

Overdiagnosis: How Our Compulsion for Diagnosis May Be Harming Children

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ABBREVIATION

ADHD—attention-deficit/hyperactivity disorder

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abstract

FREE

Overdiagnosis occurs when a true abnormality is discovered, but detection of that abnormality does not benefit the patient. It should be distinguished from misdiagnosis, in which the diagnosis is inaccurate, and it is not synonymous with overtreatment or overuse, in which excess medication or procedures are provided to patients for both correct and incorrect diagnoses. Overdiagnosis for adult conditions has gained a great deal of recognition over the last few years, led by realizations that certain screening initiatives, such as those for breast and prostate cancer, may be harming the very people they were designed to protect. In the fall of 2014, the second international Preventing Overdiagnosis Conference will be held, and the British Medical Journal will produce an overdiagnosis-themed journal issue. However, overdiagnosis in children has been less well described. This special article seeks to raise awareness of the possibility of overdiagnosis in pediatrics, suggesting that overdiagnosis may affect commonly diagnosed conditions such as attention-deficit/hyperactivity disorder, bacteremia, food allergy, hyperbilirubinemia, obstructive sleep apnea, and urinary tract infection. Through these and other examples, we discuss why overdiagnosis occurs and how it may be harming children. Additionally, we consider research and education strategies, with the goal to better elucidate pediatric overdiagnosis and mitigate its influence. *Pediatrics* 2014;134:1013–1023

Overdiagnosis is defined as the identification of an abnormality where detection will not benefit the patient. Unlike misdiagnosis, the finding is accurate; the condition detected may be precisely the condition that was meant to be detected (a true-positive). The notion that an accurate diagnosis could be anything but beneficial runs counter to the conventional wisdom that the more that is known about a patient, the better. Unfortunately, not only do overdiagnosed patients fail to benefit from their diagnosis, they may also be harmed.

Consider the following common clinical scenarios. An 8-year-old boy with tonsillar hypertrophy on examination and polysomnography consistent with obstructive sleep apnea undergoes an adenotonsillectomy. A 4 year-old girl with a head injury, 2 episodes of vomiting, and a normal physical examination undergoes a head CT scan, which shows a small subdural hematoma, for which she is admitted to the PICU. A 3-month-old girl with bronchiolitis seen in an emergency department has an oxygen saturation of 94% at triage but desaturates to 88% while asleep on continuous pulse oximetry, prompting hospital admission. In each case, the diagnoses were accurate; the diagnostic tests detected precisely what they were intended to detect. Providers may disagree on the optimal treatment approaches for these diagnosed children, but the focus of this article is not mistreatment or overtreatment but rather the incipient event of diagnosis. Did these 3 children benefit from their accurate diagnoses?

For an individual patient, determining whether a diagnosis is beneficial can be a nearly impossible task, just as it is often difficult to tell how much benefit an individual derives from treatment; one can never know with certainty what would have happened if the diagnosis had not been made or the treatment not given. However, just as it is possible to

evaluate the likelihood of benefit from treatments across populations, it is possible to know the likelihood of benefit from diagnostic testing.

RESEARCH METHODS TO INVESTIGATE OVERDIAGNOSIS

The following experimental designs have been used to detect overdiagnosis.

Randomized Trials of Screening Tests

The most convincing examples of overdiagnosis come from randomized trials of cancer screening tests. If patients randomly assigned to screening experience more diagnosis of disease but do not experience net benefit (generally measured in terms of overall mortality) compared with those randomly assigned to no screening or less screening, overdiagnosis exists. For example, in the recent Canadian trial of screening mammography involving almost 90 000 women, breast cancer diagnosis was unsurprisingly more common in women randomly assigned to receive annual mammography than in women assigned to no mammography.¹ However, over the next 25 years all-cause and breast cancer-specific mortality were equivalent in both groups. The authors estimated that 1 overdiagnosed breast cancer occurs for every 424 women who undergo screening mammography. Mammography was successful in detecting breast cancer but did not save lives. Randomized trials were similarly used to demonstrate overdiagnosis of neuroblastoma in young children with implementation of universal urine screening (Table 1). A German trial found unchanged mortality rates from neuroblastoma after widespread screening with urinary catecholamines at 1 year of age and estimated that 62% of neuroblastoma cases identified were overdiagnosed.^{2,3} A Canadian trial of universal screening for neuroblastoma yielded similar results.⁴ However, it

should be noted that randomized trial designs are often limited by a commitment to internal validity and efficacy, which limits generalizability. Testing or screening interventions may show an effect under idealized trial conditions, but post hoc naturalistic studies may be better equipped to evaluate their effectiveness in real-world conditions.

The Natural Experiment: Delayed or Missed Diagnoses Without Patient Harm

Diagnoses made after a patient has overcome the abnormality or remained asymptomatic over a lifetime, despite the absence of detection and medical intervention, suggest overdiagnosis. For example, nearly 10% of men in their 20s and >80% of men in their 70s have prostate cancer discovered incidentally on autopsy after they die from an accident, yet only 3% of men die of prostate cancer.^{5,6} In other words, although many men have or will have prostate cancer, most are not overtly harmed by this condition. Indeed, randomized trials of prostate cancer screening have demonstrated increased detection with screening without an improvement in mortality.^{7,8} In children, studies have identified proportions of missed and untreated diagnoses of bacteremia,⁹ urinary tract infection (UTI),¹⁰ and medium-chain acyl-coenzyme A dehydrogenase deficiency,¹¹ without any harm to the child (Table 1). This study design can be confounded by prognostic factors, in that missed diagnoses may be systematically different (ie, milder or more indolent) compared with conditions that reached detection.

Increasing Disease Incidence but Unchanging Morbidity or Mortality

An increasing incidence of diagnosis of a specific disease should always trigger suspicion of overdiagnosis. When the increase in incidence is accompanied by an unchanging rate of the outcome

important to patients (usually mortality), overdiagnosis is a likely explanation. For example, thyroid cancer incidence increased almost two and a half fold from 1973 to 2002, but mortality due to thyroid cancer did not change.¹² Analogous pediatric examples include hypoxemia in bronchiolitis and hyperbilirubinemia (Table 1), where increased detection and treatment of both conditions has not decreased mortality.^{13,14} An alternative explanation could be that a clinically important increase in incidence occurred, but an otherwise higher rate of outcomes important to patients was exactly matched by effective treatment modalities, keeping outcomes constant. This explanation requires both a biologic mechanism to explain a truly increased incidence and evidence of improved treatment outcomes.

Although it is clear that the most conclusive evidence of overdiagnosis comes from adult trials of cancer screening, it has been suggested that overdiagnosis also affects nonneoplastic, common adult conditions such as hypertension, diabetes, and osteoporosis.¹⁵ In these chronic diseases, lowering the threshold values for disease has further increased the risk of overdiagnosis.¹⁵ Similarly, overdiagnosis is probably affecting routine conditions in pediatrics. However, although the importance of overdiagnosis as a driver of avoidable and potentially harmful medical care in adult populations has gained prominence recently, through conferences,¹⁶ books,¹⁵ and dedicated themed journal issues,¹⁷ the phenomenon is rarely described in pediatrics.

OVERDIAGNOSIS IN CHILDREN

There will almost always be a proportion of patients who benefit from any diagnosis, including the examples we have chosen. In evaluating the importance of overdiagnosis in a condition at the population level, we propose focusing on the frequency of overdiagnoses relative

TABLE 1 Examples of Possible Overdiagnosis in Pediatrics

Diagnosis	Evidence of Overdiagnosis
ADHD	The youngest children for a given grade level are significantly more likely than their older classmates to receive a diagnosis of ADHD. ^{85–85} Although this phenomenon has been labeled overdiagnosis, one could argue that misdiagnosis is more appropriate (ie, immaturity is misdiagnosed as ADHD).
Aspiration	The natural course of aspiration detected by swallow study in anatomically and neurologically normal infants is complete resolution. ^{80,81} It is unknown whether making this diagnosis benefits infants. The largest assessment of outcomes for neurologically impaired infants found that fundoplication did not reduce their risk of hospitalization for respiratory illness. ⁸²
Bacteremia	A trial of children age 3–36 mo presenting to an emergency department with fever >39°C treated 19 children with bacteremia with placebo (no antibiotic). ⁹ Eighteen children had spontaneous resolution of bacteremia at 48 h. None developed serious morbidity (meningitis, pneumonia, bone or joint infection, cellulitis).
Cholelithiasis	50% of children diagnosed with cholelithiasis in 1 study were completely asymptomatic at diagnosis, of whom 95% were free of complications on long-term follow-up. ⁸⁶
Food allergy	Children can have positive immunoglobulin E test results indicating sensitization but not necessarily suffer from a clinical allergy. ⁸⁷ For example, 17% of people are sensitized to a major food allergen, but only 2.5% have a clinical food allergy. ⁸⁸
Gastroesophageal reflux	Reflux is common in the first 6 mo of age and nearly completely resolves by 12 mo of age, independent of any medical interventions. ^{89,90} A randomized trial found no benefit to treatment of symptoms attributed to gastroesophageal reflux disease in infants but did find that medication increased the risk of lower respiratory tract infections. ⁹¹ Yet gastroesophageal reflux disease diagnoses and treatments with medication for infants are common and increasing. ^{92,93}
Hyperbilirubinemia	There was no change in mortality due to kernicterus between 1979 and 2006, ¹⁴ despite increased vigilance for hyperbilirubinemia, including bilirubin testing and phototherapy. ^{94,95}
Hypercholesterolemia	The 2011 National Heart, Lung, and Blood Institute guidelines recommend universal screening for children age 9–11 and potentially qualify 200 000 children for treatment, ⁹⁶ with unclear evidence for long-term harms and benefits of diagnosis and treatment. ^{97–99}
Hypoxemia in bronchiolitis	Hospital admissions for children with bronchiolitis have significantly increased since 1980, a period coinciding with increased use of pulse oximetry, yet mortality from bronchiolitis during the same time period has been unchanged. ^{13,100} Oxygen saturation changes as small as 2% significantly increase a physician's decision for admission, and the diagnosis of hypoxemia by continuous pulse oximetry prolongs hospitalization, but there is no evidence that supplemental oxygen for transient desaturations benefits children. ^{101–103}
Medium-chain acyl-coenzyme A dehydrogenase deficiency	A portion of newborns identified by newborn screening may never experience symptoms of their enzymatic defect. Studies have identified affected but completely asymptomatic older siblings of screening-identified newborns, ¹¹ and some mutations identified by newborn screening have acylcarnitine profiles that normalize over time. ¹⁰⁴
Neuroblastoma	A portion of neuroblastoma diagnoses will regress without treatment. ¹⁰⁵ Screening children for neuroblastoma identifies more lower-stage cancers but does not reduce end-stage neuroblastoma or mortality. ^{2,4}

TABLE 1 Continued

Diagnosis	Evidence of Overdiagnosis
OSA	In 1 trial, almost half of children with OSA randomized to watchful waiting had complete normalization of their polysomnographic findings 7 mo after enrollment. ¹⁰⁶ The same trial failed to show a benefit for the primary outcome (attention and executive function) after surgical intervention for OSA. Tonsillectomy rates nearly doubled between 1996 and 2006, ¹⁰⁷ a proportion of which probably are attributable to the surgical indication of OSA, which increased from 12% of patients in 1970 to 77% in 2005. ¹⁰⁸
Skull fracture	Children with isolated skull fractures have excellent outcomes without neurosurgical intervention, yet they are subjected to repeat CT scanning and often hospitalized. ^{109–111}
UTI	According to a Pediatric Research in Office Settings study of young, febrile infants, of 807 febrile infants never tested or treated for UTI, 61 were predicted to have a UTI based on the application of predictors of UTI in infants who did undergo urine testing. ¹⁰ Only 2 of the 807 infants not initially tested or treated were later diagnosed with a UTI, and none suffered immediate morbidity or mortality.
VUR	Most VUR, including high-grade VUR, resolves over time, and few if any interventions for VUR decrease rates of renal scarring or insufficiency. ^{112,113}

OSA, obstructive sleep apnea; UTI, urinary tract infection; VUR, vesicoureteral reflux.

to needed diagnoses, the ratio of potential benefits from needed diagnoses to potential harms from overdiagnoses, and the amount of resource utilization resulting from overdiagnosis. Thus, the examples in Table 1 feature diagnoses with unclear or infrequent opportunity for benefit, the possibility for harm, or high resource utilization.

For example, universal or nearly universal bilirubin screening is common in the United States, intended to decrease infants' risk of kernicterus, a rare but devastating neurologic condition. However, the number of infants who must be treated with phototherapy to prevent 1 infant from needing exchange transfusion is high,¹⁸ meaning that most infants with hyperbilirubinemia do not benefit from diagnosis and treatment. The number needed to treat for the more important outcome, kernicterus, is probably much larger. Unfortunately, as concluded by the US Preventive Services Task Force¹⁹ in 2009, evidence to support the efficacy of screening and treatment to reduce the risk of kernicterus is inadequate. Nevertheless, 10 to 80 in 1000 term and preterm in-

fants are treated for hyperbilirubinemia in the United States, at a cost of \$150 million per year for the healthy term cohort.²⁰ Because kernicterus is a devastating and potentially lethal condition, overdiagnosis and overtreatment of hyperbilirubinemia have been accepted as a reasonable tradeoff. However, the potential for harm from hospitalization and treatment of hyperbilirubinemia has not been adequately researched, and recent findings of a possible association between phototherapy and childhood leukemia may affect the risk/benefit analysis.^{21,22}

HOW IS OVERDIAGNOSIS HARMFUL?

Medical tests are more accessible, rapid, and frequently consumed than ever before. Discussions between patients and providers tend to focus on the potential benefits of testing, with less regard for potential harms.²³ Yet a single test can give rise to a cascade of events, many of which have the potential to harm.²⁴ We use a recently published taxonomy of 4 harm domains to frame the harms of overdiagnosis in

pediatrics: physical effects, psychological effects, financial strain, and opportunity cost.²⁵

Physical Effects

The physical effects of testing and interventions motivated by overdiagnoses are the most visible harms of unnecessary detection of an abnormality. Until recently, the standard of care for small, localized adrenal tumors in infants, including those overdiagnosed by neuroblastoma screening, was surgical resection, the mortality of which is 2% or higher.²⁶ For young infants with fever, the detection of bacteremia leads to prolongation of antibiotic therapy,²⁷ often via a peripherally inserted central catheter, for which the complication rate necessitating line removal in children <1 year of age is 48%.²⁸ The gold standard diagnostic test for aspiration, a videofluoroscopic swallow study, exposes subjects to radiation, and an aspiration diagnosis often results in an intervention, ranging from thickening feeds to surgery for gastric tubes and Nissen funduplications.

Psychological Effects

Subtle but potentially common byproducts of overdiagnosis are psychological effects, because all diagnoses, whether beneficial to the patient or not, change the perception of the child for the child, his or her caregivers, and society. Fundamentally, diagnoses connote abnormality, something to be remedied. One recent study found that parents given a hypothetical clinical scenario of a child with a gastroesophageal reflux disease label were more likely to believe the child would benefit from medication than parents given the same scenario without a gastroesophageal reflux disease label, a belief that persisted even when parents were told that the medications were probably ineffective.²⁹

Parental belief in their child's vulnerability after illness, despite full recovery,

was first described in 1964.³⁰ Unfortunately, the debilitating effects of the “vulnerable child syndrome” require only that a diagnosis is made, regardless of a child’s ability to benefit from the diagnosis. Forty percent of junior high school children with a history of an innocent heart murmur or other cardiac nondisease in 1 study suffered physical and psychological restriction after their diagnosis.³¹ In another study, parents of children with feeding and crying problems in infancy necessitating a change in formula were more likely to perceive their child as vulnerable >3 years later, despite being no more likely to report allergies, asthma, or eczema for their child.³² Finally, parents of infants with jaundice or phototherapy exposure are more likely to seek medical attention for their child well after jaundice resolution,³³ perceive subsequent illnesses as moderate or severe, and fear leaving their baby with any other caregiver.³⁴

Diagnoses also affect how children are treated by society. Approximately one-third of children with food allergy (a diagnosis now given to ~8% of children) suffer from allergy-related bullying and an associated lower quality of life.^{35,36} The widespread bullying of children with this diagnosis has prompted the “It’s Not a Joke” campaign, highlighting the emotional toll of food allergy bullying.³⁷

Financial Strain

Overdiagnosis is also harmful because of the resultant financial costs. Unnecessary and wasteful care are estimated to constitute 21% to 47% of all expenditures, which probably ignores the contribution of overdiagnosis given that accurate diagnoses, regardless of their benefit to the patient, are assumed to be necessary.³⁸ Providing oxygen to children with bronchiolitis, stimulants to students with attention or hyperactivity problems, and phototherapy to

infants with elevated bilirubin values are unlikely to be included in waste estimates, despite the fact that in some cases these interventions are not beneficial. The annual US health care costs for each of these conditions are \$543 million,³⁹ \$1.6 billion,⁴⁰ and \$150 million,²⁰ respectively.

Opportunity Cost

Finally, consideration must be given to the opportunity cost of overdiagnosis, the possibility that needed medical care is not provided because of unnecessary diagnoses, their subsequent interventions, and the psychological and financial burdens they impose. Unfortunately, this is an almost completely unstudied harm of overdiagnosis. The value of patient and family time and the quantity of their financial resources consumed by care related to overdiagnosis are unquantified. The attention and resources that providers could divert to patients who stand to benefit from diagnoses and treatments, were they not consumed by the overdiagnosed, are also unquantified.

WHAT IS DRIVING OVERDIAGNOSIS?

Drivers of excessive care are poorly quantified in health care in general, and we are aware of no research quantifying the factors that motivate pediatricians to test or treat. Drawing on the limited available literature from adult medicine, we propose several candidate drivers of overdiagnosis in pediatrics.

Physician Factors

Overdiagnosis is rarely addressed in the pediatric literature, and some pediatric providers may not be aware that the detection of abnormalities could be harmful. If a diagnostic test discovers the condition it was meant to discover, how could it have been unnecessary or even harmful? A head CT scan revealing a small bleed or a skull fracture might

leave a practitioner feeling validated by his or her decision to obtain the CT scan, even though detection of these abnormalities is unlikely to change management in a way that benefits the patient. If physicians are not aware of the potential harms of overdiagnosis, patients and families cannot be expected to appreciate them either. A survey of adult medicine providers found that their understanding of cancer screening statistics, including overdiagnosis, was poor. Almost half of those surveyed believed that finding more cancer cases in screened as opposed to unscreened populations proved that screening saved lives.⁴¹ Unfortunately, similar knowledge assessments have not been performed in pediatrics.

Intolerance of uncertainty can be a powerful motivator for diagnostic testing.^{42–44} Providers may be troubled by not having an answer to explain a patient’s complaint and respond to this uncertainty by relying on diagnostic tests or expert consultation. Provider perceptions that families want an answer, that testing expresses caring, and that watchful waiting ignores patient needs may propagate this behavior. For example, in a study investigating decisions to obtain head CT scans in children with minor blunt head trauma, providers acknowledged the influence of parental anxiety or request on their decision to order more CT scans. Interestingly, white non-Hispanic children were more likely to undergo unnecessary cranial CT scanning than their minority counterparts.⁴⁵

The culture of medical education is an early impetus for training providers to find comfort in commission and fear in uncertainty.⁴⁶ Problem-based learning strategies in medical school encourage a shotgun approach, which tends to reward unusual diagnoses and contributes to overtesting and overdiagnosis.^{47–49} An emphasis on avoiding omission errors in case report

conferences and morbidity and mortality conferences may strengthen these tendencies. Given this milieu, the production of providers eager for diagnosis, but unsighted of its possibility to harm, is only natural.

Finally, fear of litigation may motivate unnecessary testing, exposing patients to unnecessary diagnoses. Indeed, errors of omission (a patient is harmed because a necessary test or treatment was not provided) are more frequently punished by litigation than errors of commission (a patient is harmed because an unnecessary test or treatment was provided).⁵⁰ However, although providers often cite defensive medicine as a stimulus for unnecessary testing and care,^{51,52} reforms to lessen provider liability do not necessarily change their behavior.⁵³

System Incentives

External systemic forces may incentivize testing and diagnosis. Fee-for-service reimbursement, a target for reform, financially rewards providers for providing more, and potentially excessive, care. Supply-sensitive care, where higher capacity in the form of hospital beds and imaging modalities drives medical utilization, inevitably uncovers patient abnormalities.⁵⁴ Proposed pediatric quality indicators tend to encourage greater testing and treatment. In one evaluation, only 5 in 242 proposed pediatric ambulatory indicators focused on problems of overuse (compared with 225 in 242 for underuse),⁵⁵ whereas none of the 62 pediatric emergency department indicators in a separate assessment evaluated unnecessary tests.⁵⁶ In addition, physicians more readily improve on quality indicators aimed at underuse as opposed to overuse.⁵⁷ Finally, time constraints and loss of continuity of care lead to a substitution of testing for thorough review of records and patient assessment.^{58,59}

Industry Influence

Industry interests contribute to overdiagnosis by lobbying for widened diagnostic boundaries and using the media to generate demand for diagnosis, both of which create more patients and more profit.⁶⁰ For example, lowering the definition of hypercholesterolemia in adults from 240 to 200 mg/dL, a 2002 recommendation made by an expert panel where 8 of 9 panelists had financial conflicts of interest, created >42 million new diagnoses.^{61,62} Such conflicts of interest in defining disease are not unusual. In one study, 75% of members of panels responsible for defining the most common diseases in the United States had ties to industry that stood to benefit from expanded definitions.⁶³ The 2012 attention-deficit/hyperactivity disorder (ADHD) guideline panel included 9 members, 5 of whom had industry ties to manufacturers of widely used medications for ADHD.⁶³ Based on this committee's recommendations, the definition of ADHD was broadened to include children 4 to 18 years old (previously 6–12 years old).⁶⁴ Although it is unclear how many new diagnoses of ADHD this expansion created, diagnostic creep has resulted in the prescription of stimulants to >10 000 toddlers aged 2 and 3 years old.⁶⁵ Similar to concerns generated by the extension of the diagnosis of depressive disorder to include bereavement, the ADHD expansion risks medicalizing variations of normal human behavior.⁶⁶

Patients are also influenced by industry. Pharmaceutical companies spent \$4.5 billion on direct-to-consumer marketing in 2009.⁶⁷ Advertisements capitalize on our fear of undiagnosed disease and urge us to see our doctor for testing. Industry also reaches patients through patient advocacy groups. Once considered unbiased, third-party advocacy groups are often used to deliver the same message. A random sample of

US patient groups found that 80% received industry funding.⁶⁸ The National Alliance on Mental Illness, a mental health advocacy organization, received \$23 million, or approximately three-quarters of its donations, from drug makers between 2006 and 2008.⁶⁹

Public Psyche

Belief in scientific advance and a technological imperative, a confidence that the use of technology to detect disease is always beneficial, also drive overdiagnosis. A positive feedback loop of testing ensues, in which the test results, independent of the actual value (positive, negative, false-positive, or false-negative), confirm for patients that they should have been tested and make them more likely to seek additional testing.¹⁵ In a survey of adults, 98% of those who had experienced a false-positive test were glad they had the initial screening test, and 73% of all respondents would forgo \$1000 in cash for a total body CT scan.⁷⁰ Two buttresses of public enthusiasm for screening are lead time and length bias, which mistakenly bolster the argument for testing by erroneously overestimating prevalence and improved outcomes. Lead time bias occurs when diagnoses are identified earlier than they would be discovered clinically, falsely appearing to prolong survival, and length bias occurs when screening identifies disproportionately milder diagnoses.⁷¹

THE WAY FORWARD

A research agenda aimed at evaluating the harms and benefits of individual pediatric diagnoses and the frequency of overdiagnosis is needed. Of the examples presented here, the only conclusive evidence of pediatric overdiagnosis is for neuroblastoma screening.^{2–4} Currently, most studies of diagnostic tests report on test accuracy rather than evaluating whether the test results led

to important outcomes that benefited patients. The 3 research methods previously outlined (randomized trials, natural experiments, and comparison of incidence versus outcomes) provide reasonable starting points for studying the possibility of overdiagnosis for a particular abnormality. Additionally, practice variation may be an important beacon for overdiagnosis. Conditions for which testing and diagnostic variation exist, but important patient outcomes do not differ, would suggest overdiagnosis.

Because providers may be reluctant to accept evidence that is counter to their customary practice or experience, investigations delineating pediatric overdiagnosis ultimately must be augmented by advocacy and awareness efforts. The campaigns in Table 2 have each made strong contributions to this objective. Choosing Wisely is an example of dissemination and implementation of measures that aid providers in decreasing practice variation and unnecessary diagnostic testing, which may reduce the risk of overdiagnosis. Specifically, the majority of the pediatric Choosing Wisely initiatives decrease opportunities for overdiagnosis, with recommendations that limit the use of CT scans, MRI, chest radiographs, apnea monitors, food allergy screening, and continuous pulse oximetry.^{72,73} In general, guidelines that endorse testing can address the harms of overdiagnosis and support strong recommendations for testing with evidence that important outcomes for children are improved by diagnosis. Use of the US Preventive Services Task Force analytic framework, which considers both harms and benefits and clearly delineates pertinent outcomes, would help guideline panels in this endeavor.⁷⁴

Despite efforts made by the organizations listed in Table 2, there remains a large proportion of underinformed patients: Only 9.5% of adults with high

exposure to cancer screening programs reported being advised by their physician about the risk of overdiagnosis or overtreatment from screening.⁷⁵ Future pediatric research can evaluate the impact on patient decision-making when patients are exposed to farther-reaching impacts of a diagnosis. In Table 3, we list several common clinical scenarios where diagnostic tests are performed and provide examples of both proximate and long-term perspectives on why the test might be indicated. The proximate perspective addresses the immediate rationale for a diagnostic test, whereas the long-term perspective assesses possible diagnostic results and subsequent interventions. Both perspectives are important, but discussions about less immediate diagnostic corollaries, in particular, will help patients and providers frame testing decisions within the context of potential

overdiagnosis. Although it is unclear how this type of shared decision-making would affect diagnostic testing in children, examples from adult medicine reveal that many patients opt out of tests when provided comprehensive evidence on risks and benefits.⁷⁶

Finally, the incorporation of overdiagnosis into medical education curricula is critical. Students may be guided to produce carefully crafted differentials and workups that are probabilistic rather than “possibilistic.”⁷⁷ Differential-generating teaching sessions can acknowledge the risk of overdiagnosis, and morbidity and mortality conferences can expand to include cases of harms caused by overdiagnosis. The Do No Harm Project, vignettes produced by University of Colorado internal medicine residents illustrating harms from medical overuse, can serve as a model in the development of pediatric-specific

TABLE 2 Overdiagnosis Awareness and Mitigation Resources

Resource	Description	Website
Overdiagnosis Conference	Annual international conference	http://www.preventingoverdiagnosis.net/
<i>British Medical Journal: Too Much Medicine</i>	“Aim is to highlight threat to human health posed by overdiagnosis and the waste of resources on unnecessary care.”	http://www.bmj.com/too-much-medicine
<i>Overdiagnosed: Making People Sick in the Pursuit of Health</i>	Nonfiction book by Gilbert Welch that explores overdiagnosis in adults.	
Lown Institute	Advocacy group promoting delivery of the right care to patients.	http://lowninstitute.org/
Choosing Wisely	Campaign to promote care that is “supported by evidence, not duplicative, free from harm, and truly necessary.”	http://www.choosingwisely.org/
<i>Journal of the American Medical Association Internal Medicine “Less Is More” and “Teachable Moment” sections</i>	Initiative to highlight the risks and harms of unnecessary care, including overdiagnosis.	http://jamanetwork.com/collection.aspx?categoryid=6017
<i>Hospital Pediatrics “Bending the Value Curve”</i>	Case reports submitted by trainees highlighting cases of low-value care in pediatrics.	http://www.hospitalpediatrics.org/

TABLE 3 “Why Are We Doing This test?”: Proximate Versus Long-Term Implications for Diagnostic Testing

Diagnostic Test	Clinical Scenario	Proximate Reason to Test	Long-Term Implications of Diagnosis
Voiding cystourethrogram	Infant with febrile urinary tract infection	Vesicoureteral reflux is often found in children with urinary tract infection.	Possible interventions for vesicoureteral reflux include long-term prophylactic antibiotics, urologic surgery, and additional imaging studies.
Sleep study	Toddler who snores loudly at night	Snoring may reflect obstructive sleep apnea.	If obstructive sleep apnea is detected, possible interventions include medications, continuous or bilevel positive airway pressure, and adenotonsillectomy.
Videofluoroscopic swallow study	Neurologically impaired child with frequent respiratory infections	Aspiration of food or gastric contents is common and may contribute to frequent respiratory illnesses.	Diagnosis of aspiration often leads to recommendations for changes in feeding practices, including thickening food, cessation of oral feeding, placement of a feeding tube through the child's nose, or surgery to decrease reflux of gastric contents.
Serum cholesterol	11-y-old child presents for well child examination	Reduction of elevated cholesterol levels in adults decreases rates of cardiovascular morbidity and mortality. Pediatric guidelines now suggest screening all children age 9–11 y.	Detection of abnormal cholesterol may lead to lifestyle interventions, medications, and retesting.

curricula to directly address overdiagnosis.⁷⁸ Perhaps most importantly, medical education can discourage black-and-white thinking, instead nurturing critical thinking and comfort with uncertainty. If symptoms are not severe,

a stepped approach can be undertaken to reduce the risk of overdiagnosis. This method begins with normalizing problems, if appropriate, and pursuing a period of watchful waiting.⁷⁹ If resolution or an acceptable level of improvement

does not occur with watchful waiting, minimal interventions, with the potential for diagnosis, are used. Such a patient approach is important, because the risk of overdiagnosis is greatest for the child with no symptoms or a few nonspecific symptoms; the milder an abnormality, the less potential for benefit.¹⁵ If the magnitude of hypothetical benefit is small for pursuing a diagnosis and the possibility of harm exists, perhaps the child and family are better off avoiding diagnostic exposure.

CONCLUSIONS

Substantial proportions of children may not benefit from commonly pursued pediatric diagnoses. In some cases, overdiagnosis is necessary to ensure larger gains for the children who do benefit from the diagnosis. However, for many diagnostic tests, the ratio of benefit to harm resulting from the diagnosis is incompletely understood. Patient, physician, investigator, and society-wide attention to this complex benefit assessment will help ensure that we, first, do no harm.

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