bauer et al. (2009)	(+)
Honigfeld et al. (2011)	+
Quality Improvement in Health Care Settings (n=4)	
King et al. (2009)	(+)
Malik et al. (2014)	+
Margolis et al. (2008)	+
Schonwald et al. (2009)	(+)[2]
Systems-level Approaches with Quality Improvement (n=4)	
Barry et al. (2012)	+
Earls & Hay (2006)	(+)
Gray et al. (2013)	(+)
Lannon et al. (2008)	(+)[3]
Other (n=4)	
Carroll et al. (2014)	+
Harrington & Kenney, et al. (2014)/Smith & Dye (2013)	ns
Kuhlthau et al. (2011)	(+)
Minkovitz et al. (2003)	+

[1] "+" refers to statistically significant favorable outcomes ($p<.05$); "-" refers to statistically significant unfavorable outcomes; "ns" refers to non-significant outcomes ($p>.05$); "(+)" refers to favorable outcomes without statistical analysis; "(-)" refers to unfavorable outcomes without statistical analysis; "(ns)" refers to outcomes neither favorable nor unfavorable without statistical analysis

[2] Favorable outcome determined by positive improvement seen despite baseline data unavailable; no routine developmental screening practice prior to the study (A. Schonwald, MD, email communication, July 2017). However, Schonwald et al. indicate in their article that the positive outcome was less than hypothesized.

[3] Favorable outcome calculated using a subset of the data received from C.M. Lannon MD, MPH (email communication, June 2017). The results using the entire dataset presented in the original article are reported as favorable but nonsignificant.

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