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**Citation**

**Published Version**
doi:10.1016/j.acap.2012.02.004

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Interventions to Improve Screening and Follow-Up in Primary Care: A Systematic Review of the Evidence

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Abstract

Background—The American Academy of Pediatrics and other organizations recommend several screening tests as part of preventive care. The proportion of children who are appropriately screened and who receive follow-up care is low.

Objective—To conduct a systematic review of the evidence for practice-based interventions to increase the proportion of patients receiving recommended screening and follow-up services in pediatric primary care.

Data source—Medline database of journal citations.

Study eligibility criteria, participants, and interventions—We developed a strategy to search Medline to identify relevant articles. We selected search terms to capture categories of conditions (e.g., developmental disabilities, obesity), screening tests, specific interventions (e.g., quality improvement initiatives, electronic records enhancements), and primary care. We searched references of selected articles and reviewed articles suggested by experts. We included all studies with a distinct, primary care-based intervention and post-intervention screening data, and studies that focused on children and young adults (≤21 years of age). We excluded studies of newborn screening.

Study appraisal and synthesis methods—Abstracts were screened by 2 reviewers and articles with relevant abstracts received full text review and evaluated for inclusion criteria. A structured tool was used to abstract data from selected articles. Because of heterogeneous interventions and outcomes, we did not attempt a meta-analysis.

No conflicts of interest

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Results—From 2547 returned titles and abstracts, 23 articles were reviewed. Nine were pre-post comparisons, 5 were randomized trials, 3 were post-intervention comparisons with a control group, 3 were post-intervention cross-sectional analyses only, and 3 reported time series data. Of 14 articles with pre-intervention or control group data and significance testing, 12 reported increases in the proportion of patients appropriately screened. Interventions were heterogeneous and often multifaceted, and several types of interventions, such as provider/staff training, electronic medical record templates/prompts, and learning collaboratives, appeared effective in improving screening quality. Few articles described interventions to track screening results or referral completion for those with abnormal tests. Data were often limited by single-site, non-randomized design.

Conclusions—Several feasible, practice- and provider-level interventions appear to increase the quality of screening in pediatric primary care. Evidence for interventions to improve follow-up of screening tests is scant. Future research should focus on which specific interventions are most effective, whether effects are sustained over time, and what interventions improve follow-up of abnormal screening tests.

MeSH key words
Mass Screening; Preventive Health Services; Physician’s Practice Patterns; Quality of Health Care

Introduction
Prevention of mortality and morbidity secondary to many conditions depends on effective screening and referral procedures in pediatric primary care. For many conditions, such as iron-deficiency anemia, autistic spectrum disorder, and vision and hearing problems, early detection from broad-based, primary screening with timely follow-up care enables children with these conditions to receive treatment that affects long-term health outcomes. The American Academy of Pediatrics, Bright Futures, and other organizations recommend screening procedures for several specific conditions. Although many children receive some screening via public health or school-based mechanisms, most screening beyond the newborn period occurs within the context of the primary care office at well-child visits. Even with clear, readily-accessible recommendations, quality of screening in primary care is sub-optimal, leaving children at risk when conditions are not identified. Reasons for this quality gap include lack of knowledge of recommendations, presumed patient refusal, lack of time, lack of office staff support, inadequate reimbursement, and inadequate referral resources for those found to have a problem detected through screening.

Several interventions have potential to improve screening in primary care settings and have been studied to some extent in adults. However, which practice-level interventions are most effective for improving screening in pediatric primary care is not known. Interventions in pediatrics may have a different impact compared to adult populations, for several reasons. First, children generally seek health care and make decisions through a proxy, usually a parent. Second, children undergo more rapid developmental changes, and screening recommendations change with each well-child visit. Third, most conditions for which
children are screened are not thought of as potentially life-threatening, in contrast to cancer screening in adults, which may affect the importance providers and parents place on screening in children. Examining interventions that improve receipt of recommended screening in pediatrics may help physicians and policymakers identify changes most likely to benefit a broader population and may inform a research agenda to address questions about how to improve the quality of screening in pediatric practices.

We undertook this systematic review as part of a larger project to examine evidence regarding six core objectives of the Maternal and Child Health Bureau for care for children with special health care needs. Previously, we reviewed the evidence regarding receipt of family-centered care and services to transition to adult providers; having a medical home; and having adequate health insurance coverage. We now review evidence for the objective that all children are screened early and continuously for special health care needs. Because high-quality screening in primary care is necessary for objective, we focused our review on office-based interventions to increase the proportion of children receiving recommended screening. Our specific research question was, what is the evidence for interventions to improve such screening in primary care settings? As a secondary objective, we also examined interventions to improve follow-up or referral completion, once screening tests identified concerns.

**Methods**

To guide our search strategy (Table 1), we constructed a logic model (Figure 1) that depicts the health conditions for which screening tests are recommended, interventions, and outcomes of interest. In developing and refining the model, we held a conference with relevant experts, including policymakers, family advocates, and researchers in the field of improving care for children with special health care needs. The purpose of this panel was to guide the systematic reviews around the MCHB core objectives, and the panel discussed and made recommendations for our logic model and search strategy.

**Screening tests**

To select the screening tests and corresponding specific conditions for inclusion in our search, we reviewed recommendations for preventive care screening from Bright Futures/American Academy of Pediatrics, the US Preventive Services Task Force, and the Centers for Disease Control. We selected screening tests for conditions such as developmental delay, mental health conditions, vision problems, hearing problems, lead poisoning, anemia, hypertension, sexually transmitted infections, and obesity. We did not include conditions detected by newborn screening or prenatal screening, since testing procedures and much of the follow-up occurs not in primary care but in hospitals and in conjunction with state public health authorities.

**Interventions**

We chose search terms to capture primary care interventions designed to improve receipt of recommended screening and follow up. Specific activities were derived from a review of the
literature of interventions to improve quality of other functions of primary care practices (e.g., vaccination) and recommendations from our expert panel.

Interventions included practice-level initiatives such as provider/staff education sessions and materials, quality improvement initiatives, and improvements in office workflow. Our search included interventions to improve patient identification for screening, particularly changes that led to automated identification, such as chart flagging, electronic medical record (EMR) reminders, and patient registries. We also searched for interventions that involved pay-for-performance initiatives targeted toward screening.

**Outcomes**

Our primary outcomes were the proportion of children appropriately screened, and proportion of children with abnormal screening results who received follow-up care. Appropriateness of screening was determined by the individual studies. Because follow-up care can vary among patients due to family preferences and available referral options, we broadly defined follow up care as any action by the provider that would advance a plan for additional screening, evaluation or treatment prompted by an abnormal result. This definition included discussing abnormal results with parents and patients, retesting patients, and referring to specialists or community resources for further treatment or evaluation. We also included search terms to capture secondary outcomes derived from the Institute of Medicine domains of healthcare quality.\(^{17}\)

**Database search**

We conducted a systematic search of Medline (Jan 1961–Aug 2010) for titles and abstracts relevant to our research question. We queried for articles containing MeSH terms in each of the columns in Table 1, i.e., containing terms that represented a condition, a setting, and an outcome/intervention. We also reviewed bibliographies of selected articles, as well as bibliographies of review articles related to our search. For the bibliography reviews, when we found a potentially relevant title that was missed during the previous search, we obtained the article’s Medical Subject Heading (MeSH) terms from the Medline citation to determine why the article was missed. We then refined the search to include omitted MeSH terms, reran the search and reviewed the additional abstracts. We limited our search to English-language articles studying children and youth aged 0–18 years.

**Selection of articles**

Two reviewers (JV and AAK) screened titles and abstracts for inclusion in the group of articles for full-text review. Abstracts were selected if the study examined a recommended screening practice and the study was performed in a primary care setting in the United States. Some returned studies included both adults and adolescents, and we included articles if >50% of participants were under age 21 years. Abstracts that lacked detail to make this determination also underwent full-text review. If the abstract was not appropriate for inclusion in the review but possibly referenced relevant articles, the full-text version was obtained and the bibliography scanned. The reviewers met to resolve discrepancies by discussion and mutual agreement. Each reviewer then abstracted a subset of articles using a structured form to report interventions, populations, settings, and outcomes. After
abstraction, reviewers finalized the list of articles to be included in the review through discussion and agreement. Reviewers overlapped on a random selection of approximately 20% of abstracted articles. Abstractions were qualitatively reviewed to assess for agreement, and abstracted screening rates and descriptions of the interventions were verified through a second review of the full text articles. We did not contact authors of the studies for further details. No formal assessment of study quality was done using standardized tools, but we grouped studies using a hierarchy of study design quality (e.g., RCTs, designs with control groups, and uncontrolled studies) and reported elements of potential bias in our description of the studies.

**Specific categories of excluded studies**

We excluded studies to validate screening tools and studies that documented poor-quality screening or follow-up without interventions. We also excluded studies that assessed only feasibility of screening in primary care practices without specific attention to long-term, generalizable changes within the practice (e.g., studies where the intervention was limited to research assistants performing screening procedures). We excluded articles that lacked explicit outcomes related screening or follow-up care.

**Results**

The final search strategy identified 2547 titles (Figure 2). After reviewing titles and abstracts, 105 articles underwent full-text review. Eight articles that underwent full-text review were initially identified from bibliographies of selected articles. Reviewers completed data abstraction for 29 of the 105 full-text articles. Of these 29 articles, 23 met criteria for inclusion in the final review (Table 2). Common reasons for exclusion were because no intervention was tested, proportion of patients screened was not measured, or the patient population was primarily adult-aged. The included 23 articles were 5 randomized controlled trials and 18 observational studies. Among the randomized trials, the practice was usually the unit of randomization. Among the observational studies, 9 used pre-post designs, 3 were post-intervention comparisons with a concurrent control group, 3 reported findings using time-series design where the outcome was measured at regular intervals after the intervention was initiated, and 3 were post-intervention, cross-sectional analyses with no comparison group. The diversity of interventions and outcomes prevented any meta-analysis.

**Types of interventions**

The studies described several different types of interventions. The most common interventions were 1) changes to office systems, usually part of a formal quality improvement program such as a learning collaborative, 2) physician and staff education, sometimes facilitated by a “physician champion” of a specific screening test, 3) electronic medical record enhancements (e.g., prompts), and 4) distribution of additional tools for physicians to use when screening or counseling patients. Many studies combined intervention types. In some studies where several practices were enrolled in a quality improvement initiative, specific changes were chosen by each practice. In several studies,
quality of preventive care screening was measured along with other preventive care outcomes (e.g., immunizations, preventive care visit attendance, etc).

Twelve articles from ten separate studies\textsuperscript{18–29} used interventions based largely on learning collaborative methods, including plan-do-study-act cycles and facilitated contact with other intervention practices. Typically, small teams of practitioners and staff from intervention practices addressed barriers related to office system design, provider and staff knowledge gaps, and workflow. Specific changes included chart flagging or routine chart review by non-physician staff to identify patients behind in testing. For some studies, multiple practices participated, multiple screening tests and other preventive care elements were targeted for improvement, and practices were at liberty to choose from several recommended changes those they deemed most likely to work in their practice. Thus, the specific changes associated with the global intervention varied among individual practices. Post-intervention screening ranged from 39–94\% of patients screened appropriately.

Improvement from baseline varied widely, from 0–80\%. Improvement tended to be greater if pre-intervention screening was low or non-existent and if the focus of the intervention was narrowed to specific screening tests or a specific area, such as the study reported by King et al. from a learning collaborative on developmental screening and services.\textsuperscript{24}

Five articles\textsuperscript{30–34} described interventions to implement screening using provider training and/or tools for facilitating conversations with parents, such as provider sheets to prompt screening questions or patient questionnaires. These interventions focused on screening for obesity, developmental or mental health problems, or adolescent risky behaviors. Post-intervention screening ranged from 28\% (for BMI calculations)\textsuperscript{32} to 94\% (vision screening).\textsuperscript{34}

Two articles\textsuperscript{35, 36} examined associations between implementing the Healthy Steps program and screening. Healthy Steps is designed for first-time parents and provides co-located developmental specialists to enhance well-child visits.\textsuperscript{35} Parents also receive home visits, telephone access for developmental questions, written materials, and linkages to community resources. Screening of patients enrolled in Healthy Steps was compared to screening of same-aged patients not enrolled in Healthy Steps (e.g., second-born children) after implementation. Screening for lead poisoning and anemia did not markedly change, but developmental screening doubled, from 41–43\% to 82–84\%.

Three studies\textsuperscript{27, 37, 38} examined the effect of EMR enhancements, such as EMR templates and reminders, with varying results. With EMR templates to prompt providers to elicit developmental concerns, screening improved to 65–73\% of patients for various areas of development, significant increases from baseline.\textsuperscript{37} EMR reminders enabled near universal screening (99\%) of patients if providers were able to obtain lead levels at the visit, but only 41\% for patients required by insurance to have levels drawn off-site.\textsuperscript{38} For Chlamydia screening, reminders had no effect compared to patient charts without reminders.\textsuperscript{27}

In two studies,\textsuperscript{39, 40} a nurse and a nurse practitioner were employed to identify and track patients in need of screening. Both interventions involved protocols for identifying and tracking which patients were due for testing or follow up of abnormal tests. Hull et al. found
that a nurse-driven protocol to identify and screen patients was highly effective and achieved essentially universal screening in one practice. Block et al. found that a similar intervention achieved improved documentation of a follow up plan for elevated lead levels, but smaller improvements for follow-up testing and parent education.

**Interventions to increase follow up of abnormal screening results**

We found little evidence about interventions to improve post-visit follow-up or referral completion, once screening tests identified concerns. As mentioned, Block et al. examined the effect of a nurse-driven protocol to increase retesting and parent education for abnormal lead levels. Retesting increased to 65% of those with abnormal levels, and 32% of families with persistently high levels received education. Two other studies examined discussion with patients and parents following screening tests for behavior problems or risky behaviors. Both studies found that patient/provider handouts facilitated discussion of problems detected using formal assessment tools. Schonwald et al. demonstrated that referrals for developmental evaluation remained the same, despite increases in use of formal screening tools.

**Discussion**

Three key findings emerged from this review of interventions to improve the quality of preventive care screening in pediatric primary care settings. First, most studies reported improved quality of screening post-intervention, usually a modest improvement, although differences were variable across and within studies. Second, because of variable findings, heterogeneous interventions, and relatively few studies with control groups, we could not discern whether a particular type or form of intervention is superior for improving screening. However, we saw patterns where successful interventions tended to emphasize collaborative learning, office-systems changes, and tracking progress over time. Third, we found few interventions that aimed to improve follow-up of abnormal screening results, which offers opportunities for further investigation.

From the articles reviewed, we found screening in pediatric offices generally improved after interventions were implemented. In studies where pre- and post-intervention outcomes with statistical testing were reported, over 80% of interventions demonstrated improvement in at least one area of screening. However, results varied, ranging from no change to an 8-fold increase in the proportion of children screened, and many studies could not control for secular trend with their study designs. The magnitude of the impact of interventions seemed greater when pre-intervention screening was low, and multi-faceted interventions implemented through a learning collaborative structure appeared to be, of all intervention types, more robustly studied and relatively effective. Otherwise, this review identified little regarding the patterns of variable effects or reasons for them, including type of screening or type of intervention. In addition, results varied among practices implementing similar interventions; even when an intervention was introduced in multiple practices as a single study, effects typically varied from practice to practice. No study objectively measured contextual factors (e.g., practice’s motivation to change, staff capacity for the intervention),
although some studies included qualitative discussion on contextual reasons for variability in findings across practices (e.g., physician champion left the practice).

With the exception of four studies, fewer than 85% of patients were appropriately screened post-intervention, with most studies reporting post-intervention screening between 50–75%. This finding, which mirrors findings in adult studies, suggests that some patients miss screening despite often intensive office-based improvements. Studies in our review that examined characteristics of patients who were not screened found various associations with less screening, including non-English speaking parents, parents who did not have time to complete the screening tool before seeing the physician, and having to go off-site to complete screening tests. Furthermore, this finding suggests a “ceiling effect” similar to that found with interventions to increase rates of vaccine coverage and well-child visit attendance.

The quality of the studies varied, with many using non-randomized study designs, a limited number of practice sites, and with little account for context of the practices receiving intervention. However, five articles reported on randomized trials with consistent positive effects. Most studies were pre-post designs without randomization, and some lacked comparison groups, making it difficult to assess the effect of natural trends over time. Most studies involved multiple practices, but seven studies used only one practice site, limiting the ability to draw conclusions about how broader-based improvement efforts would increase the quality of screening. Because office staff motivation and technological savvy can play a large role in the success of interventions, practices differing in these contextual factors would likely have different results.

Most interventions were multifaceted, involving several alterations in office workflow, physician and staff education, and changes in staff time allocation. While multifaceted interventions generally had more success, as did interventions tailored to best fit specific practices, no systematic approach examined which elements provide the greatest benefit, or why the same intervention performed better in some practices than others. Findings from such a systematic approach could be used to design more efficient interventions and advance the field of quality improvement research.

Few studies examined the quality of follow-up care, and few interventions contained elements specifically targeting follow-up of abnormal tests. However, the few studies that did have follow-up as an outcome found 35–65% of patients did not receive follow up care after an abnormal screening result. This finding indicates the need to include outcomes related to follow-up in studies of screening, and that measuring screening alone may overestimate changes in identification and treatment of conditions.

We found no studies testing the effects of performance incentives or physician feedback. This strategy has been studied more in adult settings for screening and in pediatrics for immunizations, attendance at well-child visits, and management of chronic conditions. Another review of adult cancer screening interventions focused on motivating patients and reducing barriers to care. These reviews found variable effects among similar interventions, with most interventions associated with some increase in screening.
The review has several limitations. Many quality improvement interventions do not reach publication, which could have limited identification of informative studies. The search terms used may not have captured all relevant studies, particularly studies examining quality of follow-up care, for which search terms were difficult to define. Many studies tested heterogeneous interventions that were modified for each practice; some interventions were multifaceted so that practices could choose specific elements to implement. This “cafeteria” approach makes comparing interventions in separate studies difficult and may limit reliability and generalizability. However, tailoring the intervention to the context of the practice likely increased the chance of the desired effect, and is more representative of how it would be applied in actual practice.

**Conclusion**

Although the quality of studies varied, we found a moderate level of evidence that interventions are effective in improving screening in pediatric practices. This review also reveals several avenues for future study that will guide policy makers and practitioners in what specific interventions provide the most value.

Interventions reviewed here appeared to have ceiling effects, which invites the question, given the broad aims of pediatric primary care, what should be the goals for screening, and is there a point of diminishing return where a practice’s extra efforts exceed the value of the gain? Policies around reimbursement based on screening performance should match the right amount of effort to achieve the right rate. Also, improving screening rates from a high baseline will likely require different interventions; near-perfect screening may not be achievable without a large degree of automation and standardization and multiple layers of double-checks performed by non-clinicians or through electronic mechanisms. Lastly, when aiming for high proportions of children appropriately screened, defining the right denominator becomes increasingly important and worth measuring accurately and thoughtfully. A denominator measured by well child visits, versus empanelled patients, might drive different interventions with ultimately different outcomes.

No single type of intervention arose as consistently more effective in increasing screening quality, and few studies addressed the critical issue of assuring adequate follow-up. This review did not identify specific interventions that work better than others, however multifaceted, practice-tailored interventions with ongoing outcome assessment seemed to be effective, and most comprehensively evaluated. Policies supporting such interventions broadly will likely lead to earlier detection and more effective treatment for a large population of children. Quality improvement activities are now required for maintenance of board certification, and many local health systems and payers ask or require practices to participate. Medical societies, such as the American Academy of Pediatrics, can help provide infrastructure to encourage efforts by individual practices.

This review leaves several additional questions: Which components of interventions add to effectiveness, and which are ineffective? What interventions improve follow-up care? How sustainable are the effects of these interventions? Are different interventions more effective for different types of screening procedures (e.g., questionnaires versus blood draws)? How is
practice context best measured, and how is it associated with the success of interventions? Such future avenues for research will help refine interventions to move toward effective, efficient screening in primary care pediatrics.

Acknowledgments

Funding: Maternal and Child Health Bureau, cooperative agreement # 5 U53MC04473-03-00

We are grateful to the Maternal and Child Health Bureau, who provided funding for this study (Cooperative agreement # 5 U53MC04473-03-00).

Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>MCHB</td>
<td>Maternal and Child Health Bureau</td>
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<tr>
<td>HS</td>
<td>Healthy Steps</td>
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<tr>
<td>LC</td>
<td>Learning collaborative</td>
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<tr>
<td>BMI</td>
<td>Body mass index</td>
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<tr>
<td>BP</td>
<td>Blood pressure</td>
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<tr>
<td>QI</td>
<td>Quality improvement</td>
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<tr>
<td>HMO</td>
<td>Health maintenance organization</td>
</tr>
<tr>
<td>PEDS</td>
<td>Parents’ evaluation of developmental status</td>
</tr>
<tr>
<td>EMR</td>
<td>Electronic medical record</td>
</tr>
<tr>
<td>EPSDT</td>
<td>Early periodic screening, diagnosis and treatment</td>
</tr>
<tr>
<td>ASQ</td>
<td>Ages and stages questionnaire</td>
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<tr>
<td>AAP</td>
<td>American Academy of Pediatrics</td>
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<tr>
<td>RCT</td>
<td>Randomized controlled trial</td>
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</table>

References


### Specific conditions for which routine screening is recommended:
- Developmental delays, autism spectrum disorder
- Mental health, behavioral, psychosocial problems
- Vision problems
- Hearing loss
- Lead poisoning
- Anemia
- Tuberculosis
- Hypertension
- Obesity
- Substance abuse
- STI's (Chlamydia, HIV)

### Interventions:
- Interventions to improve quality of screening process (including results follow-up)
  - Physician training/education
  - Office-based quality improvement initiatives
  - Incorporation of screening procedures in office workflow
  - EMR/paper chart enhancements
    - Screening reminders
    - Chart flagging
    - Methods of charting screening results
  - Registries of patients with abnormal screening results
  - Patient reminder/recall of need for screening tests
  - Hiring and/or training non-physician staff to facilitate screening
  - Pay-for-performance incentives or other reimbursement changes

### Outcomes:
- Improved quality of screening
  - Primary outcomes
    - Proportion of children appropriately screened
    - Proportion of children receiving appropriate secondary evaluation
  - Secondary outcomes
    - Earlier identification of problems
    - More equitable screening among different populations
    - More efficient health care utilization/treatment

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**Figure 1.**
Logic Model for Core Objective: Practice-based interventions to improve screening
Figure 2.
Flow of titles, abstract and articles included in review
### Table 1

Specific search terms to identify articles testing practice-based interventions to increase the quality of screening in pediatric practices

<table>
<thead>
<tr>
<th>Screening/specific disorders</th>
<th>Setting</th>
<th>Interventions/outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass screening</td>
<td>Primary health care</td>
<td>Physician’s Practice Patterns</td>
</tr>
<tr>
<td>Population surveillance</td>
<td>Community health centers</td>
<td>Child Health Services</td>
</tr>
<tr>
<td>Preventive health services</td>
<td>Managed care programs</td>
<td>Medical Records Systems, Computerized</td>
</tr>
<tr>
<td>Child development</td>
<td>Group practice</td>
<td>Decision Support Systems, Clinical</td>
</tr>
<tr>
<td>Developmental disabilities</td>
<td></td>
<td>Information Systems</td>
</tr>
<tr>
<td>Language disorders</td>
<td></td>
<td>Education, Medical</td>
</tr>
<tr>
<td>Child behavior disorders</td>
<td></td>
<td>Education, Medical, Continuing</td>
</tr>
<tr>
<td>Cerebral palsy</td>
<td></td>
<td>Insurance, Health, Reimbursement</td>
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<tr>
<td>Autistic disorder</td>
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<td>Total Quality Management</td>
</tr>
<tr>
<td>Mental retardation</td>
<td></td>
<td>Quality Assurance, Health Care</td>
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<tr>
<td>Vision disorders</td>
<td></td>
<td>Referral and Consultation</td>
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<tr>
<td>Hearing loss</td>
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<td>Primary Prevention</td>
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<td>Lead poisoning</td>
<td></td>
<td>Healthcare Disparities</td>
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<tr>
<td>Anemia</td>
<td></td>
<td>Health Care Costs</td>
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<td>Iron deficiency</td>
<td></td>
<td>Quality of Health Care</td>
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<td>Hypertension</td>
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<td>Outcome Assessment</td>
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<td>Obesity</td>
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<td>Process Assessment</td>
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<td>Depression</td>
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<tr>
<td>Tuberculosis</td>
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<tr>
<td>Sexually transmitted infections</td>
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</tbody>
</table>

* In PubMed, language was limited to “English” and population was limited to “All child: 0–18 years”
Table 2
Interventions to improve screening and follow-up of abnormal screening tests in pediatric primary care, by type of study design

<table>
<thead>
<tr>
<th>Author, year, design</th>
<th>Condition(s) being screened and screening test(s)</th>
<th>Pre-Intervention or control group screening (% of patients screened, unless otherwise specified)</th>
<th>Post-Intervention or experimental group screening (% of patients screened, unless otherwise specified)</th>
<th>Significance testing (p-value unless otherwise specified)</th>
<th>Nature of the intervention, setting/population, and other comments about the study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Randomized Controlled Trials</strong></td>
<td></td>
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<tr>
<td>1. Margolis PA, et al. (2004) RCT</td>
<td>Lead poisoning, anemia, and tuberculosis: Serum lead level: Intervention Control</td>
<td>23% 18%</td>
<td>68% 30%</td>
<td>&lt;0.05</td>
<td><strong>Intervention</strong>: Process improvement methods (aka “knowledge translation”) to improve office systems around preventive care services.</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>• Formation of practice-based improvement teams</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>• Ongoing academic detailing by project staff</td>
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<td></td>
<td>• Plan-do-study-act cycles with goal setting, workflow mapping, audit/feedback.</td>
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<tr>
<td></td>
<td>Hematocrit: Intervention Control</td>
<td>65% 64%</td>
<td>79% 71%</td>
<td>&lt;0.05</td>
<td><strong>Setting/population</strong>: 44 practices in North Carolina were randomized to intervention vs. usual care; n=~660 each for post-intervention control and experimental groups; children aged 24–30 months.</td>
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<td></td>
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<td></td>
<td></td>
<td><strong>Other comments</strong>: Data were collected pre- and post-intervention for both control and experimental group practices. Tuberculosis screening was PPD, Mantoux test, or risk assessment</td>
</tr>
<tr>
<td></td>
<td>Tuberculosis screening: Intervention Control</td>
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<tr>
<td>2. Minkovitz CS, et al. (2003) RCT</td>
<td>Developmental problems: Parent-reported developmental assessment</td>
<td>41-43%</td>
<td>82-84%</td>
<td>&lt;0.001</td>
<td><strong>Intervention</strong>: Healthy Steps (HS) program a. Co-located developmental specialists to enhance well-child visits; also conducted home visits, provided telephone information line for parents about development, written materials, parent groups, linkages to community resources. <strong>Setting/population</strong>: 15 practices randomized in 14 states; experimental n=2021 patients, control n=1716 patients; post-intervention data were collected for children aged 30–33 months.</td>
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<td><strong>Other comments</strong>: Parents reported any developmental screening questions (not specifically whether a formal tool was used)</td>
</tr>
<tr>
<td>3. Scholes D, et al. (2006) RCT</td>
<td>Chlamydia infection: Urine Chlamydia screening</td>
<td>Practice-level intervention: 37.5%</td>
<td>39.6%</td>
<td>0.31</td>
<td><strong>Intervention</strong>: Practice and patient-level interventions</td>
</tr>
<tr>
<td></td>
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<td>EMR reminder: 40.8%</td>
<td>42.6%</td>
<td>0.27</td>
<td>• Practice-level intervention—Use of peer opinion leader teams; 1 day training session around implementing screening guidelines; quarterly feedback reports on screening quality</td>
</tr>
<tr>
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<tr>
<td>4. Shafer MA, et al. (2002) RCT</td>
<td>Chlamydia infection: Urine Chlamydia screening</td>
<td>EMR reminder: 40.8% 21%</td>
<td>42.6% 65%</td>
<td>0.27 &lt;0.001</td>
<td>Intervention: Quality improvement initiative within managed care network  • Practices formed improvement teams; monthly meetings to strategize about solutions to self-identified barriers to screening, using Plan-Do-Study-Act cycles; performance monitoring  • Intervention targeted preventive care visits Setting/population: 10 pediatric practices in California; experimental n=1017 patients, control n=1194 patients; sexually active adolescent females. Other comments: Data were collected pre- and post-intervention for both control and experimental group practices.</td>
</tr>
<tr>
<td>5. Tebb KP, et al. (2009) RCT</td>
<td>Chlamydia infection: Urine Chlamydia screening Intervention Control</td>
<td>26% 32%</td>
<td>42% 30%</td>
<td>&lt;0.001</td>
<td>Intervention: Quality improvement initiative within managed care network  • Practices formed improvement teams; monthly meetings with focus on workflow, performance monitoring using Plan-Do-Study-Act cycles  • Intervention targeted urgent care visits Setting/population: 10 pediatric practices in California; n was not reported; sexually active adolescent females. Other comments: Data were collected pre- and post-intervention for both control and experimental group practices.</td>
</tr>
<tr>
<td>6. Adams WG et al. (2003) Pre-post</td>
<td>Developmental problems, anemia, lead poisoning, hearing and vision problems: Language development</td>
<td>65.1% 70.0%</td>
<td>Relative risk (95% confidence interval): 1.07 (0.97–1.09)</td>
<td>1.16 (1.04–1.28)</td>
<td>Intervention: EMR template with prompts to improve preventive care services  • Prompts included were age-specific milestones regarding development in social, fine/gross motor, and language skills, with checkboxes and normal ranges.</td>
</tr>
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</table>
| 7. Applegate H, et al. (2003) Pre-post<sup>33</sup> | Behavior, developmental and emotional problems: Discussion about behavior, developmental or emotional problems (# items discussed per visit) | 1.6 items | 10.4 items per visit after Stage 1; 9.9 items per visit after Stage 2 | | Intervention: Provider education and support tools to implement Pediatric Symptom Checklist (PSC); intervention was 2 stages  
• Stage 1: Provider training session about screening tool, importance of screening, screener placed on medical chart  
• Stage 2: Implementation of provider and patient handouts that followed the structure of the PSC and were designed to address specific subgroups of symptoms.  
Setting/population: One academic pediatric practice; pre-intervention n=16 patients; post-intervention n=38 patients; children aged 6–16 years.  
Other comments: No significance testing reported |
|                      | Intervention for behavior and emotional problems (# of interventions per visit) | 0 interventions | 0.125 interventions per visit after Stage 1; 1.9 interventions per visit after Stage 2 | | |
| 8. Block B, et al. (1996) Pre-post<sup>40</sup> | Follow up of elevated lead levels: Follow up plan in chart | 32% | 100% | | Intervention: Nurse-led protocol to follow up abnormally elevated lead levels--  
• Case management performed by a nurse  
• Nurse-initiated physician education on specific cases  
• Electronic tracking of patients within the practice  
• Joint tracking of patients with public health department  
Setting/population: One academic family medicine practice in Pennsylvania; pre-intervention n=22 patients with abnormal lead levels, post-intervention n=99 patients with abnormal lead levels |
<p>|                      | Follow up serum lead level done | 9% | 65% | | |
|                      | Parent education about reducing exposure, if persistently high levels | Not measured | 28% | | |</p>
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</table>
| 9. Bordley WC, et al. (2001) Pre-post<sup>22</sup> | Follow up serum lead level done | 9%                                                                                           | 65%                                                                                           | 67%                                                                                           | **Intervention:** Quality improvement intervention to improve preventive care:  
  - Practice improvement teams  
  - Specific changes to workflow were individualized by practices and included:  
    - Sending patient reminder cards  
    - Chart screening prior to patient being seen  
    - Chart flagging  
    - Using flowsheets and medical record templates  
**Setting/population:** 8 practices in North Carolina; pre-intervention n=339 patients; post-intervention n=300; children aged 24–30 months  
**Other comments:** Lead and tuberculosis screening was risk assessment and laboratory/skin testing, if indicated |
| 10. Dunlop AL, et al. (2007) Pre-post<sup>23</sup> | Obesity: BMI percentile documented in chart | 12%                                                                                           | 15% after Stage 1  
  28% after Stage 2                                                                 | NS                                                                                           | **Intervention:** Provider training and support tools for obesity.  
  2 staged intervention:  
    - Stage 1: 2-hour provider training explaining guidelines for assessing and managing overweight and counseling framework (AIM—Advise, Identify, Motivate); training on using BMI calculator and growth charts  
    - Stage 2: 3 month supply of tools—parent screening tool/counseling guide, BMI charts, "prescription pad" for nutrition/physical activity  
**Population/setting:** 6 academic family medicine and pediatric practices in Georgia; pre-intervention n=466; Stage 1 n=538, Stage 2 n=344; children aged 2–17 years |
<p>| 11. Lannon CM, et al. (2008) Pre-post&lt;sup&gt;21&lt;/sup&gt; | Developmental problems PEDS or ASQ | 30% (received any developmental screening)                                                                 | 45% (using structured tool (e.g., ASQ)) | NS | <strong>Intervention:</strong> Bright Futures Training Intervention Project: learning collaborative/quality improvement initiative to improve preventive care services |</p>
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| 12. Polacsek M, et al. (2009) Pre-post25 | Obesity: BMI documented in chart screening with previsit, self-administered tool to assess patient’s behavior around nutrition and physical activity | 38% Not measured | 94% 82% | <0.001 0.001 | • Key practice-level changes included:  
  – Structured developmental screening (PEDS or ASQ)  
  – Chart prompts  
  – Patient recall/reminder  
  – Linkages with community agencies  
  • Used practice improvement teams and plan-do-study-act cycles  
  *Population/setting:* 15 practices in 9 states; experimental n=305 patients, control n=171 patients; children aged 0–5 years  
  Other comments: No participating practices used formal developmental screening tools pre-intervention.  |
| 13. Shaw JS, et al. (2006) Pre-post19 | Lead poisoning, anemia, tuberculosis, hypertension: Lead screening | 72% | 85% | 0.001 |  
  **Intervention:** Learning collaborative  
  • Teams of physician, nurse and administrator from each practice; 3 1.5 day learning sessions for teams; practices set goals around nutrition and physical activity screening and counseling.  
  • Patient screening instruments and provider decision support tools for obesity management  
  *Population/setting:* 12 practices in Maine; n=600 patients with visits during both pre and post intervention periods; children aged 5–18 years.  |

<table>
<thead>
<tr>
<th></th>
<th>Hematocrit</th>
<th>Vision screening</th>
<th>Tuberculosis screening</th>
<th>Blood pressure</th>
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<tbody>
<tr>
<td></td>
<td>70%</td>
<td>62%</td>
<td>18%</td>
<td>85%</td>
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<tr>
<td></td>
<td>74%</td>
<td>75%</td>
<td>39%</td>
<td>82%</td>
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<tr>
<td></td>
<td>NS</td>
<td>0.013</td>
<td>0.001</td>
<td>NS</td>
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</table>

**Interventions:** State-wide learning collaborative with 4 1-day learning sessions  
• Practices formed teams (physician, nurse, administrator) and chose preventive care outcomes to address through practice improvements.  
• Included periodic statewide gatherings for QI training, collaborative tele-telephone calls, audit/feedback to practices
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<tr>
<td>14. Young PC, et al. (2006) Pre-post</td>
<td>Hematocrit</td>
<td>70%</td>
<td>74%</td>
<td>NS</td>
<td></td>
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<tr>
<td></td>
<td>Vision screening</td>
<td>62%</td>
<td>75%</td>
<td>0.013</td>
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<tr>
<td></td>
<td>Tuberculosis screening</td>
<td>18%</td>
<td>39%</td>
<td>0.001</td>
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<tr>
<td></td>
<td>Blood pressure</td>
<td>85%</td>
<td>82%</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anemia, vision problems, hypertension, obesity: Hematocrit</td>
<td>49%</td>
<td>57%</td>
<td>0.36</td>
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</tr>
<tr>
<td></td>
<td>Vision screening</td>
<td>46%</td>
<td>75%</td>
<td>0.007</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BP screening</td>
<td>59%</td>
<td>74%</td>
<td>0.010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BMI recorded</td>
<td>32%</td>
<td>45%</td>
<td>0.078</td>
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<tr>
<td><strong>Post-intervention with and without a control group</strong></td>
<td></td>
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<tr>
<td>15. Gioia PC. (2001) Post intervention without control group</td>
<td>Lead poisoning: Serum lead level</td>
<td>Not measured</td>
<td>81%</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Vision disorders: monocular visual acuity and stereopsis 3 year olds</td>
<td>Not measured</td>
<td>70–85%</td>
<td></td>
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<tr>
<td></td>
<td>4 year olds</td>
<td>Not measured</td>
<td>93–94%</td>
<td></td>
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<tr>
<td>16. Hartmann EE, et al. (2006) Post-intervention without control group</td>
<td>Lead poisoning, anemia, hearing, vision:</td>
<td>74%</td>
<td>100%</td>
<td>&lt;0.001</td>
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</table>

Other comments: Tuberculosis and lead screening were risk assessment and laboratory/skin testing, if indicated.
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<tr>
<td>with concurrent control group&lt;sup&gt;9&lt;/sup&gt;</td>
<td>“Laboratory testing” (serum lead level and hematocrit)</td>
<td>Hearing 12%</td>
<td>100%</td>
<td>&lt;0.001</td>
<td>• EPSDT screening, carried out by a nurse with a specific preventive care role, using protocol attached to medical record. Population/setting: One academic practice received intervention; control group was sample of children from other practices. Intervention group n=514, control n=115 patients; children aged 0–17 years</td>
</tr>
<tr>
<td>Niederman LG, et al. (2007) Post-intervention with concurrent control group&lt;sup&gt;10&lt;/sup&gt;</td>
<td>Anemia and lead poisoning: Hematocrit</td>
<td>77%</td>
<td>73%</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Serum lead level</td>
<td>64%</td>
<td>67%</td>
<td>NS</td>
<td></td>
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<tr>
<td>Ozer EM, et al. (2005) Post-intervention with concurrent control group&lt;sup&gt;11&lt;/sup&gt;</td>
<td>Adolescent health risk behaviors: Adolescent health screening questionnaire</td>
<td>Not measured</td>
<td>80%</td>
<td>NA</td>
<td>Intervention: Provider training, patient questionnaire, and prompts to facilitate communication about adolescent risk behaviors 2 stage intervention: • Stage 1: 8-hour provider training workshop around knowledge and skills regarding adolescent preventive care • Stage 2: Introduction of patient questionnaire and provider form to screen for and document discussion and counseling regarding risky behaviors. Population/setting: 4 practices in California (2 practices received the intervention); experimental n=1717, control n=911 patients; adolescents aged 14–17 years Other comments: Control practices’ screening did not differ over study period</td>
</tr>
<tr>
<td></td>
<td>Provider asked about alcohol use during visit</td>
<td>67%</td>
<td>82% after Stage 1 83% after Stage 2</td>
<td>&lt;0.01 &lt;0.001</td>
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<tr>
<td></td>
<td>Provider counseled on alcohol use during visit</td>
<td>59%</td>
<td>77% after Stage 1 81% after Stage 2</td>
<td>&lt;0.01 &lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Schonwald A, et al. (2009) Post intervention without concurrent control group&lt;sup&gt;12&lt;/sup&gt;</td>
<td>Behavior and development problems: PEDS</td>
<td>Not measured</td>
<td>61%</td>
<td></td>
<td>Intervention: Implementation of developmental screening using PEDS • 1-hour provider and staff training: physician champion who was available to answer questions from providers and staff. • Offered as option for referral a second-stage screening service at the practice staffed by an educational specialist</td>
</tr>
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<tr>
<td><strong>Time Series</strong></td>
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</table>
| 21. Earls M, et al. (2006) Time series<sup>28</sup> | Developmental problems: ASQ | 24% | 62% at year 2; 76% at year 5 |                                                                                              | Intervention: Quality improvement initiative to improve child development services:  
- Practices completed Plan-Do-Study-Act cycles  
- Emphasized physician champion, workflow map, staff involvement, and periodic data review  
- Part of a larger state-wide initiative that involved state-level policy changes around child developmental services |
|                       | Population/setting: 1 practice in Massachusetts; pre-intervention n=338 patients, post-intervention n=278 patients; children aged 20–40 months | Other comments: Use of structured developmental assessments was not routine pre-intervention; authors reported an increase in developmental concerns identified post-intervention (21% vs. 26%, p=0.05); proportion of children referred for developmental concerns did not change post intervention (10% vs 11%). |
| 22. King TM, et al. (2010) Time series<sup>24</sup> | Development problems: PEDS or ASQ | Not measured | 67% at 1 month; 85% at 9 months |                                                                                              | Intervention: Provider and staff education, physician champion identification  
- One-day workshop for practice teams. Practices teams were a group of three key stakeholders within each practice (physician champion, staff member, and another person).  
- AAP-sponsored national pilot project to implement guideline-adherent developmental screening |
|                       | Population/setting: Several practices in North Carolina; sample size was not reported | Other comments: No significance testing reported |

<sup>24</sup> Upper bound estimated for 22 months plus 30% growth in the number of children screened. <sup>28</sup>No significance testing reported.
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- Practices participated in 3 8-hour training sessions, monthly phone calls, and practice-based coaching in QI, which included on-site visits to practices  
- Coincided with community-level efforts to better manage chronic conditions, including obesity  
Population/setting: 8 practices in Washington state. Chart audits of 20 pediatric patients per month per practice were tracked for 9 months. Age range of patients was not reported. Other comments: No significance testing reported |

Abbreviations:  
HS – Healthy Steps  
LC – Learning collaborative  
BMI – Body mass index  
BP – Blood pressure  
QI – Quality improvement  
HMO – Health maintenance organization  
PEDS – Parents’ evaluation of developmental status  
EMR – Electronic medical record  
EPSDT – Early periodic screening, diagnosis and treatment  
ASQ – Ages and stages questionnaire  
AAP – American Academy of Pediatrics  
RCT – Randomized controlled trial