Screening and surveillance are integral aspects of child health promotion and disease prevention. The American Academy of Pediatrics recommends that primary care clinicians screen children and adolescents for a broad array of conditions, conduct surveillance of growth and development, and identify social determinants of health and protective and risk factors that might impact health over time. However, access to and outcomes of preventive services vary on the basis of the features of children’s social ecology, including family and community contexts. The proposed five-stage socio-ecological model considers multiple contextual dimensions of pediatric screening: (1) individual, (2) interpersonal, (3) organizational, (4) community/population, and (5) public policy. Incorporating this model into routine care might improve outcomes at the individual and population level. Future endeavors should focus on integration of this model with validated risk screening tools as part of a supportive electronic health record, culture, and incentive structure. Further research assessing the contributors and outcomes of differences in beliefs, resources, practices, and opportunities among individuals, families, providers, primary care organizations, communities, health systems, and policy partners will be essential in advancing knowledge and policies to improve preventive services delivery.

Screening and surveillance are important activities in child health promotion and disease prevention. The American Academy of Pediatrics recommends a wide range of specific preventive services to allow for early implementation of effective interventions to maximize development and quality of life. The need is clear; >17% of children are at risk for developmental delay, and screening can facilitate entry into critical services. Unfortunately, nearly 40% of pediatricians do not routinely screen for developmental problems with a validated tool. A total of 22% of mothers experience postpartum depression, but most of them are not recognized. Approximately 45% of children ages 2 to 19 in the United States have dental caries, one of the most prevalent chronic diseases among children and one of the most common unmet health care needs of poor and minority children. Across states, only 48% of children aged 1 to 20 enrolled in public insurance in 2014 received...
preventive dental service, and 22% received dental treatment.\textsuperscript{11}

Persistent disparities in preventive care for children have been linked to differences in social and ecological environments.\textsuperscript{12} Drawing on Urie Bronfenbrenner’s ecological systems theory, we use terms like ecological environments and social ecology to refer to gradually broadening levels of social contexts that support individual children’s development, starting from the microsystems of family and social networks, continuing with schools, health care providers, and other organizations, to the macrosystems of populations and public policy.\textsuperscript{13}

Across different ecological levels, socioeconomic factors, such as unsafe housing, food insecurity, and violence, have been found to contribute to health risks to children.\textsuperscript{14} Primary care clinicians can identify the specific ecological levels of these health risk factors and refer families to targeted services as well as recognize and support assets, strengths and resiliency that could be mobilized in different stages to support families and reduce the impact of health risks.

Children’s social ecology, including family and community contexts, substantially impact access to and the implementation and outcomes of pediatric and developmental screenings, but these social forces are still rarely integrated in models of pediatric preventive care. This article focuses on pediatric screening using a socio-ecological perspective in standard medical practice and includes a more in-depth illustration of this model in the delivery of targeted dentistry.

The socio-ecological model considers the individuals and their affiliations to people, organizations, and their community. We use the concept of stages to highlight the need for attention to and implementation of ideas that help address selection forces across 5 broad ecological levels. There are, thus, 5 stages to this model: individual, interpersonal, organizational, community/population, and public policy (Fig 1).

### Improving Developmental Screening and Optimal Outcomes

#### Individual and Family Unit

Parents’ and children’s knowledge, attitudes, and skills are essential in shaping health promoting behaviors. Parental knowledge of child development is associated with quality parent and child interactions.\textsuperscript{15} Parent attitudes and

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**FIGURE 1**
A 5-stage socio-ecological model of selection forces in pediatric preventive care.
beliefs must be considered in the design and implementation of programs and services. Parenting practices are associated with improvements in health, safety, and emotional, behavioral, social, and cognitive competence. Parenting behaviors are contingent on responsiveness, showing warmth and sensitivity, having routines, shared book reading and talking with children, promoting health and safety, and using less harsh discipline. Research is needed in areas such as how parents’ knowledge of available services affects use; parenting and child outcomes; parenting knowledge, attitudes, and practices of fathers and grandparents; and how parenting affects math and problem-solving skills of children. This research should also consider the impact of social determinants of health on these knowledge and practices.

**Interpersonal Level**

Relational continuity between individuals and their practitioners is an essential principle of primary care and is highly valued by families. Such continuity may improve child health outcomes and lower the cost of care by increasing the uptake of child preventive services, reducing the use of emergency services and hospitalization. Gaps in insurance have been shown to decrease continuity among preschoolers.

**Organizational Level**

Primary care organizations can improve developmental and oral health screening practices using quality improvement approaches. Effective approaches include appointing an initiative champion, training clinicians and staff about a consistent screening process with specific responsibilities, using standardized screening tools embedded in electronic records, employing Plan-Do-Study-Act cycles with specific aims and key drivers, posting electronic health record prompts, providing financial incentives, and monitoring and reporting screening rates by using control charts. Parents might serve as advisors to guide a patient-centered approach. Personnel might be interviewed to assess barriers and their suggestions to improve the process. Pediatrician’s experience, knowledge, own parenting, and readiness to change and learn of each individual practitioner are critical to implementing screening. Evidence-based algorithms can also be used to guide screening decisions. At academic centers, pediatric residents can promote screening at continuity clinic sites. When children are diagnosed with a developmental delay or an oral health problem, for example, clinics can provide self-management guides for parents. Quality improvement research and implementation science are needed to evaluate how to disseminate the best evidence-based approaches across primary care groups.

**Community and Population Level**

In addition to prevention services provided in the primary care setting, early childhood developmental screening is often done by community partners like Early Head Start, Head Start agencies, some early childhood education centers, home visiting nurses, and elsewhere. Primary care medical homes can coordinate care with these community partners and establish data sharing agreements with parental consent. Research is needed about how to optimize these partnerships and data sharing exchanges. Although there is a lot of enthusiasm about the role that electronic medical records can play in facilitating this work, clinical integration is challenging. Work is needed to develop strategies for measuring the delivery of services at the population level.

**Public Policy Level**

Advocating for public policies to support health screenings is important to improving population health. For example, the US Administration for Children and Families provides block grants to support child care developmental screening. In 2019, California established a funded developmental screening policy, including monitoring and oversight. Other states can employ similar strategies to support developmental screening in early childhood settings. Research is needed to compare the effectiveness of policies and programs.

**THE SPATIAL AND CULTURAL ECOSCOPY OF SCREENING: DIFFERENCES IN ACCESS AND OUTCOMES**

Access to and outcomes of child health preventive services can vary widely on the basis of social ecology, including family and community contexts. In a review of the effects of childhood screening on health outcomes by the US Preventive Services Task Force, researchers found gaps in the available evidence in close to one-half of the reviewed preventive services. A fundamental contributor to these gaps is insufficient attention to how selective forces (eg, large differences in socioeconomic status or norms) at each level of social ecology contribute to disparities in access to preventive services like screening. These differences can significantly affect estimates of screening effects on outcomes in nonrandomized studies. The importance of community and institutional contexts in contributing to population disparities in health service uptake and outcomes has
been often highlighted in the literature on social determinants of health. Accounting for community influences in assessing screening is important because health promotion efforts focused too narrowly on individuals miss a large part of the picture and can have unexpected consequences.

Without accounting for the 5 stages of the socio-ecological model, even randomized studies on the impact of communities on health, in which researcher address important selection concerns, can still miss the bigger picture, leading to unexpected results. For example, in studies of low-income families randomly assigned to participate in the Moving to Opportunity housing mobility intervention, researchers found that beyond the expected negative effects of neighborhood’s concentrated disadvantage, the wider social and geographical context of the area also affected participants’ mental health issues, child victimization, and boys’ health risk behavior, three dimensions that have largely been ignored in previous studies. Such findings suggest that, in child health studies, researchers need to not only account for the communities where children reside but also pay attention to the broader spatial and network interactions and institutional context of communities.

Many features of communities contribute to variations in children’s selection into screening (ie, children are not screened consistently across the country) and in the long-term health outcomes of screening. Communities’ socioeconomic statuses differ widely across space and so do local resources, norms, institutions, and parents’ knowledge about the benefits of screening, contributing to inconsistencies in children’s access to screening. The presence of links to institutions, workplaces, and health centers relevant for access to childhood screening also may vary greatly across communities. Parents’ assessment of the benefits and costs of screening also vary across communities, affecting participation in screening. Outcomes of screening may also differ fundamentally across community, organizational, and cultural settings. Institutional actions derived from screening often depend on community resources, norms, and their perceptions of benefits and costs.

For instance, when young children exhibit behavioral problems, some schools suspend them, whereas other schools offer screening for attention-deficit disorder and attention-deficit/hyperactivity disorder or autism. In some settings, suspensions may be used and even the criminal justice system is called on in cases of illegal substance use or abuse by teenagers, whereas in other communities similar issues are dealt with through behavioral training or medical interventions. Such differences contribute to important racial disparities in school treatment of children of color as well as the subsequent criminalization of otherwise developmentally normal behavior (ie, the cradle to prison pipeline).

Many characteristics of communities are relevant for children’s development and health screening outcomes, including the social and physical infrastructure of communities as reflected in the (1) socioeconomic status of the residents (eg, children in poverty), (2) social and physical disorder; (3) access to institutions, services, and amenities, such as recreation services, local grocery stores, affordable housing, parks and green spaces, sidewalks, and air and water quality, and (4) the organization of social networks, and (5) safety indicators relevant for health, such as crime incidents, gang presence, and injury data. Importantly, aggregating existing clinical care data to the community level, to get a sense of the geographic concentration of people uninsured; the concentration of primary care physicians, medical health providers, dentists, and mental health providers; of flu vaccinations; and preventable hospital stays will help researchers of future studies to better understand the community health context of screening.

A distinctive dimension of variation in the social ecology of health and screening is formed by culture and norms. Cultural capital indicators may include the racial, ethnic, and ancestry backgrounds of the community, which may affect the norms and information accessible to resident children and parents. Cultural diffusion mechanisms may include social contagion of norms, attitudes, and behaviors regarding health behaviors. For example, the health behaviors and outcomes of members in a community (eg, tobacco use, nutrition and exercise, alcohol and drug use, and sexual risky behavior) can spill over to affect behaviors of children in the community. Social capital (including bonding or bridging ties) at the community level may be assessed on the basis of surveys or, more recently, social media data to highlight private, parochial, and public mechanisms of influence: (1) those via local norms and collective efficacy, (2) social interactions and social support, and (3) external links of a community to outside resources and information.

PEDIATRIC DENTISTRY: PREVENTION AND EARLY INTERVENTION IN ECOLOGICAL CONTEXTS

An emerging illustration of an ecological and integrative approach to child health screening and prevention is the identification of children at risk for dental caries by
nondental professionals in medical and school settings. Indeed, social and ecological contexts are relevant for child health screening, both in standard medical practice as well as in the delivery of targeted dentistry. Context-specific, culturally responsive, targeted health care delivery for dental caries has become paramount in an environment of increasing health care costs, resource constraints, and need to improve health outcomes. During the last several decades, most developing countries have experienced a major decline in the prevalence of dental caries, due primarily to the increased availability of and exposure to fluoride. Despite this, by the time children reach the age of 18 years, most of them have had caries experience. Untreated cavities result in pain, loss of tooth structure, and infection of periodontal tissues, with lasting effects on the function, growth, development, and quality of life. In 2016, in a national survey, researchers found that ~8.6 million 6- to 12-year-old children miss school annually because of an oral problem.

The current standard of care for management of caries lesions once they cavitate is primarily focused on restoring these lesions or extracting the tooth. In the case of young children who need extensive treatment or are uncooperative and/or have immature cognitive functioning, disabilities, or medical conditions, treatment is provided in many cases under general anesthesia, in most cases in hospital operating rooms. In 2009, the total dental expenditures for US children aged 5 to 17 years were ~$20 billion or 18% of all health care expenses for this age group. From birth to the age of 19 years, the treatment of dental caries ranked as the fifth highest condition of health care expending in the United States, surpassing expenses associated with well-newborn visits, attention-deficit/hyperactivity disorder, and asthma.

Comprehensive preventive services that account for the 5-stage ecological model are important. Most young children do not receive a dental examination, nor do the parents receive needed education on oral health. Although 89% of infants and 1 year olds have been examined by a physician, only 1.5% have had a dental appointment. Because children, especially those with lower socioeconomic status or who are racial and/or ethnic minorities, have relatively greater access to medical care than dental care, health care providers have been called on to assess the oral health of their young patients, provide anticipatory guidance and counseling, assist with referrals, and apply fluoride varnish (FV).

FV is one of the simplest, easiest and most effective strategies available to prevent dental caries and treat earlier stages of the disease process. The US Preventive Services Task Force recommends FV for all children, regardless of risk. These recommendations contrast with dental organizations, including the American Dental Association, which recommend FV on the basis of caries risk. Current evidence in the dental literature suggests that application of FV in a clinic setting is unlikely to be cost-effective in low caries-risk populations. This suggests there is a need to either target higher caries-risk groups or to provide FV at lower costs, possibly in nonclinic settings. For example, in a cost-effectiveness study, Schwendicke et al concluded that in low caries-risk groups, FV was nearly twice as costly and minimally more effective than no varnish. The incremental cost-effectiveness ratio was lower in moderate and high caries-risk groups.

However, although several caries risk assessment tools exist, none have been validated for use in children in the United States in the primary care practice setting. A 2014 study assessing pediatricians’ oral health attitudes and practices concluded that, compared with 2008, most respondents supported providing oral health activities in medical offices but fewer now reported engaging in these activities with all patients, and limited data suggest fluoride is being recommended on the basis of perceived risk. With a current research project funded by the National Institutes of Health (grant U01-DE021412), researchers are developing and validating a risk assessment-screening tool to identify children from 1 to 10 years of age at risk for dental caries in nondental settings, including primary care. Such a tool would allow nondental professionals in medical- and school-based settings to become more actively involved in preventing dental caries and referring high caries-risk children. Once a tool is developed, challenges remain around its dissemination and implementation and assessing the economic impact of establishing a risk-based approach to caries screening and prevention. In addition, high-risk individuals require a periodicity of preventive services that may be difficult to achieve in a single setting, and thus working in an integrated manner might be the only way to address the access to care needed for the efficacy of interventions delivered.

CONCLUSIONS
The 5-stage ecological model of screening presented here is a valuable tool for understanding the multidimensional sources of support and promising avenues for potential
improvements in children’s developmental and health screenings. Further research is needed on how relational continuity in care may be improved by addressing gaps in insurance. Doing so could improve preventive care delivery. More research is needed on how larger, efficiency-focused group practices and narrow health insurance networks impact continuity relationships and their benefits. Quality improvement approaches have been identified and show great promise for the future. Parents’ input might guide a patient-centered approach. Personnel interviews and evidence-based algorithms can guide referral decisions. Community partnerships and data sharing exchanges can be used to substantially improve the coordination of care. Research would greatly benefit from further focus on how to optimize such partnerships and sharing agreements to improve the health outcomes of individual children as well as better understand and improve screening access and outcomes at the population level.

Differences in beliefs, resources, practices, and opportunities among individuals, family, providers, primary care organizations, wider communities, health systems, and policy partners can contribute to differences in child screening and developmental outcomes. Research studies that assess the contributors and outcomes of these differences across the 5 stages of the socio-ecological model will be important in advancing knowledge and policies to improve screening access and outcomes, while accounting for and avoiding harms to children and their families. Rapid advances in health analytics combined with linkages among increasingly large and complex health related data systems are important. Furthermore, connecting them to the long history of social science theory and concepts is an important priority for future studies. Doing so will enable a better understanding of social and cultural capital, legitimacy, cultural norms, contagion, and reciprocal trust among patients, providers, primary care organizations, and different community and state actors in contributing to increases in access to screening and improving children’s health and developmental outcomes.68–62

ABBREVIATION
FV: fluoride varnish

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An Ecological Model to Frame the Delivery of Pediatric Preventive Care
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