Academic Achievement of Children and Adolescents With Oral Clefts

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KEY WORDS

academic achievement, learning disability, academic testing, cleft lip, cleft palate

ABBREVIATIONS

CL—isolated cleft lip only
CLP—cleft lip and palate
CP—cleft palate only
ITBS—Iowa Tests of Basic Skills
ITED—Iowa Tests of Educational Development
ITP—Iowa Testing Programs
NPR—national percentile ranking

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WHAT'S KNOWN ON THIS SUBJECT: Previous studies that reported learning deficits among children with oral clefts mostly used small, clinic-based samples prone to ascertainment bias. No previous studies in the United States have used a population-based sample and direct testing of academic achievement.

WHAT THIS STUDY ADDS: Using a large population-based sample from the United States and standardized school tests for achievement, we found that children with oral clefts scored significantly lower than their classmates on all evaluated domains of achievement and had higher rates of learning disability.

abstract

BACKGROUND AND OBJECTIVE: Previous studies of academic achievement of children with oral clefts have mostly relied on small, clinic-based samples prone to ascertainment bias. In the first study in the United States to use a population-based sample with direct assessment, we evaluated the academic achievement of children with oral clefts relative to their classmates.

METHODS: Children born with isolated oral clefts in Iowa from 1983 to 2003 were identified from the Iowa Registry for Congenital and Inherited Disorders and matched to unaffected classmates by gender, school/school district, and month and year of birth. Academic achievement was assessed by using standardized tests of academic progress developed by the Iowa Testing Programs. Iowa Testing Programs data were linked to birth certificates for all children. Regression models controlled for household demographic and socioeconomic factors. The analytical sample included 588 children with clefts contributing 3735 child-grade observations and 1874 classmates contributing 13 159 child-grade observations.

RESULTS: Children with oral clefts had lower scores than their classmates across all domains and school levels, with a 5-percentile difference in the overall composite score. Children with clefts were approximately one-half grade level behind their classmates and had higher rates of academic underachievement and use of special education services by 8 percentage points. Group differences were slightly lower but remained large and significant after adjusting for many background characteristics.

CONCLUSIONS: Children with oral clefts underperformed across all academic areas and grade levels compared with their classmates. The results support a model of early testing and intervention among affected children to identify and reduce academic deficits. *Pediatrics* 2014;133:785–792

Oral clefts are the most common craniofacial birth defect, occurring in 1 per 1250 births in the United States.[1] Most cases are "isolated," meaning that they occur without other birth defects or syndromes, and follow a complex etiology of genetic and environmental factors.[2] Sequelae include infant feeding problems, recurrent otitis media, and speech difficulties.[3–5]

Several studies have shown that children with isolated clefts have an increased incidence of learning problems and academic underachievement.[6] This work focused primarily on reading and, although there are exceptions,[7] most studies reported that affected children score lower than expected compared with test norms and unaffected controls.[8–12] However, population-based investigations are rare, and most studies have included small, clinic-based patient samples. The only 2 existing population-based studies relied on indirect measures of academic performance, including classroom grades and graduation rates from compulsory schools in Sweden[13] and frequency of special education placement in Atlanta, Georgia.[14] Both studies suggested poor academic functioning among individuals with clefts. However, the lack of direct testing limits the certainty of this conclusion, because factors other than academic ability can influence grades and special education placement (eg, social adjustment).

In this study we evaluated academic achievement in children in Iowa with isolated oral clefts compared with unaffected classmates, allowing us to control for school effects. Academic achievement was directly assessed by using tests of academic progress administered to all children in Iowa. Data from birth certificates allowed us to control for several household factors.

METHODS

Study Population and Data Linkages

The study population consisted of 763 children with isolated oral clefts born to Iowa-resident mothers from January 1983 through December 2003 and their unaffected classmates. Children with oral clefts were identified from the Iowa Registry for Congenital and Inherited Disorders, which conducts active surveillance of birth defects through field staff who conduct systematic reviews of medical records in hospitals and clinics in Iowa and neighboring states that serve Iowa residents. Children with isolated cleft lip only (CL), cleft lip and palate (CLP), and cleft palate only (CP) were included; a small number of cases (n = 20) died before school entry. Iowa Registry for Congenital and Inherited Disorders data were linked with data on academic achievement from the Iowa Testing Programs (ITP), described below, and birth certificate data to measure household demographic and socioeconomic factors. Of the eligible population of children with isolated oral clefts, 614 (82.6%) were found in the ITP database.

Classmates of children with oral clefts were identified from the ITP database. For each affected child, 2 classmates were matched by gender, month, and year of birth; grade; and school. Two additional classmates were selected and matched when an affected child switched school districts. A new classmate was also matched when a previous classmate switched school district (see below). Matching criteria were relaxed, when needed, to locate 2 classmates, beginning with month then year of birth and then school; classmates were always matched by gender, grade, and school district.

Academic Achievement

We measured academic achievement by using the Iowa Tests of Basic Skills (ITBS) for children in kindergarten through eighth grade and the Iowa Tests of Educational Development (ITED) for high school students.[15] The ITBS and ITED are nationally recognized, standardized achievement tests that cover all major academic subject areas. Both tests have strong psychometrics, and the norms and standardization were developed by using a nationally representative student sample. These norms permit tracking each student's achievement across time compared with national averages. The tests include multiple-choice questions with 4 or 5 response options. These tests are administered to nearly all students in Iowa and are among the most commonly used school tests of academic achievement nationwide.

We measured students' performance in Reading, Language, Mathematics, Science, Social Studies (eg, History, Economics, and Government), and Sources of Information (eg, use of maps and diagrams) on the basis of their test scores in each area. In addition to area-specific scores, we evaluated a composite score (Composite Total) combining these domain scores. The primary dependent variables for analyses were the national percentile rankings (NPRs). In addition to the NPRs, we created a dichotomous score indicating whether the child had NPR scores below the 25th percentile on $\geq$1 of the 3 core testing areas (Reading, Language, and Mathematics), a commonly used cutoff to identify children in need of academic remediation.[16]

Test scores were linked to each study child (case/classmate) across all of their years in Iowa schools found in ITP data. In addition, we evaluated the use of special education services, which was first measured in 2001 and available for all academic years thereafter. The study was approved by the University of Iowa Institutional Review Board.

Study Sample

Our analytical sample consisted of child-grade observations with the child's

achievement in each grade as the unit of the analysis. To improve generalizability and data quality, we dropped kindergarten, grade 1, and grade 12, because these grades had limited testing of students. We also included ITP data through 2010 because tests and scoring changed significantly in 2011 (last year of available data at the time of analysis). After exclusions, our analytical sample consisted of 588 children with oral clefts (219 CL, 135 CP, 234 CLP) contributing 3735 child-grade observations and 1874 classmates contributing 13 159 child-grade observations. The classmate sample is more than double that of affected children because we compared affected children to all of their matched controls on all grades with available ITP data (before and after switching school districts). This approach preserved the classmate sample composition when comparing academic achievement over multiple grades (2–11) or school levels instead of including classmate data only for overlapping grades with the affected child (which would include different classmates at different grades for children who switched school districts). Also, this comparison reduces potential biases from selective switching on the basis of the child's academic performance and characteristics of the new school district. Approximately 21.1% of affected children in the analytical sample (5.2% of child-grade observations) and 25.4% of classmates (6.2% of child-grade observations) switched school districts. When children repeated a grade, only their first-year tests were retained for analysis because they reflect a more accurate measurement of their initial achievement at that grade. Approximately 2% of affected children and 3.4% of classmates in the analytical sample ever repeated a grade.

Statistical Analysis

For each measure of academic achievement, we used 2 regression specifications with child-grade observations as the analysis unit. The first specification was a basic regression to evaluate overall differences in academic achievement between children with oral clefts and their own classmates as follows:

$$ACHIEVEMENT = \beta_0 + \beta_1 CLEFT + \beta_2 GRADE + \boldsymbol{\beta_3}\mathbf{FORM} + \beta_4 YEARS + \boldsymbol{\beta_5}\mathbf{GROUP} + e$$

CLEFT is an indicator for a child with an oral cleft and *GRADE* is grade level at testing. *FORM* includes dummy variables for the test version (3 versions during study period) to account for any potential shifts in scoring scale or test effects on achievement. Also, we adjusted for the number of years since the test-battery version had been used *(YEARS)* to account for any learning effects on teachers or students. **GROUP** includes dummy variables (fixed effects) for the affected child and his or her group of classmates to compare an affected child only to his or her own matched classmates (and not to classmates of other affected children), holding constant all common characteristics, including gender and school (or school district), which were dropped from the model (as they are represented in **GROUP**).

The following second specification added potential demographic background and socioeconomic confounders to capture as much as possible (with the observed data set) differences in academic achievement resulting from having an oral cleft:

$$ACHIEVEMENT = \beta_0 + \beta_1 CLEFT + \beta_2 GRADE + \boldsymbol{\beta_3}\mathbf{FORM} + \beta_4 YEARS + \boldsymbol{\beta_5}\mathbf{GROUP} + \boldsymbol{\beta_6}\mathbf{X} + e$$

X included the following maternal and paternal characteristics obtained from the birth certificate data: maternal age and marital status at child's birth, race/ethnicity, education, any smoking and any alcohol consumption anytime during pregnancy, and father's education and age at child's birth, which were all represented by dummy variables to allow for nonlinear effects. Data on smoking, alcohol, and race/ethnicity were not captured in birth certificates before 1989. More than 10% of the sample had missing data on father's characteristics. To preserve the sample size to be as close as possible to the first specification, we represented observations with missing data on covariates in **X** by dummy variables instead of excluding them, except for marital status which only had a few observations missing. The regressions were estimated by using ordinary least squares, clustering SEs at **GROUP** level. We estimated the models by first combining all grades to estimate an overall difference in educational achievement; we then stratified by school level (elementary, middle, and high school). In additional models when combining all grades, we replaced the indicator for *CLEFT* with indicators for cleft type (CL, CP, CLP).

RESULTS

Sample Description

Children with oral clefts and classmates were similar with regard to demographic and socioeconomic characteristics (Table 1). In both groups, most mothers were married, 20 through 35 years of age at the time of the child's birth, and had graduated high school or completed some college. Maternal race/ethnicity was missing for ∼40% of the sample, but the majority (>95%) of those with data were non-Hispanic white.

Table 2 reports descriptive statistics for the academic achievement measures. Across the domains, average NPRs ranged from the 56th to 60th percentiles for affected children and from the 58th to 62nd percentiles for classmates. Approximately 31% of affected children and 26% of classmates scored below the 25th percentile on Reading, Language, and/or Mathematics. The rates of special education placement were ∼20% among affected children and 13% among classmates.

TABLE 1 Sample Demographic and Socioeconomic Characteristics

Variable	Children With Oral Clefts (n = 3735)		Classmates (n = 13159)	
	n	%	n	%
Oral clefts				
CL	1384	37.0	—	—
CP	864	23.1	—	—
CLP	1487	39.8	—	—
Child's gender				
Female	2248	44.2	5730	43.5
Male	1487	55.8	7429	56.5
Mother married				
No	652	17.5	2296	17.5
Yes	3730	82.5	10 823	82.5
Maternal race/ethnicity				
Nonwhite and/or Hispanic	126	3.4	614	4.7
Non-Hispanic white	2154	57.7	7124	54.1
Missing	1455	38.9	5421	41.2
Maternal age				
<20 years	356	9.5	1141	8.7
20–35 years	3046	81.6	11 073	84.1
>35 years	333	8.9	938	7.1
Missing	0	0.0	7	0.1
Father's age				
<20 years	94	2.5	227	1.7
20–35 years	2571	68.8	9376	71.3
>35 years	660	17.7	1924	14.6
Missing	410	11.0	1632	12.4
Mother's education				
Less than high school	434	11.6	1395	10.6
High school to some college	2630	70.4	9148	69.5
≥4 years of college	634	17.0	2536	19.3
Missing	37	1.0	80	0.6
Father's education				
Less than high school	181	4.9	780	5.9
High school to some college	2318	62.1	7554	57.4
≥4 years of college	604	16.2	2512	19.1
Missing	632	16.9	2313	17.6
Maternal smoking				
No	1729	46.3	5984	45.5
Yes	534	14.3	1543	11.7
Missing	1472	39.4	5632	42.8
Maternal alcohol consumption				
No	1729	57.9	7315	55.6
Yes	534	2.4	230	1.8
Missing	1472	39.7	5614	42.6

Data are presented for the demographic and socioeconomic variables for children with oral clefts and matched classmates attending schools in Iowa between 1990 and 2010. Because some affected children had >2 matched classmates (because of school switching), the overall percentages of males/females are not exactly equal between the 2 groups.

Descriptive statistics for grade/test covariates are provided in Supplemental Table 5.

Differences in Academic Achievement

Children with oral clefts ranked significantly lower on all domains compared with their classmates (Table 3; results for Science, Social Studies, and Sources of Information in Supplemental Table 6). In the basic regression, the average difference in NPRs ranged from 3.5 percentiles for Science to 5 percentiles for Mathematics and Language. Compared with classmates, children with clefts were more likely to have scores suggestive of learning disability (NPR <25th percentile) by 8 percentage points for Reading, Language, and/or Mathematics. Similarly, children with clefts were more likely to use special education by 8 percentage points. Group differences remained statistically significant but decreased slightly in the expanded regression (Table 3, Supplemental Table 6).

Among cases, there were no statistically significant differences by cleft type. Case-classmate differences were typically largest for children with CP versus classmates. Children with CP and CLP (but not CL) were more likely than classmates to use special education services. All 3 cleft types were associated with increased probability for scoring below the 25th percentile on Reading, Language, and/or Mathematics. The differences from classmates changed slightly in the expanded regression but most remained prominent and statistically significant.

Next, we evaluated differences by school level by using basic regression (Table 4, Supplemental Table 7). Children with oral clefts had lower achievement than did their classmates at all school levels and domains, and there were no consistent patterns of changes across school levels. The largest gradient among the main areas of achievement was for Mathematics in high school (>5.5 percentiles) and the lowest was for Reading in high school (~3 percentiles). The differences were similar, although slightly smaller in magnitude, in the expanded regression (detailed results available upon request).

In sensitivity analyses, we evaluated the impact of matching new classmates when a child switched schools by comparing each case to all children in the classmate sample at the same grade level (not just their matched classmates). The same pattern of results was observed. Similarly, excluding cases whose classmates repeated a grade had virtually no impact

TABLE 2 Descriptive Statistics for the Academic Achievement Measures

Variable	Children With Oral Clefts	Classmates
Reading	55.7 ± 28.1	58.3 ± 27.4
Language	56.1 ± 28.4	59.6 ± 27.6
Math	58.0 ± 27.9	61.8 ± 27.3
Science	59.9 ± 27.1	62.4 ± 26.4
Social Studies	57.8 ± 27.8	60.4 ± 26.9
Sources of Information	58.8 ± 27.4	62.0 ± 26.2
Composite Total	58.9 ± 27.7	62.1 ± 26.5
Reading, Language, or Math scores less than national 25th percentile		
No	2230 (68.6)	8563 (74.4)
Yes	1022 (31.4)	2946 (25.6)
Special education		
No	1847 (80.3)	6847 (87.1)
Yes	453 (19.7)	1018 (12.9)

Data are presented as means ± SDs for continuous variables or as *n* (%) for categorical variables. The table summarizes the academic achievement of children with oral clefts and matched classmates attending schools in Iowa between 1990 and 2010. The number of observations with complete data for the variables ranged from 2300 to 3548 for children with oral clefts and from 7865 to 12 533 for classmates.

on the results. Detailed results are available upon request.

DISCUSSION

Compared with their unaffected classmates, children with oral clefts scored lower on all measures of academic achievement. This effect was present across grade levels and academic skills tested. These findings are consistent with those from earlier population-based studies.[13,14] Our study extends these findings to more rigorous and direct methods of assessment of academic achievement, controlling for several potential demographic and socioeconomic confounders.

Previous studies of neurodevelopmental and academic functioning in children with oral clefts have generated 3 distinct impressions with which our findings can be compared: (1) children with oral clefts have shown greater difficulty in reading and language than in other areas[8,12]; (2) among cleft types, neurodevelopmental outcomes are poorer for those with CP or CLP than CL[6]; and (3) individuals with clefts have much higher rates of "learning disability" than classmates,[10,17] more than a twofold increase over the population-based estimate of ∼20%.[18–20]

With respect to areas of academic functioning, group differences were equivalent across domains, including those with greater and lesser degrees of verbal mediation (eg, Reading versus Mathematics). This finding may reflect the fact that the specific verbal impairments found in children with clefts (eg, rapid naming and verbal memory[10,12]) are not directly captured by tests such as the ITBS/ITED, which focus on vocabulary and reading comprehension. Nevertheless, our findings suggest that reading and language are not the only academic vulnerabilities for children with clefts. Our findings regarding cleft type are largely consistent with previous studies. Although differences by cleft type were statistically insignificant, differences from classmates tended to be largest for children with CP, and children with CP or CLP had significantly higher rates of special education placement. However, children with CL in this sample scored lower than their classmates and had a higher rate of learning problems.

TABLE 3 Differences in Educational Achievement Between Children With Oral Clefts and Their Classmates

Case Group	Reading	Language	Math	Composite Total	Reading, Language, or Math <25th Percentile	Special Education
Basic regression specification						
n	15 495	14 855	16 081	11 598	14 761	10 165
Any cleft	−3.92 (1.29)***	−5.04 (1.26)***	−5.00 (1.16)***	−4.87 (1.40)***	0.077 (0.019)***	0.078 (0.020)***
CL	−4.07 (2.16)*	−5.06 (2.13)**	−4.20 (1.94)**	−5.20 (2.43)**	0.071 (0.031)**	0.035 (0.032)[a]
CP	−6.24 (2.70)**	−6.24 (2.64)**	−6.33 (2.48)**	−6.61 (2.80)**	0.115 (0.040)***	0.126 (0.040)***[a]
CLP	−2.41 (1.98)	−4.26 (1.92)**	−4.97 (1.79)***	−3.47 (2.13)	0.059 (0.029)**	0.093 (0.032)***
Expanded regression specification						
n	15 457	14 819	16 030	11 587	14 725	10 113
Any cleft	−3.49 (1.21)***	−4.42 (1.19)***	−4.40 (1.10)***	−4.14 (1.31)***	0.069 (0.018)***	0.069 (0.019)***
CL	−3.61 (2.06)*	−4.35 (2.02)**	−3.42 (1.80)*	−3.90 (2.27)*	0.060 (0.029)**	0.019 (0.030)[a]
CP	−6.42 (2.51)**	−5.95 (2.54)**	−6.26 (2.39)***	−7.01 (2.56)***	0.115 (0.038)***	0.117 (0.039)***[a]
CLP	−1.66 (1.84)	−3.57 (1.80)**	−4.20 (1.69)**	−2.62 (1.99)	0.050 (0.028)*	0.088 (0.030)***

Data are presented as β (SE) unless otherwise indicated. Adjusted differences in areas of academic achievement between children with oral clefts and matched classmates attending schools in Iowa between 1990 and 2010 are presented. Two separate regression models (with the same sample size) were estimated for any cleft and for the cleft types. The Composite Total includes Reading, Language, Math, Science, Social Studies, and Sources of Information. *$P < .1$, **$P < .05$, ***$P < .01$.

[a] Indicates that the coefficients are different from each other at $P < .1$.

TABLE 4 Differences in Educational Achievement Between Children With Oral Clefts and Their Classmates by School Level

Case Group	Reading	Language	Math	Composite Total	Reading, Language, or Math < 25th Percentile	Special Education
Elementary school						
n	6627	6553	6700	4696	6276	3591
β (SE)	−4.49 (1.35)***	−4.89 (1.29)***	−4.46 (1.22)***	−4.96 (1.51)***	0.080 (0.020)***	0.075 (0.023)***
Middle school						
n	5237	4875	5426	4010	4990	3387
β (SE)	−3.64 (1.53)**	−5.32 (1.53)***	−5.19 (1.39)***	−5.52 (1.68)***	0.078 (0.024)***	0.089 (0.026)***
High school						
n	3631	3427	3955	2892	3495	3187
β (SE)	−3.17 (1.69)*	−4.89 (1.65)***	−5.63 (1.53)***	−3.51 (1.85)*	0.067 (0.026)**	0.070 (0.025)***

Adjusted differences in areas of academic achievement between children with oral clefts and matched classmates attending schools in Iowa between 1990 and 2010 are presented. Separate regression models were estimated for the school levels. The Composite Total includes Reading, Language, Math, Science, Social Studies, and Sources of Information. *$P < .1$, **$P < .05$, ***$P < .01$.

Recognizing these risks is especially important for this group because they are less frequently followed by cleft teams than children with CP.

Measuring "learning disability" is challenging, given the changing definitions of this term.[16] Because the ITBS and ITED do not specify a cutoff for determining learning disability, we used a widely known criterion (<25th percentile) for identifying children who may benefit from academic remediation.[16,21] We found that 31% of children with oral clefts met this criterion in ≥1 core areas of academic functioning, compared with 26% of their classmates. This proportion of children with clefts is lower than that reported in the few previous studies that examined this issue (as high as 46%).[10,17] This finding may reflect ascertainment differences, because samples in previous studies were recruited through hospital craniofacial teams, which may overrepresent children with greater impairment. Specifically, as children age, families with less impaired children are less likely to maintain contact with hospital-based programs and therefore less likely to be included in these studies. Alternatively, ITBS/ITED assessment data might underrepresent children with developmental delays because children receiving special education do not always participate in these tests. However, lack of testing due to special education is limited because federal guidelines require schools to test at least 95% of students using standardized tests such as the ITBS/ITED. Another factor may be the higher socioeconomic status in our sample (eg, >87% maternal high school graduation rate) compared with national estimates, which could reduce learning problems. Regardless, our findings and those from previous investigations all indicate that a significant minority of children with clefts are in need of additional educational support.

The etiology of observed differences in academic achievement is unclear. Our findings suggest that these differences are not exclusively due to differences in family demographic/socioeconomic characteristics or the rate of prenatal exposures to alcohol or tobacco. There may be other prenatal factors that place children at risk for both clefting and learning problems (eg, maternal nutrition). Alternatively, sequelae associated with clefting (eg, speech/language impairment, repeated surgeries and exposure to anesthesia, social stigmatization) may contribute to poor learning outcomes. Finally, some studies have suggested that individuals with clefts show differences in brain morphology relative to unaffected controls,[22] providing a possible explanation for learning differences.

Regardless of the origins of academic differences, our findings of prominent group differences beginning in the second grade support previous recommendations[23–25] for routine, early screening of children with oral clefts, ideally before school entry, allowing for intervention when it is most likely to be effective, which is consistent with recent proposals and implementation of universal screening through "Response to Intervention" school programs.[26] Screening would ideally involve collaborations between schools and craniofacial teams, typically staffed by psychologists and other health care providers who could conduct screening, because nearly all children with clefts are seen by such teams in early childhood. Our results suggest that both verbal and nonverbal learning abilities should be screened.

A strength of this study is our comparison of children with oral clefts to their unaffected classmates by using a large population-based sample, providing a more generalizable and accurate estimation of the full gradient in academic achievement than previous clinic-based studies. Furthermore, our analysis controlled for school and classroom quality effects and for several measured demographic and socioeconomic confounders. The consistency of results between the basic and expanded regressions suggests that representing missing data on

demographic/socioeconomic covariates by dummy variables had no effect on our inference. Finally, the longitudinal data allowed us to examine group differences as a function of grade level.

The study limitations are largely those associated with the trade-offs between population-based versus smaller convenience samples. Group-administered tests such as the ITBS/ITED provide broad coverage of academic status for a large number of students, but with less precision and specificity than individually administrated neuropsychological tests, which would be impractical in a large cohort. Also, we had no data on students who may have received accommodations in testing. The sample is less racially/ethnically diverse than the US population. However, this characteristic does not necessarily limit the generalizability of the differences in academic achievement that we found between affected children and classmates. Even though academic achievement in both groups may vary in a more diverse sample, the difference in achievement between the 2 groups may not necessarily change.

CONCLUSIONS

In the first study, to our knowledge, of academic achievement of children with oral clefts in the United States relative to classmates using direct tests of academic functioning and a large population-based sample, we found that children with oral clefts underperformed across all domains and school levels. The results emphasize the need for early screening and intervention for learning deficits among children with oral clefts. Future research should explore the etiology of these gaps and identify groups experiencing the greatest deficits in achievement.

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FREQUENT TESTS FOR PERFORMANCE BESTS: *While many students, myself included, grumble about having to prepare for classroom quizzes, it appears that regular testing may provide educational benefits. As reported in* The New York Times *(Education: November 20, 2013), researchers tracked the performance of 901 students at the University of Texas in a psychology course. Rather than giving a series of exams or a final exam, each class began with a computerized quiz. The daily quizzes contained seven questions that all students in the class took and one personalized question that the individual student had answered incorrectly on a previous quiz. Student performance was compared to student performance in the same course taught by the same professors the previous year. Class attendance in the middle of the daily quiz course was 90%, while in the previous year it had been 60%. More importantly, students taking daily quizzes scored 10 percent higher on a subset of 17 questions that appeared on tests given both years. Overall course grades were also higher. The grade improvements were greatest among students from lower-income backgrounds. The authors hypothesized that daily quizzes keep students from falling behind. The findings confirm data from other experiments showing that altering the timing of educational tests can have a significant impact on performance. Forcing students to demonstrate what they know early and often leads to better memory of the material. With these known benefits, I'll certainly try to keep them in the forefront of my mind as I study for my next course!*

Noted by Leah H. Carr, MS-IV

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