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The Awareness-to-Adherence Model of the Steps to Clinical Guideline Compliance: The Case of Pediatric Vaccine Recommendations

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Abstract

OBJECTIVES: This article proposes, tests, and explores the potential applications of a model of the cognitive and behavioral steps physicians take when they comply with national clinical practice guidelines. The authors propose that when physicians comply with practice guidelines, they must first become *aware* of the guidelines, then intellectually *agree* with them, then decide to *adopt* them in the care they provide, then regularly *adhere* to them at appropriate times.

METHODS: Data used to test this model address physicians' responses to national pediatric vaccine recommendations. Questionnaires were mailed to 3,014 family physicians and pediatricians who were working in communities of various sizes in nine states.

RESULTS: The survey response rate was 66.2%. In the case of the recommendation to provide hepatitis B vaccine to all infants, guideline awareness among respondents was 98.4%, agreement 70.4%, adoption 77.7%, and adherence 30.1%. The data for 87.9% of physicians fit the model at every step. Significant deviation from the model occurred only for the 11% of all physicians who adopted the hepatitis B recommendation without agreeing with it. In the case of the recommendation to provide the acellular variety of the pertussis vaccine for children's fourth and fifth pertussis doses, guideline awareness among respondents was 89.8%, agreement 66.5%, adoption 46.3%, and adherence 35.2%. Data fit the model at every step for 90.6% of physicians. Greater likelihood of movement from each step to the next in the path to adherence was found for physicians with certain characteristics, information sources, and beliefs about the vaccines, and those in certain types of practice settings. Specific physician and practice characteristics typically predicted movement along only one or two of the steps to adherence to either the hepatitis B or acellular pertussis recommendations.

CONCLUSIONS: These data on physicians' use of pediatric vaccine recommendations generally support the awareness-to-adherence model. This model may prove useful in identifying ways to improve physicians' adherence to a variety of guidelines by demonstrating where physicians fall off the path to adherence, which physicians are at greatest risk for not attaining each step in the path, and factors associated with a greater likelihood of attaining each step toward guideline adherence.

Clinical practice guidelines have been created and disseminated by numerous authorities in the hope that physicians will follow succinctly stated, professionally sanctioned prescriptions for best clinical practice. Yet, many physicians are unaware of or little influenced by many available guidelines.¹⁻⁴ As a partial explanation, it has been pointed out that experts' recommendations are sometimes untenable to practicing physicians,^{5,6} and that many factors other than experts' opinions affect physicians' clinical decisions.^{2,6}

The traditional model to explain how new medical knowledge affects physician behavior—the active dissemination model⁷—assumed that information synthesized and disseminated by respected national authorities reliably leads to change in physician clinical behavior. This model, upon which the success of the guidelines movement initially was anticipated, is now recognized to be too simplistic and rarely accurate. Clinical information well known to practicing physicians, including national practice guidelines, often has little effect on the care physicians provide.^{1-4,8,9} Information alone often does not change physician behavior.

Few attempts have been made to generate new models to explain why physicians' care does or does not follow recommended practice. We propose and test such a model in this article. We postulate that there are sequential, cognitive, and behavioral steps physicians make as they comply with a guideline: physicians, who are initially unaware of a specific guideline, must first become *aware* of it, then intellectually *agree* with it, then decide to follow it in their practice (*adopt* it), then actually succeed in following it at appropriate times (*adhere* to it) (Fig. 1). We also postulate that for each physician, progression along the path to adherence can stop at any step for a variety of reasons. Failure to progress along the path from preawareness to adherence results in non-compliance with the guideline. Although previous research has demonstrated that various factors predict physician awareness and agreement with guidelines for care,^{2,3,10-14} there has been no attempt to identify the sequence of these cognitive events and their relation to overall guideline adherence.

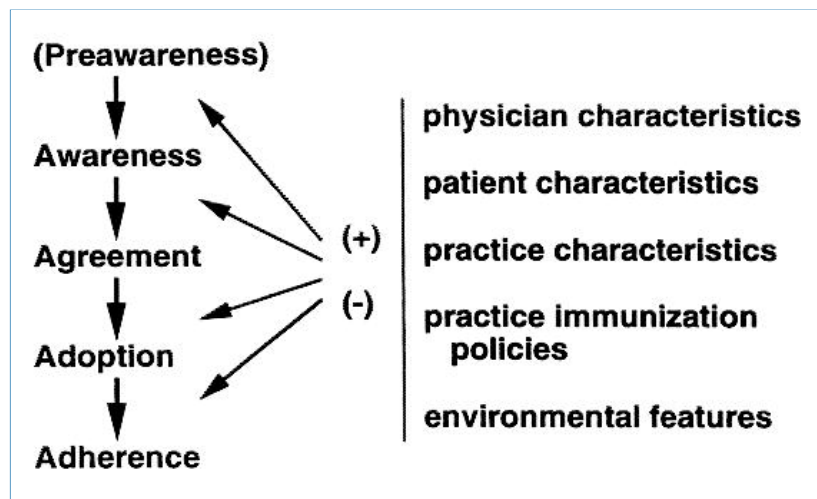


FIG. 1. Model of cognitive steps physicians make in adhering to clinical guidelines, and types of factors that facilitate or hinder movement along these steps.

The goal of this study is to assess whether the steps of awareness, agreement, adoption, and adherence accurately describe the sequence of cognitive and behavioral processes through which guidelines influence physicians' clinical behaviors. This study also explores how efforts to improve physicians' compliance with guidelines may be better targeted by understanding where failure occurs in the progression from preawareness to adherence and by identifying the physicians, practice settings, and situations for which progression at each step is less likely. Data used for this study involve the illustrative case of family physicians' and pediatricians' use of national recommendations for selected pediatric vaccines, which serves as the test cases for assessing the model.

Background to Pediatric Vaccine Recommendations

The Public Health Service's Advisory Committee on Immunization Practices (ACIP), the American Academy of Pediatrics (AAP), and the American Academy of Family Practice (AAFP) create and disseminate pediatric immunization recommendations to serve as guides for physicians' immunization practices. Imperfect adherence by physicians to these recommendations contributes to the 40% of 2-year-old children in the United States who do not receive the complete immunization series on schedule.¹⁵ Although the cost of vaccines to families is partially responsible for low vaccination rates, other factors in the vaccine delivery system likely play a greater role, including missed opportunities for vaccinations in physicians' offices.¹⁶ More than half of the 8-month-old infants found not fully immunized in one study had at least three well-child visits to doctors' offices when vaccines could have been provided.^{17,18} In another study, it was estimated that eliminating missed opportunities for vaccinations would increase age-appropriate vaccine coverage rates for 12-month-old infants by up to 27%.¹⁹ Two studies found that health-care providers, rather than parents, are responsible in 78% and 97% of cases when children seen in the office fail to receive vaccines.^{20,21}

Pediatric vaccine recommendations have changed significantly since the mid-1980s. The ACIP, AAP, and AAFP, acting relatively independently, each issued new or revised recommendations for a second dose of measles vaccine (1988), a *Haemophilus influenza* type b (HIB) primary series starting at 2 months of age (1990), a hepatitis B series for all infants (1992), and acellular vaccine use for the fourth and fifth pertussis doses (1992)—a total of seven new vaccine doses and product changes for two doses. These recommendation changes accompanied the release of new vaccine products for HIB and acellular pertussis. Although the hepatitis B and measles vaccines had been available previously, very few physicians were providing them in the ways advocated by the revised recommendations. This article looks at the cognitive steps involved in physicians' adherence to these four relatively new and still current pediatric vaccine recommendations.

Methods

Study Subjects

Survey data were collected from family physicians and pediatricians practicing in nine states chosen for their variability in regional location, proportion of rural versus urban residents, population characteristics, health-care provider characteristics, predominant insurance types, and types of vaccine distribution systems. By design, the selected states also varied in terms of their immunization rates; however, their combined immunization rate was comparable to that of all 50 US states.^{22,23} Selected states were California, Colorado, Georgia, Hawaii, Massachusetts, Pennsylvania, Tennessee, Texas, and Wisconsin. A broad and representative range of community sizes was obtained for study by sorting all metropolitan statistical areas (MSA) within each state into four strata based on population size. A total of 36 specific MSAs were then selected randomly from among the three strata with the larger MSAs, with oversampling in larger states and in strata within specific states that contained greater proportions of their states' MSAs. Also selected from each state was a single "rural" area comprised of all areas in the stratum with the smallest MSAs plus all nonmetropolitan areas in that state.

Using the American Medical Association's Physician Masterfile, we randomly selected clinically active pediatricians and family physicians from each of the chosen MSAs and rural areas, including both allopathic and osteopathic physicians, and both members and nonmembers of the American Medical Association. Physicians were given higher sampling probabilities if they worked in states with larger physician populations and, in particular, MSAs that had greater proportions of their state's physicians. Family physicians were oversampled relative to pediatricians ($n = 1,849$ versus $n = 1,165$) because we anticipated that fewer family physicians would provide vaccines in their offices, and because we have found that family physicians respond less readily to childhood vaccine surveys.⁸

Questionnaire Design

A survey instrument was pilot tested for clarity and ease of completion with 100 pediatricians, family physicians, and general practitioners in South Carolina during the summer of 1993. Based on the returns from the 70 respondents, relatively minor formatting and content revisions were made in the survey instrument. Because few of the general practitioners in South Carolina were found to provide vaccines to children, general practitioners were dropped from the main study. Pilot data were not incorporated in the analyses of the main study presented here because of differences in some questionnaire items and in the processes by which subjects were selected.

During the period from October 1993 through January 1994, 3,014 subjects in the nine selected states were mailed seven-page questionnaires. At least two subsequent mailings were sent to nonrespondents. The final mailing contained an abbreviated version of the questionnaire to promote subjects' participation. Abbreviated questionnaires contained items to verify physicians' eligibility and their awareness, agreement, adoption, and adherence to the study's four vaccine recommendations, but did not solicit data on the predictors of these cognitive and behavioral steps.

The four hypothesized steps to vaccine adherence—awareness, agreement, adoption, and adherence—were operationalized as dichotomous variables created from physicians' responses to questions about their beliefs and behaviors relative to the recommendations for each of four vaccines: Hib, second measles, hepatitis B, and acellular pertussis.

1. Awareness. Physicians were classified as unaware of a recommendation if they had heard or read "nothing at all" or less than "some" about the recommendation. Those who had heard or read "some," more than "some," or "a lot" were classified as aware.
2. Agreement. Physicians directly indicated whether they agreed with, disagreed with, or were uncertain about each recommendation. In most analyses, those uncertain about a recommendation were grouped with those who disagreed with it.
3. Adoption. Physicians indicated from among five or six response options how they provided each of the four study vaccines to their patients. Adopters were defined as those who provided the vaccines to their patients consistent with national recommendations. All others were nonadopters.
4. Adherence. For two of the vaccines (hepatitis B and acellular pertussis), physicians estimated the percentage of their pediatric patients who received doses as recommended, such as the percentage who received "the acellular pertussis vaccine for the fourth dose." Those who indicated that 90% or greater of their patients received the vaccine as recommended were classified as adherers, following the 90% goal set by the US Department of Health and Human Services.²⁴

If the awareness, agreement, adoption, and adherence sequence accurately describes the steps to vaccine recommendation adherence, then few physicians who had not attained a given step would attain a subsequent step of the proposed sequence. For example, if a physician did not agree with a specific recommendation, he or she would not be expected to have adopted the recommendation in his or her practice. As a test of the accuracy of the model,

we calculated the percentage of physicians for whom data for their response to each vaccine recommendation fit the model perfectly.

Physicians provided descriptive data about themselves, their practices, and their patient populations through a series of fixed and short-response questionnaire items. From these data, we identified physicians and practice settings for which progression along each of the steps from vaccine guideline preawareness to adherence was more likely. Other factors assessed were physicians' beliefs and opinions about various vaccine-relevant issues, such as whether they believed that their patients are generally at low risk for hepatitis B disease. Five indices were created from physicians' rating of their agreement or disagreement with these belief statements. Each index was composed of two or three questionnaire items that were closely related conceptually and statistically. Indices were formed for items that assessed physicians' beliefs that:

1. Vaccine recommendations are (A) too confusing, (B) too difficult to keep up with, and (C) too often contradictory;
2. The number of injections required at a single visit creates resistance to vaccinations in (A) parents and (B) office staff;
3. Parents (A) know about the universal hepatitis B recommendation and (B) request this vaccine;
4. Parents (A) know about the acellular pertussis recommendation and (B) request the acellular vaccine; and
5. (A) The inactivated pertussis vaccine carries more risk than the acellular vaccine and (B) children are less likely to have an adverse reaction with the acellular vaccine.

Statistics

Weights were used in all descriptive analyses and inferential statistical tests to adjust for sampling probabilities and differential response rates among those surveyed. Weighted chi-square analyses and logistic regression models were constructed to identify associations between (1) physicians' awareness, agreement, adoption, and adherence to vaccine guidelines and (2) characteristics and beliefs of physicians as well as characteristics of their patients and practices. Final logistic models used the backward elimination approach to generate a reduced list of variables. Statistical significance was set at the $P = 0.01$ level, although Bonferroni's inequality would indicate that an alpha of 0.00625 was needed to guarantee that the study's overall alpha not exceed 0.05 given its approximately 80 comparisons.²⁵ However, because of the exploratory nature of these analyses and the need to balance the risk of type I and type II errors, a compromise alpha level of 0.01 was selected.²⁶ Readers for whom it is important to identify specific factors for which relations with vaccine guideline awareness, agreement, adoption, or adherence are known with greater certainty are advised to look only to those associations significant at $P \leq 0.001$.

Results

Of the 3,014 physicians in the original sample, 1,996 reported sufficient information to determine their study eligibility. A total of 575 (28.8%) of the 1,996 reporting physicians were determined to be ineligible, most often because they did not provide well-child care or immunizations, and, in fewer cases, because they were deceased, retired, in training programs, no longer working, no longer located in the selected MSAs, or working locum tenens. To calculate the study response rate, we adjusted down the overall sample size by 28.8% to 2,146 physicians, under the assumption that physicians who provided us with no information were just as likely to be ineligible as those who did provide information.²⁷ Of the estimated 2,146 eligible physicians in the sample, 1,421 responded, for a response rate of 66.2%. Response rates varied by specialty, state, board certification status, federal versus nonfederal employee status, and hospital versus nonhospital practice setting. Response rates did not vary by physician gender, age, country of training (United States versus international), graduation year, discipline (allopath versus osteopath), or metropolitan versus nonmetropolitan practice location. The 139 respondents (9.8%) who completed abbreviated questionnaires did not differ from other respondents in terms of gender, age, specialty, discipline, or metropolitan versus nonmetropolitan location; however, they were less likely to be board certified.

Descriptions of the 1,421 eligible respondent physicians, their patient populations, their sources of information about vaccines, their beliefs about pediatric vaccines and guidelines, and vaccination procedures in their practices are shown in [Table 1](#). Half of the respondents were pediatricians and half were family physicians. Physicians' median age was 43 years (not shown). Sixty-one percent of physicians were in practices with two or more physicians (median group size = five physicians), 25% were in solo practices, and the remaining 14% were in teaching practices, hospital-based practices, health departments, and "other" practice settings. Practice settings were similar for family physicians and pediatricians.

	Percent (Weighted)
Physician Characteristics	
Pediatrics specialty (vs family practice)	49.3
Board certified	79.1
Specialty society member	72.4
Male gender	70.3
<9 years since medical school graduation	31.3
>20 years since medical school graduation	27.8
Practice and Patient Characteristics	
Solo practice	25.1
>40% of patients are enrolled in a managed care plan	34.2
>20% of patients are covered under Medicaid	30.1
>10% of patients are uninsured	23.2
Physicians' Sources of Vaccine Information	
Relies on specialty society for vaccine recommendations	67.8
Relies on the CDC for vaccine recommendations	55.8
Relies on the health department for vaccine recommendations	41.0
Relies on colleagues for vaccine information	35.5
Reads medical information 2 or more hours weekly	56.5
Physicians' Beliefs About Vaccine Issues	
Believes vaccine guidelines are confusing, contradictory, and/or changing too fast	37.0
Believes parents and/or staff resist number of injections required	33.9
Believes providing vaccines increases liability	12.3
Believes his or her patients are at low risk for hepatitis B	62.0
Believes hepatitis B vaccine may not provide long-term immunity	32.3
Believes parents know about and/or request hepatitis B vaccine	25.5
Believes whole-cell pertussis vaccine is risky and/or acellular pertussis vaccine is safer	69.5
Personal patient has had severe reaction to whole-cell pertussis vaccine	16.1
Believes parents know about and/or request acellular pertussis vaccine	5.5
Practices' Vaccine Routines	
Reviews needed vaccines at acute care visits	80.1
Provides needed vaccines at acute care visits	85.7
Records vaccinations on computerized system	15.1
Sends reminders to parents when vaccines are due	24.1
Routinely audits patient records for vaccine coverage	35.2
Reports difficulty changing vaccine office procedures	23.8

CDC, Centers for Disease Control and Prevention.

TABLE 1. Description of Physicians, Patient Populations, Physicians' Sources of Vaccine Information, Physicians' Beliefs About Vaccines, and Practices' Vaccination Protocols (n = 1,421)

On average, physicians reported that 34% of their pediatric patients were insured under some type of managed care plan, 36% had traditional indemnity insurance coverage, 19% were covered by Medicaid, and 10% were uninsured. Children cared for by family physicians and pediatricians differed minimally in terms of their insurance status. However, pediatricians provided well-child visits for an average of 34.7 children under age 2 on a typical week, compared with 9.8 children for family physicians ($P = 0.0001$).

Vaccine Guideline Awareness, Agreement, Adoption, and Adherence

HIB and Second Measles Vaccines. Physicians were well aware of the guidelines for universal HIB vaccine for infants (98.3%) and a second measles vaccine for children (99.3%), and the vast majority of both physician groups also agreed with them (96.6% agreement for HIB and 94.8% for second measles). In fact, nearly all physicians (97.4% for HIB and 93.7% for second measles) recommended these vaccines for all children under their care. Physicians were not asked how many children under their care actually received these particular vaccines. In summary for these two vaccines, and as the awareness-to-adherence model predicts, we find that where guideline adoption rates are high, awareness and agreement also are high.

Hepatitis B Vaccine. Physicians were much less likely to embrace the universal hepatitis B vaccine recommendation (Fig. 2). Although awareness of the recommendation was virtually universal (98.4%), only 70.3% agreed with it. A total of 12.7% of the physicians expressed outright disagreement with the recommendation and 17.0% were uncertain whether or not they agreed with it. Contrary to the guideline awareness-to-adherence model, more physicians indicated that they had adopted the hepatitis B recommendation (77.7%) than had agreed with it. On the other hand, as the model predicts, adoption rates were higher—in a “dose-response” relation—as the level of agreement with the recommendation increased. Guideline adoption rates were 94.4% among physicians who agreed with the recommendation, 44.2% among those uncertain whether they agreed with the recommendation, and 24.0% among those who disagreed with it.

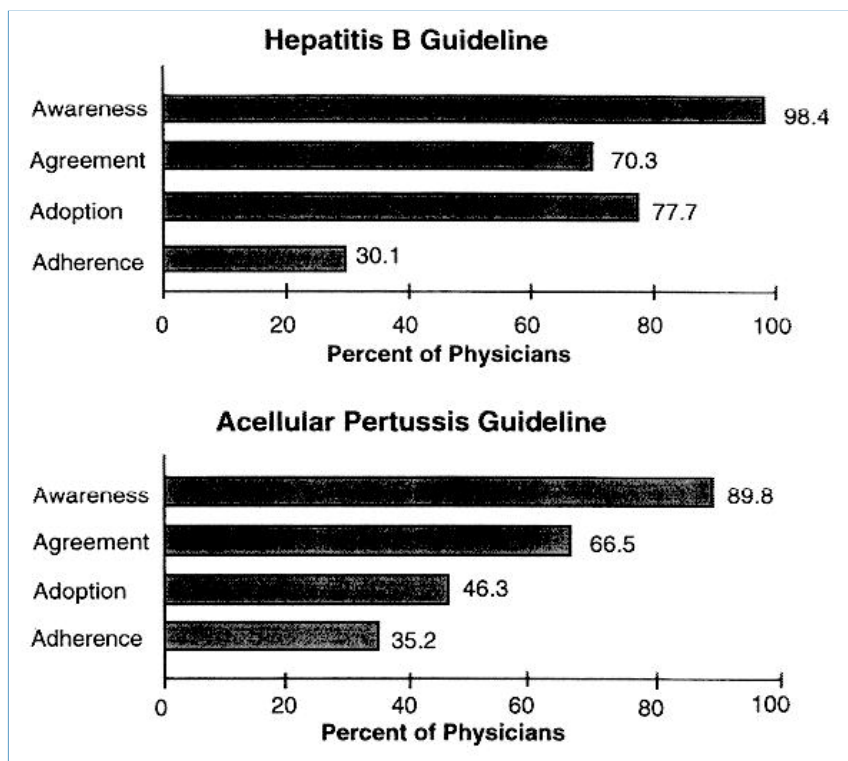


FIG. 2. Physicians' awareness of, agreement with, adoption of, and adherence to pediatric hepatitis B and acellular pertussis vaccine guidelines.

The greatest fall-off along the path to adherence to the hepatitis B vaccine recommendation occurred at the last step of adherence. Only 30.1% of physicians adhered to the recommendation, as defined by 90% or more of the children under their care reportedly receiving three hepatitis B vaccine doses before 18 months of age.

In support of the awareness-to-adherence model, it was found that data for 87.9% of physicians fit the model at every step. Eighty-two percent of the 30% of physicians who adhered to the hepatitis B recommendation also indicated that they were aware of it, agreed with it, and had adopted it.

Acellular Pertussis Vaccine. One in 10 physicians (10.2%) had heard or read very little or nothing (ie, were "unaware") of the guideline recommending acellular pertussis vaccine for the fourth and fifth pertussis doses for all children. Only 66.5% of physicians indicated that they agreed with the guideline, 5.3% disagreed with it, and 30.4% were uncertain. More than half or those indicating uncertainty also noted that they did not know enough about the guideline to decide. Only 46.3% of the physicians recommended acellular pertussis for the fourth and fifth doses for all children, that is, had adopted the recommendation. A smaller proportion of physicians (35.2%) reported that more than 90% of their patients received acellular vaccine for their fourth dose as recommended, ie, adhered. Thus, significant fall-off occurred at every step from awareness to adherence for the acellular pertussis vaccine recommendation. Particular problems found for many physicians for this vaccine recommendation, which were not found with the hepatitis B vaccine recommendation, were a significant lack of awareness of the recommendation and a shallow depth of knowledge about the recommendation that prevented many physicians from being able to decide whether or not they agreed with it.

The awareness-to-adherence model well described how these physicians were responding to the acellular pertussis vaccine recommendation. The data for 90.6% of physicians fit the model at each step. A total of 84% of the approximately one third of all physicians who were adhering to the acellular pertussis guideline also were aware of, agreed with, and had adopted this guideline in their practices.

Physicians and Practice Settings for Which Attainment of Each Step from Awareness to Adherence Was More Likely

The bivariate associations of physician, practice, and patient population characteristics with the attainment of each step in the awareness-to-adherence model for the hepatitis B and acellular pertussis vaccines are shown in [Table 2](#). The likelihood of movement along each step to guideline adherence differs for physicians with certain characteristics and those caring for patients covered by various types of insurance. Family physicians were less likely than pediatricians to attain each of the steps to hepatitis B guideline adherence, and were less likely to attain two of the four steps to adherence to the acellular pertussis guideline. Physicians caring for more than 20% Medicaid patients were less likely to agree with, adopt, and adhere to the acellular pertussis guideline, and physicians caring for more

than 10% uninsured patients were less likely to agree with and adhere to the hepatitis B guideline.

	Guideline Awareness Among All Physicians (OR)	Guideline Agreement Among Those Aware (OR)	Guideline Adoption Among Those Agreeing (OR)	Guideline Adherence Among Those Adopting (OR)
Hepatitis B				
Pediatrics specialty (vs family practice)	71.9 ^{a,c}	3.53 ^c	3.23 ^c	1.72 ^c
<9 years since medical school graduation	6.98 ^b	0.80	1.31	0.74
>20 years since medical school graduation	0.44	1.23	0.55	1.18
Board certified	4.47 ^c	0.66 ^b	2.01	1.80 ^c
Specialty society member	7.84 ^c	0.69 ^b	1.75	0.97
Male gender	0.16	0.84	0.36 ^b	1.33
Solo practice	0.44	0.83	0.73	1.14
>40% of patients are in managed care plan	2.93	1.04	1.26	1.86 ^c
>20% of patients covered under Medicaid	2.73	1.47 ^b	1.25	0.51 ^c
>10% of patients uninsured	0.35	0.62 ^c	1.13	0.41 ^c
Acellular Pertussis				
Pediatrics specialty (vs family practice)	14.5 ^c	1.26	2.98 ^c	0.78
<9 years since medical school graduation	0.88	1.20	0.96	1.50
>20 years since medical school graduation	1.20	0.81	0.88	0.61 ^b
Board certified	1.12	1.03	0.99	1.76 ^b
Specialty society member	1.23	1.18	1.45	1.25
Male gender	0.46 ^c	0.90	0.56 ^c	0.66 ^b
Solo practice	0.64	0.89	0.86	0.91
>40% of patients are in managed care plan	1.14	0.75	0.94	1.13
>20% of patients covered under Medicaid	0.97	0.69 ^b	0.52 ^c	0.30 ^c
>10% of patients uninsured	0.66	1.24	0.51 ^c	0.81

OR, odds ratio.
^a0.5 observations were added to each cell of the 2 × 2 table used to calculate this odds ratio, because there was a frequency of 0 in one cell.
^bP ≤ 0.01.
^cP ≤ 0.001.

TABLE 2. Physicians and Practice Settings for Which Awareness, Agreement, Adoption, and Adherence to Guidelines for Hepatitis B and Acellular Pertussis Vaccines Were More Likely: Bivariate Associations

Physician and practice settings for which movement along the steps to guideline adherence was more or less likely often were unique to one or two steps. Certain groups and settings even had associations in opposite directions at various steps. For example, physicians who were board certified and members of specialty societies were more likely to be aware of the hepatitis B recommendation, but less likely to agree with it.

Other Factors Associated with Each Step to Adherence: Multivariate Model Findings

Hepatitis B Vaccine Guideline. Virtually all physicians were aware of the universal hepatitis B vaccine recommendation, precluding separate multivariate analyses of the predictors of awareness. Therefore, logistic models were run for predictors of awareness and agreement together, by studying agreement factors among all respondents rather than only among those who were aware of the recommendation. All variables listed in Table 1 were included in the logistic models, with the exception of the three variables relevant only to the pertussis vaccine. Only variables found to be significantly related to agreement, adoption, or adherence are shown in Table 3.

	Guideline Agreement Among All Physicians (n = 1062) (OR)	Guideline Adoption Among Those Agreeing (n = 714) (OR)	Guideline Adherence Among Those Adopting (n = 762) (OR)	Guideline Adherence Among All Physicians (n = 1024) (OR)
Physician Characteristics				
Pediatrics specialty (vs family practice)	2.85 ^d	4.13 ^c	1.99 ^d	2.51 ^d
>20 years since medical school graduation	—	0.29 ^c	—	—
Board certified	—	3.59 ^c	2.47 ^d	2.57 ^d
Practice and Patient Characteristics				
>40% of patients are in managed care plan	—	—	1.60 ^b	1.55 ^b
>10% of patients uninsured	—	—	—	0.54 ^b
Physicians' Sources of Vaccine Information				
Relies on specialty society for vaccine recommendations	—	—	—	0.64 ^b
Relies on CDC for vaccine recommendations	—	—	1.61 ^b	1.70 ^c
Relies on colleagues for vaccine information	1.75 ^c	—	—	—
Physicians' Beliefs About Vaccine Issues				
Believes guidelines are confusing, contradictory, and/or changing too fast	0.60 ^b	—	—	—
Believes his or her patients are at low risk for hepatitis B	0.29 ^d	—	—	—
Believes hepatitis B may not provide long-term immunity	0.32 ^d	—	—	—
Believes parents know about and/or request hepatitis B vaccine	—	9.62 ^b	—	1.56 ^b
Practices' Vaccine Routines				
Reports difficulty changing vaccine office procedures	—	—	—	0.56 ^b

CDC, Centers for Disease Control and Prevention; OR, odds ratio.

^aFull list of variables used in logistic models is shown in Table 1, less three variables that relate only to the acellular pertussis vaccine.

^b $P \leq 0.01$.

^c $P \leq 0.001$.

^d $P \leq 0.0001$.

TABLE 3. Factors Significantly Associated with Physicians' Agreement, Adoption, and Adherence to Guidelines for Hepatitis B Vaccine for Children: Findings from Logistic Regression Models Using Backwards Elimination^a

Pediatric specialty remained the only variable related to each of the steps of agreement, adoption, and adherence. Specialty society membership no longer predicted attainment of any of the steps, suggesting that the awareness advantage and agreement disadvantage shown by specialty society members in the bivariate analyses were explained by other variables included in the multivariate models.

Physicians who rely on their colleagues for vaccine information were more likely to be aware and/or agree with the hepatitis B guideline. In contrast, physicians in this study who relied on official sources for vaccine information (ie, specialty societies, the Centers for Disease Control and Prevention [CDC], local and state health departments) did not differ from others in their awareness/agreement and adoption of the hepatitis B guideline. Those who relied on the CDC for vaccine information reported greater adherence rates than others when they had adopted the recommendation. Not surprisingly, physicians who found vaccine guidelines to be confusing, contradictory, or changing too fast reported lower awareness/agreement with the hepatitis B guideline.

Two beliefs about the hepatitis B vaccine were found to be associated strongly with physicians' lack of awareness of and/or agreement with the hepatitis B guideline, ie, that the vaccine may not provide long-term immunity and that a physician's particular patient population was at low risk for hepatitis B. On the other hand, if physicians believed that parents knew about and/or requested the hepatitis vaccine, they were much more likely to adopt the recommendation. No practice vaccination routines predicted location along the steps toward guideline adherence.

The full logistic model of hepatitis B vaccine guideline adherence was repeated for all respondents to identify predictors of overall adherence, that is, to demonstrate the summative effects of all factors across all four steps to adherence for all physicians (Table 3, last column). The correlates of overall adherence with the hepatitis B recommendation generally were those factors found to be the strongest correlates for multiple steps in the path from awareness to adherence. It is of note that a number of factors significant to specific steps were not significant in the models of overall adherence, sometimes due to opposite and counteracting effects at different steps in the awareness-to-agreement model. In the overall adherence model, those who relied on vaccine information from the CDC showed an adherence advantage, and those who relied on their specialty society showed an adherence disadvantage.

That 18% of the subgroup of physicians who did not agree with the hepatitis B vaccine recommendation nevertheless adopted it in their practice runs counter to the predictions of the awareness-to-adherence model. To understand this better, we examined the correlates of adoption among only those physicians who indicated either that they were uncertain about or frankly disagreed with the guideline. We used the full list of explanatory variables in a logistic model, with an additional dichotomous variable indicating guideline disagreement versus uncertainty. Adopters were more likely to be (1) uncertain about the guideline rather than disagree with it, (2) pediatricians, and (3) specialty society members. Adopters also were more likely to believe that the vaccine provided long-term immunity and that parents knew about and requested the vaccine.

Acellular Pertussis Vaccine Guideline. The correlates of awareness of and agreement with the acellular pertussis vaccine guideline also were examined together because too few physicians were unaware of the guideline to allow for separate logistic analysis. After controlling for all of the features of physicians, their beliefs about the acellular vaccine, their practices, and their practices' immunization procedures, pediatrics specialty predicted greater awareness/agreement and adoption of the acellular pertussis guideline, and male gender predicted lower adherence (Table 4).

	Guideline Agreement Among All Physicians (n = 1020) (OR)	Guideline Adoption Among Those Agreeing (n = 641) (OR)	Guideline Adherence Among Those Adopting (n = 481) (OR)	Guideline Adherence Among All Physicians (n = 978) (OR)
Physician Characteristics				
Pediatrics specialty (vs family practice)	1.92 ^d	3.18 ^d	—	—
Male gender	—	—	0.48 ^b	0.60 ^b
Practice and Patient Characteristics				
>40% of patients are in managed care plan	—	—	—	0.48 ^d
>20% of patients covered under Medicaid	—	—	0.32 ^d	0.34 ^d
>10% of patients uninsured	—	0.55 ^b	—	—
Physicians' Sources of Vaccine Information				
Relies on CDC for vaccine recommendations	1.54 ^b	—	2.37 ^c	1.87 ^d
Relies on health department for vaccine recommendations	—	—	—	0.51 ^d
Relies on colleagues for vaccine information	—	—	3.08 ^d	1.62 ^b
Physicians' Beliefs About Vaccine Issues				
Believes whole-cell vaccine risky and/or acellular vaccine safer	5.21 ^d	2.05 ^b	2.93 ^c	4.47 ^d
Personal patient had severe reaction to inactivated vaccine	—	—	—	1.90 ^d
Believes parents know about and/or request acellular pertussis	7.50 ^c	—	—	2.99 ^b
Believes providing vaccines increases liability	—	—	0.31 ^b	0.49 ^b
Practices' Vaccine Routines				
Reviews vaccines needed at acute-care visits	—	—	0.29 ^c	0.66 ^b
CDC, Centers for Disease Control and Prevention; OR, odds ratio.				
^a Full list of variables used in logistic models is shown in Table 1, less three variables that relate only to the hepatitis B vaccine.				
^b P ≤ 0.01.				
^c P ≤ 0.001.				
^d P ≤ 0.0001.				

TABLE 4. Factors Significantly Associated with Physicians' Agreement, Adoption, and Adherence to Guidelines for Acellular Pertussis Vaccine for Children: Findings from Logistic Regression Models Using Backwards Elimination^a

Colleagues and the CDC again were found to be effective information sources. The belief that the acellular vaccine offers a safety advantage over the whole-cell vaccine was particularly important, predicting greater odds of attaining each step from awareness/agreement to adherence. The belief that parents know about and/or request the acellular vaccine positively predicted guideline awareness/agreement, as was the case for the hepatitis B vaccine. Surprisingly, physicians who reviewed children's vaccine needs at acute care visits reported lower adherence rates.

In the model of overall adherence to the acellular pertussis recommendation, it is seen that physicians who rely on the CDC and colleagues for immunization information reported greater adherence and those who relied on the health department reported lower adherence. Among the other factors found to be positively associated with overall adherence were physicians' beliefs that the acellular vaccine offers a safety advantage and that parents request the acellular vaccine, and physicians' personal experience with a patient who had a severe reaction to the inactivated pertussis vaccine.

Discussion

Data from this study of physicians' responses to pediatric vaccine recommendations generally support the model that physician adherence to clinical guidelines occurs through the sequential steps of guideline awareness, agreement, and adoption. The significance of the awareness-to-adherence model is that it provides researchers and those interested in guideline compliance (practice organizations, specialty societies, health advocacy groups, government agencies, and insurers) with a more detailed understanding of what occurs when physician clinical care deviates from guidelines. Interventions to improve guideline compliance are likely to miss their target and thus prove ineffective if they do not recognize that guideline compliance can fail at any of four steps. Redoubling guideline dissemination efforts when compliance is low—historically the most common intervention to promote guideline adherence—may be helpful in the case of the acellular pertussis recommendation, where significant numbers of physicians were unaware of or did not understand the recommendations. On the other hand, because physicians already know about the hepatitis B recommendation, intensifying dissemination efforts will not improve adherence. With the hepatitis B recommendation, agreement and adherence are problematic, and successful interventions will need to convince physicians that this already familiar guideline is sound, and then help them adhere to the guideline when they decide to adopt it. Physician attitudes and beliefs about the hepatitis B vaccine and its appropriateness for their patient populations will need to be changed.

These data also demonstrate that deviations occur from the model's four sequential steps, as evidenced best by the 11% of physicians who adopted the hepatitis B recommendation without agreeing with it. We suspect that the principal reason adoption occurs in the absence of agreement in this and other cases is because physicians are affected by other forces, such as peer pressure, malpractice fears, patient demand, community norms, and practice organization policies. This belief is supported by the findings that adoption and adherence without agreement were more likely when physicians believed that parents know about and request the hepatitis B vaccine and when physicians belong to specialty societies, where peer expectations are likely to be greater. Adoption and adherence without agreement may become increasingly common as physicians' clinical practices are more often monitored against established clinical standards (guidelines) by their practices, the government, and insurers. Nevertheless, it is reasonable to conclude that the four-step awareness-to-adherence model generally holds for physicians' voluntary compliance with guidelines. In cases where guideline compliance is "forced," further efforts to promote agreement become less relevant, whereas interventions to enhance adoption and adherence remain important.

These analyses suggest a number of ways in which the awareness-to-adherence model could be used to identify particularly promising approaches to enhance guideline compliance. The model can be used to identify physicians whose backgrounds and work settings place them at greater risk for stalling at one or more of the steps to guideline adherence. For example in the case of the hepatitis B guideline, family physicians could be targeted in programs to promote each of the steps from agreement to adherence. Similarly, male physicians could receive special attention in efforts to promote compliance with the acellular pertussis vaccine recommendation. To our knowledge, these groups have never received specifically targeted interventions.

The application of the awareness-to-adherence model can direct our attention to promising interventions beyond targeting certain physician groups. For both the hepatitis B and acellular pertussis vaccine recommendations, the value of directly educating parents is underscored. This study also adds to the evidence that rank-and-file physicians can influence the guideline compliance of other local physicians.²⁸ It also may be useful to help physicians overcome the difficulties they encounter changing office procedures to accommodate new vaccine recommendations. In addition, because physicians who relied on the CDC to learn about new pediatric vaccine recommendations demonstrated greater adherence, the CDC should consider expanding its dissemination efforts. Further, the recent efforts of the CDC, AAP, and AAFP to produce a unified, single-page vaccine recommendation schedule ²⁹ may help the sizable number of physicians who find pediatric vaccine recommendations to be confusing and contradictory.

By applying the awareness-to-adherence model, we are able to move beyond the simple assumption that noncomplying physicians are uninformed, uninterested, entrenched in old ways, or unwilling to act in their patients' best interests. The correlates of the steps to hepatitis B vaccine guideline adherence suggest that adherence is affected adversely by physicians' concerns about the long-term efficacy of this vaccine and the perceived inappropriateness of the vaccine for their particular patients. The data suggest that physicians are not unaware of the recommendation, but rather they believe countervailing arguments against the recommendation and tend to reassess the value of recommended care for their patients. Thus, the tenets of the "health belief model"—which holds that patients' compliance with recommended treatment is affected by their perception of whether the diagnosis is correct, the illness is serious, the recommended treatment will be successful, and the costs of treatment are acceptable—seem also to apply to physicians' compliance with vaccine guidelines, and should be considered when compliance is low despite broad guideline awareness.^{30,31}

The awareness-to-adherence model also can be used to reveal inaccuracies in physicians' claims for why they do not agree with or adhere to guidelines. Although physicians have reported in other studies that the number of injections required at a single visit discourages them from providing the hepatitis B vaccine,^{8,32} statistical evidence from this study suggests this is not so. Physicians' claims of the importance of the "pincushion effect"³³ may be a

misattribution or rationalization.³⁴ Perhaps physicians who are disinclined for a variety of reasons to provide recommended vaccines offer the pincushion effect as an explanation when queried. Thus, the current trend to develop combined vaccines to reduce the number of injections may decrease infant, parent, and staff discomfort, but may not actually increase physicians' adherence to vaccine recommendations.

This study demonstrates the application of the awareness-to-adherence model for four pediatric vaccine recommendations with pediatricians and family physicians working in nine states. We see no reason why this model will not prove equally useful in identifying the factors underlying adherence to other clinical guidelines by physicians of other specialties and in other states. We anticipate that in each situation where the model is applied, new wrinkles and complexities will be revealed in the reasons why guidelines do or do not affect physicians' clinical behaviors.³⁵ Because data comparable to those assembled here—requiring surveys of hundreds or thousands of physicians—would be necessary to run these types of analyses for other practice guidelines, the application of this model is not a trivial task. Perhaps researchers, public health advocacy groups, the government, and funding agencies will find this degree of effort is warranted only for guidelines for certain types of medical interventions, such as those for conditions that are common or have serious health consequences. In the future, focus-group interviews and other types of qualitative data collection efforts might be used to further our understanding of how a number of barriers to the steps to guideline adherence play out for individual physicians and in specific practice organizations and communities.

Study Limitations

This study, and others previously,^{8,9} find that many physicians do not agree with the recommendation to provide hepatitis B to all infants. Given this study's purpose, we have treated physician disagreement with this recommendation as a barrier to adherence to recommended care. We leave it to others to explore whether physicians' disagreement with the universal hepatitis B recommendation should make us reconsider whether this recommendation truly is in the best interests of all children.

This study's cross-sectional data are not ideal for validating a model that postulates a sequence of events. Cross-sectional data also increase chances that associations found are noncausal. Future longitudinal studies will provide more convincing evidence for the model and for the factors affecting progression along the pathway to guideline adherence.

It is possible that a number of real associations were overlooked in this study where statistical significance was defined at $P \leq 0.01$. Further, nearly all data used in this study were self-reported, thus subject to reporting inaccuracies. We do not believe this posed significant problems for the findings, except possibly for the analyses involving physicians' reports of their vaccine guideline adherence rates.^{36,37} However, even if physicians overestimated their vaccination rates, those who reported rates of 90% or greater likely had higher true adherence rates than others³⁶; thus, the identified predictors of high adherence generally should be accurate. If actual adherence rates indeed were lower than physicians estimated, then the factors affecting fall-off at the adherence step become even more important.

A number of potentially important explanatory variables were not available and thus did not appear in the analyses. These include practices' use of performance feed-back to physicians and the use of prompts placed on charts by office staff to alert physicians to vaccine needs. Also absent from the models were indicators of state vaccine distribution system features and state and county vaccination requirements for matriculation into public schools.

Conclusions

Through this study of physicians' response to national pediatric vaccine recommendations, the awareness-to-adherence model was found to be generally accurate in describing the sequence of cognitive steps physicians make when adhering to clinical guidelines. The model demonstrated its potential use in efforts to promote physicians' compliance with guidelines. Applications of this model to specific guidelines allows one to identify where fall-off occurs in the steps to guideline adherence, which types of physicians and practice settings are most at risk for failure to attain each step, and the factors likely to be affecting fall-off at each step. There also are circumstances when the awareness-to-adherence model does not hold, such as for the small but significant number of physicians who provided the hepatitis B vaccine to all infants without agreeing with the recommendation to do so. Nevertheless, the findings of this study generally support the awareness-to-adherence model and demonstrate its potential use in efforts to enhance practice guideline compliance.

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Key words: practice guidelines; physicians; models; theoretical; immunization; knowledge; attitudes

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