Middle School Vaccination Requirements and Adolescent Vaccination Coverage

WHAT'S KNOWN ON THIS SUBJECT: Kindergarten entry vaccination requirements are associated with higher coverage for early childhood vaccines.

WHAT THIS STUDY ADDS: Middle school entry vaccination requirements may also be associated with higher coverage for adolescent vaccines, whereas education-only requirements appear not to have an impact at this time.

abstract

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OBJECTIVE: To determine if middle school vaccination requirements are associated with higher coverage for adolescent vaccines.

METHODS: School entry requirements for receipt of vaccination for school entry or education of parents for 3 vaccines recommended for adolescents: tetanus/diphtheria-containing (Td) or tetanus/diphtheria/acellular pertussis (TdaP), meningococcal conjugate (MenACWY), and human papillomavirus (HPV) vaccines in place for the 2008–2009 school year were reviewed for the 50 states and the District of Columbia. Vaccination coverage levels for adolescents 13 to 17 years of age by state requirement status and change in coverage from 2008 to 2009 were assessed by using the 2008–2009 National Immunization Survey-Teen.

RESULTS: For the 2008–2009 school year, 32 states had requirements for Td/TdaP (14 specifically requiring TdaP) and none required education; 3 states required MenACWY vaccine and 10 others required education; and 1 state required HPV vaccine and 5 required education. Compared with states with no requirements, vaccination requirements were associated with significantly higher coverage for MenACWY (71% vs 53%, $P < .001$) and Td/TdaP (80% vs 70%, $P < .001$) vaccines. No association was found between education-only requirements and coverage levels for MenACWY and HPV vaccines. States with new 2008–2009 vaccination requirements ($n = 6$, $P = .04$) and states with preexisting vaccination requirements ($n = 26$, $P = .02$) for Td/TdaP experienced a significant increase in TdaP coverage over states with no requirements.

CONCLUSIONS: Middle school vaccination requirements are associated with higher coverage for Td/TdaP and MenACWY vaccines, whereas education-only requirements do not appear to increase coverage levels for MenACWY or HPV vaccines. The impact on coverage should continue to be monitored as more states adopt requirements. *Pediatrics* 2012;129:1056–1063

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KEY WORDS

vaccination, adolescents, middle school vaccine requirements

ABBREVIATIONS

ACIP—Advisory Committee on Immunization Practices
CDC—Centers for Disease Control and Prevention
HPV—human papillomavirus
MenACWY—meningococcal conjugate vaccine
NIS-Teen—National Immunization Survey-Teen
Td—tetanus/diphtheria
TdaP—tetanus/diphtheria/acellular pertussis
UTD—up-to-date

Ms Bugenske had full access to all of the data in the study, and takes responsibility for the integrity of the data, the acquisition of the data, and the accuracy of the data analysis; Ms Bugenske, Stokley, and Kennedy and Dr Dorell were responsible for the study concept and design, analysis and interpretation of the data, and critical revision of the manuscript for important intellectual content; and Ms Bugenske drafted the manuscript, performed statistical analysis, and was responsible for study supervision.

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School vaccination requirements have a long history in the United States dating back to 1855, when Massachusetts became the first state to require smallpox vaccine for school entry.[1] Over time, school requirements were expanded to include newly developed vaccines such as diphtheria-tetanus-pertussis and measles vaccines. Requirements for vaccination have proven effective in increasing vaccination coverage and decreasing vaccine-preventable disease in the targeted population.[1–4]

Although most school requirements target children entering kindergarten, many states have also implemented requirements targeting children entering middle school. At the start of the 2005–2006 school year, 36 states had vaccination requirements for middle school entry for hepatitis B vaccine and 22 had requirements for a tetanus booster.[5–7] Similar to the experience with kindergarten requirements, middle school requirements for a tetanus booster and hepatitis B vaccine led to rapid increases in coverage levels.[8–12] A 2004 study evaluating hepatitis B vaccination coverage among adolescents in 23 states found that middle school requirements were associated with nearly twice the rate of hepatitis B vaccination of those without requirements.[12] In addition, a 2007 study of adolescents with managed care insurance found that middle school vaccination requirements were the only state policy associated with higher coverage for both hepatitis B and varicella vaccines, whereas other policies including universal purchase of vaccines and availability of philosophical exemptions were not associated with higher coverage.[13]

Education-only requirements are somewhat unique to middle school entry, although they are also common in college entry requirements. This type of requirement mandates that information about a particular disease and/or the vaccine that prevents it be distributed to parents, generally through the school system, although the distribution methods may vary. Educational requirements are sometimes pursued by states without vaccination requirements for a particular vaccine, although a state may have a vaccination requirement for 1 vaccine and an educational requirement for another.

From 2005 to 2007, new vaccines to protect against meningococcal disease; human papillomavirus (HPV); and tetanus, diphtheria, and pertussis were licensed by the Food and Drug Administration and added to the recommended vaccination schedule for adolescents by the Advisory Committee on Immunization Practices (ACIP).[14–17] Following ACIP recommendation of these vaccines, several states updated existing or introduced new vaccination or education requirements for 1 or more of these vaccines. Some requirements specify vaccine type, such as those requiring tetanus/diphtheria/acellular pertussis (TdaP) over the older tetanus/diphtheria (Td), whereas others simply require a tetanus booster.[3]

We analyzed data from the 2008–2009 National Immunization Survey-Teen (NIS-Teen) to determine whether states with middle school entry requirements for Td or TdaP, meningococcal conjugate vaccine (MenACWY), and HPV (1) have higher vaccination coverage for the required vaccine(s) and (2) have higher overall vaccination coverage for all recommended vaccines. In addition, we evaluated if the timing and type of the recommendation had an effect on the change in vaccination coverage from 2008 to 2009 for the required vaccines.

METHODS

State Requirements

We reviewed data from the Centers for Disease Control and Prevention (CDC),[6,7] Immunization Action Coalition,[5] and National Conference of State Legislatures[18] Web sites regarding immunization requirements in place by the start of the 2008–2009 school year for the 50 states and the District of Columbia. Because new requirements generally become effective at the start of the new school year, 2009–2010 school year requirements were not included in our analysis because they would not have affected most adolescents included in the 2009 NIS-Teen. In the case of any discrepancies among these sources, we consulted state public health Web sites for exact wording of requirements. We included requirements that required vaccination for school entry or required education of parents on Td or TdaP, MenACWY, and HPV vaccine. We included requirements that applied to grades 6 to 8 and did not include college entry requirements or requirements that did not apply to all students (eg, new entrants only, residential students only) in a given grade.

Survey Data

We analyzed data from the 2008–2009 NIS-Teen, which has been conducted by CDC since 2006 to estimate vaccination coverage rates for US adolescents aged 13 to 17 years.[19,20] The survey was modeled after the National Immunization Survey[20] and reflects provider-reported vaccination rates. The NIS-Teen uses random-digit dialing to survey parents in households with age-eligible adolescents and obtains consent to contact vaccination providers. An Immunization History Questionnaire is mailed to named providers. A single immunization history is constructed for adolescents with multiple providers. The NIS-Teen was approved by the CDC's Institutional Review Board.

Analysis of NIS-Teen data is limited to adolescents with a completed household interview and adequate vaccination history information from the vaccination provider(s) to determine whether the adolescent was up-to-date

(UTD) with respect to the recommended vaccination schedule. All estimates are weighted to adjust for nonresponse. The National Immunization Survey weighting methodology has been described previously.[19,20] The 2008 NIS-Teen was conducted January 2008 through February 2009 with a Council of American Survey Research Organization response rate of 58.7%. A total of 17 835 adolescents with provider-reported immunization history (58.1%) made up the analytic sample. The 2009 NIS-Teen was conducted January 2009 through February 2010, with a Council of American Survey Research Organization response rate of 58.0%. A total of 20 066 adolescents with provider-reported immunization history (56.3%) made up the analytic sample.

Outcome Measures

We considered adolescents UTD for recommended vaccines if they had received ≥1 dose of Td or TdaP, ≥1 dose of MenACWY, and among adolescent girls, ≥1 dose of HPV. For the HPV vaccine, we limited our analysis to the first dose among adolescent girls to investigate whether requirements influenced initiation of the series. We calculated the percentage of adolescents UTD for each individual vaccine as well as for all vaccines appropriate for gender, stratified by middle school requirement status. States were placed into 1 of 3 categories based on whether they required receipt of vaccination, required education of parents, or had no requirement for each of the 3 vaccines. Because only 1 state had a vaccination requirement for HPV vaccine for the 2008–2009 school year, this requirement was grouped together with the educational requirements to ensure adequate sample size for analysis.

We calculated change in vaccination coverage for each state from 2008 to 2009 by subtracting the percentage of adolescents UTD for 2008 from that of 2009, stratified by timing of implementation of requirement. States were placed into 1 of 5 categories based on type of requirement and timing of implementation of requirement: (1) pre-2008 vaccination requirement, (2) vaccination requirement implemented during 2008–2009 school year, (3) pre-2008 education requirement, (4) education requirement implemented during 2008–2009 school year, or (5) no requirement.

Analysis

Data management was conducted by using SAS version 9.2 (SAS Institute, Cary, NC). Estimates of percentages, 95% confidence intervals, and *P* values were calculated by using SUDAAN version 10.0 (Research Triangle Institute, Research Triangle Park, NC). Statistical significance was determined by χ^2 tests. All analyses were weighted to account for the unequal probabilities of selection and adjustment for nonresponse.

RESULTS

Middle school entry requirements by state are shown in Table 1. For the 2008–2009 school year, 32 states had requirements for Td/TdaP, with 14 of them specifically requiring TdaP. No state requirements required education only for Td/TdaP. Three states required receipt of MenACWY vaccine and 10 required education of parents about meningococcal disease and MenACWY vaccine. One state required receipt of HPV vaccine for adolescent girls, and 5 required education of parents for HPV infection and vaccine. Thirty-nine states had at least 1 vaccination or education requirement, although 7 of these states had only education requirements.

Table 2 displays the percentage of adolescents UTD with vaccination(s) by state requirement status. School entry vaccination requirements were associated with significantly higher coverage for Td/TdaP ($P < .0001$) and MenACWY ($P < .0001$) vaccines. Additional evaluation of tetanus-containing requirements found that states with TdaP-specific requirements had significantly higher TdaP coverage than states with Td-containing or no requirements (64.0% vs 55.9% vs 49.2%, respectively; $P < .0001$). No association was found between requirements for parental education and coverage levels for MenACWY and HPV vaccines. States with at least 1 requirement for receipt of Td/TdaP, MenACWY, and/or HPV vaccine (adolescent girls only) ($n = 32$) at middle school entry had significantly higher overall coverage for all 3 vaccines than states with educational requirements only ($n = 7$) ($P < .0001$) but coverage levels were not significantly different from states with no requirements. To determine if results varied by age, analyses were repeated for 2 age groups: 13 to 15 years and 16 to 17 years. Results for both age groups followed a similar pattern as seen for the overall sample (data not shown).

Table 3 shows the average percentage point change in vaccination coverage from 2008 to 2009 by timing of implementation of requirement. Among 6 states that implemented new tetanus vaccination requirements for 2008–2009, 5 requirements were TdaP-specific; among 26 states that had pre-existing tetanus requirements, 9 were TdaP-specific. All groups experienced a significant increase in TdaP coverage between 2008 and 2009. The magnitude in change was significantly greater for states who implemented their vaccination requirement in 2008–2009 ($P = .04$) and states with preexisting requirements ($P = .02$) compared with states with no requirement, but there was no significant difference between states with new requirements for 2008–2009 and those with preexisting requirements. Although all groups experienced a

TABLE 1 Middle School Immunization Requirements by State, 2008–2009 School Year

State	Td-containing	TdaP-specific	MenACWY	HPV
Alabama	V			
Alaska	V			
Arizona		V[a]	V[a]	
Arkansas				
California				
Colorado		V		
Connecticut			E[a]	
Delaware				
District of Columbia		V		
Florida	V			
Georgia				
Hawaii				
Idaho				
Illinois	V			
Indiana			E	E
Iowa				E
Kansas	V			
Kentucky	V			
Louisiana	V			
Maine				
Maryland				
Massachusetts	V		E	
Michigan	V			
Minnesota	V			
Mississippi			E	
Missouri	V			
Montana	V			
Nebraska				
Nevada		V		
New Hampshire	V			
New Jersey		V[a]	V[a]	E
New Mexico		V		
New York		V		
North Carolina		V	E	E
North Dakota		V[a]	V[a]	
Ohio			E	
Oklahoma			E	
Oregon		V[a]		
Pennsylvania	V[a]			
Rhode Island	V			
South Carolina				
South Dakota				
Tennessee			E	
Texas	V		E	
Utah	V			
Vermont		V		
Virginia		V		V[a]
Washington		V	E	E
West Virginia				
Wisconsin		V[a]		
Wyoming	V			
Vaccination Requirements	18	14	3	1
Education Requirements	0	0	10	5

E, requires dissemination of education information about the disease and vaccine to parents; V, requires receipt of vaccine.
[a] Newly implemented requirement for 2008–2009 school year.

significant increase in MenACWY coverage from 2008 to 2009, the increase in coverage was not statistically different between groups. On average, states that implemented an education requirement pre-2008 and states that had no requirement observed statistically significant increases in coverage from 2008 to 2009. Like MenACWY, the change in HPV coverage from 2008 to 2009 was not statistically significant between groups.

DISCUSSION

To our knowledge, this is the first study to evaluate the association of middle school vaccination and education requirements with vaccination coverage for the most recently recommended vaccines for adolescents (TdaP, MenACWY, and HPV). Results from our analysis indicate that requirements for adolescent vaccination for school entry were associated with higher coverage for Td/TdaP and MenACWY vaccines and no association was found between educational requirements and coverage levels for MenACWY or HPV vaccines.

Among the vaccines studied, requirements for a tetanus booster were more frequent and had been in place the longest given that Td had been recommended for adolescents before the licensure of TdaP. Vaccination coverage with ≥1 doses of Td/TdaP was 10 percentage points higher among states that had a Td/TdaP requirement in comparison with states with no requirement. Vaccine specificity was also found to be important as coverage with TdaP was 8 percentage points higher among states with a TdaP-specific requirement in comparison with states that did not specify TdaP in their requirement. The importance of vaccine specificity in the tetanus booster requirement may lessen over time given several factors. When TdaP was first licensed, the ACIP recommended that persons who previously received Td wait 2 to 5 years before receiving TdaP; thus, some adolescents included in the 2009 NIS-Teen who had received Td may not have been eligible to receive TdaP. Recently, the ACIP removed the 2- to 5-year interval and now recommends that providers do not wait to administer TdaP.[21] Because the majority of adolescents who received a tetanus booster since 2006 have received TdaP,[22] even if

TABLE 2 Percentage of Adolescents 13–17 Years of Age UTD With Vaccination(s) by State Requirement Status

Vaccine	Vaccination Requirements Only		Education Requirements Only		No Requirements	
	No. of States	% (95% CI)	No. of States	% (95% CI)	No. of States	% (95% CI)
≥1 MCV4	3	70.5 (66.5–74.2)	10	51.0 (48.7–53.2)[a]	38	53.4 (51.8–55.0)
≥1 Td/TdaP	32	79.8 (78.7–80.9)	—	—	19	69.5 (67.3–71.7)[a]
≥1 HPV[b]	—	—	6[c]	45.0 (41.3–48.7)	45	44.2 (42.1–46.2)
UTD Overall[d]	32[e]	42.2 (40.7–43.7)	7[e]	35.4 (32.9–37.9)[a]	12	42.1 (38.4–45.9)
Male		51.1 (49.0–53.2)		40.5 (37.1–44.1)[a]		48.9 (43.8–53.9)
Female		32.9 (30.9–35.0)		29.9 (26.4–33.6)		35.0 (29.7–40.6)

[a] Significantly different from vaccination requirements only ($P < .05$).
[b] HPV was assessed among adolescent girls only; because of sample size, education requirement group includes the 1 state that had a vaccine requirement for this vaccine.
[c] One vaccination requirement for HPV vaccine combined with 5 education requirements to ensure adequate sample size.
[d] UTD Overall was defined for males as receiving ≥1 MenACWY and ≥1 Td/TdaP and among adolescent girls as receiving ≥1 MenACWY, ≥1 Td/TdaP, and ≥1 HPV.
[e] Vaccination requirements only defined as states with ≥1 vaccination requirement for Td/TdaP, MenACWY, and/or HPV vaccines; education requirements only defined as states with no vaccination requirements and ≥1 educational requirement.

a requirement is not vaccine-specific, it is expected that most adolescents will receive TdaP for their booster. TdaP-specific requirements were represented in both new requirements for the 2008–2009 school year and preexisting tetanus requirements, which may explain why we observed similar increases in TdaP coverage from 2008 to 2009 for new Td/TdaP requirements in comparison with preexisting requirements.

States with a MenACWY requirement had coverage 17 percentage points higher than states without a MenACWY requirement. Caution should be used when interpreting these results, because only 3 states had a requirement. However, all 3 states implemented their requirement during the 2008–2009 school year and, on average, achieved 70% coverage with MenACWY 1 year after implementation, well over the national average.

Preventive health care visits, when vaccines are most likely to be administered, occur less frequently among adolescents.[23] Providers are encouraged to take advantage of every encounter to assess an adolescent's vaccination status and administer needed vaccines.[24] When an adolescent visits a provider to obtain the vaccine(s) required for school entry, this would be an ideal opportunity to administer other recommended (though not required) vaccines. Unfortunately, our study found that the presence of 1 or more vaccine requirements for school entry was not associated with higher overall vaccination coverage in comparison with states with no requirements. The low overall coverage observed among adolescent girls is driven by low HPV coverage. Studies have shown that providers are less likely to recommend this vaccine to younger adolescents, and parental acceptance of the vaccine is variable.[25–27] Thus, there may be greater issues that need to be addressed to increase HPV vaccination coverage beyond creating a vaccination opportunity.

TABLE 3 Average Percentage Point Change in Coverage From 2008 to 2009 by Timing of Implementation of Middle School Requirement

	No. of States	Percentage Point Change (95% CI)
≥1 TdaP		
2008–2009 SY vaccination requirement	6	17.8 (13.8 to 21.8)[a,b]
Pre-2008 vaccination requirement	26	16.2 (13.8 to 18.6)[a,b]
No requirement	19	12.8 (8.9 to 16.7)[a]
≥1 MenACWY		
2008–2009 SY vaccination requirement	3	15.9 (9.9 to 21.9)[a]
2008–2009 SY education requirement	1	22.9 (13.5 to 32.3)[a]
Pre-2008 education requirement	9	12.7 (9.1 to 16.3)[a]
No requirement	38	10.9 (8.5 to 13.3)[a]
≥1 HPV[c]		
2008–2009 SY vaccination requirement	1	−3.8 (−10.9 to 3.3)
Pre-2008 education requirement	5	8.0 (4.7 to 11.3)[a]
No requirement	45	9.8 (8.1 to 11.6)[a]

SY, school year.
[a] Change in coverage from 2008 to 2009 statistically significant ($P < .05$).
[b] Significantly different from no requirement ($P < .05$).
[c] HPV assessed among adolescent girls only.

School vaccination requirements are recommended as an evidence-based strategy by the Task Force on Community Preventive Services to improve vaccination coverage levels.[28,29] Although vaccination requirements may be an important public health policy, they may not be feasible for every vaccine or in every location. Several organizations, including the National Vaccine Advisory Committee,[15] the Association of Immunization Managers,[30] and the State of Washington[31] have come forward with position statements outlining the factors that states should consider when pursuing a vaccine requirement for school entry, including (1) partnership with state and local personnel and providers; (2) infrastructure issues such as vaccine purchasing, supply, and storage; (3) consistency with existing school entry requirements; and (4) adequate political and public support.[15]

Lacking the necessary political, public, or financial support to implement a vaccine requirement, some states may pursue education requirements. Several studies have shown that parental awareness of the vaccines recommended for adolescents is low,[32–34]

lending support to these types of requirements. Most educational requirements require dissemination of educational materials to parents through the school system, which can take many forms; materials may be mailed directly to parents, sent home with children, or included on forms for reporting receipt of required vaccinations. Educational materials may or may not require documentation that parents have received them, such as a parental signature. Results from our study indicate that unlike vaccine requirements, educational requirements are not associated with higher coverage. Overall vaccination coverage for educational-only requirement states was significantly lower than states with no requirements; however, statistical differences were not observed for MenACWY and HPV coverage, respectively. Although the NIS-Teen prevents us from assessing causality, we do not think the educational materials themselves caused lower overall coverage levels, and perhaps other sociodemographic factors not controlled for may be contributing to the finding. The more likely scenario behind the individual vaccine results is that the educational materials are not reaching the target audience. A 2010 study found that despite North Carolina's education requirement for HPV vaccine, only 9% of mothers surveyed in the state had heard about the vaccine via their daughters' schools.[35] Further evaluation of education requirements including distribution methods, message content, and influence on parental attitudes toward vaccines is needed to ensure that states are utilizing resources effectively.

Level of enforcement of school entry requirements varies among states and even within states.[36,37] A 2004 study suggests that knowledge and attitudes of school nurses and individuals charged with enforcing requirements may have an important impact on level of enforcement and number of exemptions granted.[36] Although school entry requirements do appear to lead to increased vaccination coverage levels, such an increase is not guaranteed without adequate enforcement of requirements.

This study is not without limitations. The NIS-Teen is a random-digit–dialed survey limited to landline households; it may not be representative of nonlandline and wireless-only households, which could contribute to noncoverage bias. The exclusive use of provider-verified vaccination histories may lead to underestimates of vaccination coverage, because the completeness of these records is unknown. This analysis does not account for any activities states may have implemented promoting adolescent immunization or differences in state policies such as vaccine financing. The potential influence of any differences in sociodemographic factors across states was also not taken into account. The vaccine and education requirements that were reviewed generally apply to adolescents ages 11 to 13. The NIS-Teen includes adolescents 13 to 17 years of age; therefore, depending on when the requirement was implemented, most of the teens included in the NIS-Teen may not have been directly affected by the requirements. However, we observed higher coverage levels in states with requirements for TdaP and MenACWY, which may suggest an indirect benefit to older teens. The NIS-Teen began collecting state-level vaccination data in 2008; therefore, we were unable to evaluate change in vaccination coverage pre- and postimplementation among states that implemented a requirement before the 2008–2009 school year. The number of states with requirements for MenACWY and HPV vaccines in 2008–2009 was small, so caution should be used when interpreting results for these vaccines. Many of the requirements for MenACWY and HPV were only in place for 1 year at the time of our analysis; additional time may be needed before full implementation of the requirements has been achieved.

Adolescent vaccination coverage levels are increasing but remain low. Less than half of adolescent girls 13 to 17 years of age have initiated the HPV series. A statistical model predicting HPV vaccine uptake over a 50-year time horizon shows that, in the absence of school requirements, it will take 23 years to achieve 70% coverage for the complete series.[38] The likelihood of widespread HPV vaccine requirements for school entry appears to be low. Since the HPV vaccine was licensed in 2006, 24 states have proposed legislation regarding middle school entry requirements for HPV vaccine for adolescent girls. To date, only 2 of these proposals have resulted in vaccination requirements (District of Columbia and Virginia).[18] Reasons for this low rate of success for proposals include the high cost of the 3-dose vaccine series, sexual transmission of the virus, and lack of public support for a requirement.[39] In the absence of school requirements for HPV vaccine, identifying effective strategies to increase initiation and completion of the HPV vaccine series will be necessary.

Since the 2008–2009 school year, 21 states have enacted new or updated vaccination requirements for TdaP, 6 new requirements for MenACWY, and 1 new requirement for HPV vaccine. Of the new TdaP requirements, 14 replaced older Td requirements and 7 are states with no previous Td requirement.[5,18,40] We will continue to monitor the impact these requirements have on coverage.

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SMALLER MAY BE BETTER: *It is mid-winter as I write this and the temperature in northern Vermont is almost 50 degrees. The ski pass I bought last June has been used exactly four times. Our lawn and driveway, rather than lying under inches or feet of snow, are mud. While I have lived through other warm spells and warm winters, I keep thinking that the weather patterns in Vermont have changed a lot in the past 20 years. I keep wondering about other effects of warm weather. According to an article in* The New York Times *(Science: February 2, 2012), one possible outcome may be that mammals will become smaller. Scientists studied the fossil record of the Sifrhippus, the first horse, in the Bighorn Basin of Wyoming. The horse roamed the area approximately 56 million years ago and survived the Paleocene-Eocene thermal maximum period: a 175,000-year time period in which ambient temperatures are thought to have risen by 9 to 18 degrees Fahrenheit before dropping at the end. The fossil record of the Sifrhippus is extensive and quite well preserved, showing that over the first 130,000 years of this warming period the horse shrank in size almost 30% (dropping from an average weight of 12 to eight and a half pounds). During the next 45,000 years, as the temperatures cooled, the average weight shot up and approached 15 pounds. Some scientists theorized that the most likely explanation for the shrinkage was natural selection driven by the warming trend. One hypothesis is that smaller animals do better in warmer climates because it is easier for small animals to shed heat. Other scientists dispute the findings, suggesting that the warming trend and changes in the ecosystem led smaller animals to migrate to different locations. Still, the findings seem to fit with Bergmann's rule, which holds that mammals of a particular species tend to be smaller in hotter climates. How applicable the findings are to modern mammals is unclear. After all, the changes in the Sifrhippus took place over thousands of years. Still, the study is a reminder how interconnected all living creatures are with nature.*

Noted by WVR, MD

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