



# **MAP College Readiness Benchmarks: A Research Brief**

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# MAP College Readiness Benchmarks: A Research Brief\*

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Preparing students for success in college and the workplace is at the center of educational policy debates across the country. According to a widely-accepted definition (Conley, 2007, p. 5), a student who is college ready is someone who can “enroll and succeed – without remediation – in a credit-bearing general education course at a postsecondary institution that offers a baccalaureate degree or transfer to a baccalaureate program.” With college and career readiness as the new focus of K-12 education<sup>1</sup>, increasing attention has been given to traditional college entrance examination.

Prospective college applicants typically take the ACT<sup>®</sup>, SAT<sup>®</sup>, or both, when they are high school sophomores, juniors, and seniors. A college admissions office would evaluate an applicant’s ACT (ACT, 1997) or SAT (The College Board) scores as part of the decision to admit students. More pertinent to this study is that both ACT and The College Board have published benchmarks for their respective tests to address whether students might be college ready (Allen & Sconing, 2005; Kobrin & Michel, 2006). However, college entrance examination results obtained during the end of high school lack utility for educators because it may be too late to help weak-performing high school students make-up the deficit in their preparation for college. To help younger students gauge their preparation prior to taking the ACT, 8<sup>th</sup> and 9<sup>th</sup> graders may take EXPLORE<sup>®</sup> and 10<sup>th</sup> graders may take PLAN<sup>®</sup> from ACT’s Educational Planning and Assessment Series (or EPAS). Scores from EXPLORE and PLAN not only share the scale of the ACT, they may be used to predict performance on the ACT itself; therefore, indirectly serving as early indicators for college readiness<sup>2</sup>. The Preliminary SAT, or PSAT, from The College Board, plays a similar role for

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<sup>1</sup>See, for example, the President’s clarion call identifying college and career preparedness as the goal of US public education (US Department of Education, 2010).

<sup>2</sup>Although the EPAS series has recently been discontinued, its role as a early indicator of college preparedness

students taking the SAT.

For many educators, receiving indications of whether their students are on a track to be college ready earlier in their schooling would be very helpful. Such indicators may inspire students who otherwise may not have thought post-secondary study was a possibility to consider college. Likewise, early indicators of college readiness can enable teachers to identify students who are off-track and put in place the appropriate interventions. Gavin (2011), writing for the Evanston Roundtable in May 2011, described just such an effort in Illinois. The results are back-mapped ACT college readiness benchmarks for grades 3-8 reading and mathematics for the Illinois Standard Achievement Test (ISAT). Northwest Evaluation Association<sup>TM</sup> (NWEA<sup>TM</sup>) partners similarly recognize the value of college readiness information for Measures of Academic Progress<sup>®</sup> (MAP<sup>®</sup>).

## Overview

This brief reports a set of college readiness benchmarks for use with MAP reading and mathematics tests from grades 5 through 9<sup>3</sup>. The report also outlines how the study meets some of the data and statistical challenges to arrive at defensible results for MAP users. A fairly diverse group of 14 small to medium-sized school districts from across the country participated in the study. In all, over 621,058 test events from 410 schools that serve a total of 83,318 students are analyzed. Evidence suggests that districts vary in a number of student and school factors (as measured by NWEA's *School Challenge Index*<sup>4</sup>, or SCI).

Critical to the benchmarking effort, participating districts also vary widely in the proportion of high school students who take ACT (from about 20% to 70%). It seems reasonable to believe that whether or not a student takes the ACT is not a random outcome but is one that reflects some degree of self-selection. Introducing an approach to mitigate potential self-selection biases in the benchmark estimates is a central contribution of the study.

Generally, the study finds that middle school<sup>5</sup> students are likely to be college ready if they per-

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remains important to this discussion. These remarks regarding ACT's EPAS applies to ACT Aspire, which replaces EPAS and extends college readiness assessments into earlier grades.

<sup>3</sup>College readiness is the focus of this work. It is widely-recognized that College and Career Readiness is a much greater challenge, in definition of "success" and its measurement, and is beyond the scope of the research reported here.

<sup>4</sup>The SCI is a school-level indicator of how public schools compare "in terms of the challenges and opportunities they operate under as reflected by an array of factors they do not control" (Northwest Evaluation Association, 2015). This indicator is keyed on the proportion of students who are eligible for a free-and-reduced-priced lunch program in a school. Thus, it generally taps the collective economic circumstance of its students but it also offers a broader view of the "economic strain" they experience, as seen through a relevant set of socio-demographic, organizational, and educational policy programming factors. The SCI ranges from 1 to 99, with higher values for schools serving lesser-privileged student bodies. It has an average of 50 among public schools in the US.

<sup>5</sup>The study addresses grades 5 through 9, which represent more than the standard designation for the middle school grade span. "Middle school" is mostly used in this study for ease of communication.

formed between the 70<sup>th</sup> to 84<sup>th</sup> percentiles in mathematics or between the 66<sup>th</sup> to 75<sup>th</sup> percentiles in reading<sup>6</sup>. Results also suggest, according to the 2015 achievement norms for MAP, that college readiness benchmarks are more stringent the closer it is to graduation from high school. It is important to stress that the estimated MAP benchmarks are anchored on the ACT score of 24, for both reading and mathematics, a benchmark recommended for use with NWEA partners. This benchmark, which takes into consideration the college admissions profile of enrolled students in major state universities across the country, is more stringent than the widely-circulated ACT college readiness benchmark of 22<sup>7</sup>. For the less stringent ACT = 22 benchmark, middle school students are likely to be college ready if they performed between the 61<sup>st</sup> to 76<sup>th</sup> percentiles in mathematics or between the 59<sup>th</sup> to 69<sup>th</sup> percentiles in reading on MAP.

The Digest of Educational Statistics estimates of 18.9 and 24.9 are the 25<sup>th</sup> and 75<sup>th</sup> percentiles on ACT English for about 1 million freshmen enrolled in public 4-year institutions in 2013 (Snyder & Dillow, 2013, Table 305.40). The interquartile range for ACT Math is given by 19.2 and 24.9. Although an ACT score of 22 is roughly at the middle of this range for both subjects, it is very likely that an ACT score of 22 is not stringent enough as a goal for admissions to modestly selective state universities such as the University of California, Florida, Oregon, South Carolina, or Wisconsin. For many of these universities, the lower quartile of students who were admitted is just above the ACT score of 24. That is, about 75% of entering class for these institutions have an ACT score of 24 or greater. Just being on-track in preparation for college (*i.e.*, the student is predicted to obtain a score of 22 or greater on his ACT) will be a vacuous achievement without also having a measurable likelihood of being admitted to the class of institutions of your choice. To recognize the importance of college admissions standards, targeting an ACT of 24 would seem like a prudent aspirational goal for staying on-track in college preparation. For comparison purposes, MAP college readiness benchmarks corresponding to an ACT score of 22 are also provided.

Using the more stringent MAP college readiness benchmarks (ACT = 24), about 63 to 73 students out of 100 who meet or exceed the benchmarks are correctly classified as college ready and only 10 to 18 students of 100 of those students who are not on-track are misclassified. Similarly, MAP college readiness benchmarks, which assume the ACT college readiness benchmark is 22, about 67 to 75 students out of 100 who meet or exceed the benchmarks are correctly classified as college ready and only 13 to 20 students of 100 of those students who are not on-track are misclassified. These benchmarks are selected with the view that higher misclassification rates of non-college ready students are more costly than the misclassification of college ready student to all stakeholders. Mistaking a student to be on-track when he is not would mean missing the opportunity to intervene and returning him to the path of college preparedness.

<sup>6</sup>All achievement percentiles are from the NWEA 2015 MAP Norms (Northwest Evaluation Association, 2015).

<sup>7</sup>ACT estimates that students meeting or exceeding 22 points on the ACT have a 50% chance of obtaining a grade of “B” or higher or about a 75% chance of obtaining a “C” or higher in corresponding credit-bearing first-year college courses.

Table 1: Illustrative Cohort Structure for a District

| Grade | 2003 |    | 2004 |    | 2005 |    | 2006 |    | 2007 |    | 2008 |    | 2009 |    |
|-------|------|----|------|----|------|----|------|----|------|----|------|----|------|----|
|       | Fa   | Sp | Fa   | Sp | Fa   | Sp | Fa   | Sp | Fa   | Sp | Fa   | Sp | Fa   | Sp |
| 12    | 1    | 1  | 2    | 2  | 3    | 3  | 4    | 4  | 5    | 5  | 6    | 6  | 7    | 7  |
| 11    | 2    | 2  | 3    | 3  | 4    | 4  | 5    | 5  | 6    | 6  | 7    | 7  | 8    | 8  |
| 10    | 3    | 3  | 4    | 4  | 5    | 5  | 6    | 6  | 7    | 7  | 8    | 8  | 9    | 9  |
| 9     | 4    | 4  | 5    | 5  | 6    | 6  | 7    | 7  | 8    | 8  | 9    | 9  | 10   | 10 |
| 8     | 5    | 5  | 6    | 6  | 7    | 7  | 8    | 8  | 9    | 9  | 10   | 10 | 11   | 11 |
| 7     | 6    | 6  | 7    | 7  | 8    | 8  | 9    | 9  | 10   | 10 | 11   | 11 | 12   | 12 |
| 6     | 7    | 7  | 8    | 8  | 9    | 9  | 10   | 10 | 11   | 11 | 12   | 12 | 13   | 13 |
| 5     | 8    | 8  | 9    | 9  | 10   | 10 | 11   | 11 | 12   | 12 | 13   | 13 | 14   | 14 |
| 4     | 9    | 9  | 10   | 10 | 11   | 11 | 12   | 12 | 13   | 13 | 14   | 14 | 15   | 15 |

*Note: Used with permission from Thum & Matta (2015).*

These robust classification accuracy rates are achieved through the use of all relevant longitudinal student MAP scores within each district and adjustments are made for self-selection in college admissions test-taking practices. Benchmarks that are generally applicable to middle-school students are the result. The study also provides a rationale for aggregating the benchmarks from individual districts for use with the wider MAP partner-base. Finally, ways with which the benchmarks may be used (a) to give the comparative standing of the middle school student in terms of his college readiness in relation to his peers and (b) to ascertain whether a student has met or exceeded a benchmark are suggested.

## Data and Design

Longitudinal, as opposed to cross-sectional, data hold the most information for describing and predicting individual and collective growth in learning. This study employed MAP and ACT assessments for mathematics and reading from multiple age-cohorts of students from 14 school districts across the US. From each district, the study uses data from age-cohorts of 4<sup>th</sup> through 12<sup>th</sup> grade students to provide the requisite MAP results (grades 4 through 9 only) and, if available, their ACT results in high schools. Fall and spring MAP scores are available for each grade. For the illustrative district data-layout in Table 1, Cohorts 6 through 9 will be selected for analysis although only Cohorts 6 and 7 contribute to benchmark estimation because these student have ACT scores. For the students in Cohorts 8 and 9, only their MAP scores from grade 4 through 9 contribute to the estimation of the MAP score trends from the 4<sup>th</sup> through the 9<sup>th</sup> grade.

Table 2 provides the counts of students, schools, MAP Reading test events, and cohorts per district. Districts ranged in cohort size from large (District 10,  $N = 6,545$ ) to small (District 13,  $N = 113$ ). A total of 83,318 students from 410 schools, in 52 cohorts were used to estimate the MAP reading

Table 2: Descriptive statistics for the 14 districts in the study: MAP Reading

| District | Count   |          |        |         | Take ACT | SCI             |                 |
|----------|---------|----------|--------|---------|----------|-----------------|-----------------|
|          | Schools | Students | Tests  | Cohorts | %        | Mean            | SD              |
| 1        | 57      | 15148    | 111007 | 4       | 66       | 51              | 32              |
| 2        | 10      | 2067     | 15868  | 3       | 58       | 42              | 10              |
| 3        | 18      | 3760     | 23635  | 4       | 51       | 59              | 4               |
| 4        | 12      | 2013     | 15998  | 3       | 67       | 55              | 5               |
| 5        | 10      | 1300     | 8173   | 4       | 54       | 60              | 5               |
| 6        | 30      | 8784     | 31200  | 4       | 49       | 39              | 13              |
| 7        | 27      | 3243     | 28838  | 3       | 56       | 35              | 12              |
| 8        | 18      | 1464     | 10990  | 3       | 61       | 41              | 9               |
| 9        | 17      | 3296     | 19121  | 4       | 24       | 38              | 13              |
| 10       | 106     | 19635    | 148857 | 3       | 23       | 47              | 14              |
| 11       | 55      | 14816    | 89022  | 4       | 19       | 53              | 7               |
| 12       | 31      | 6132     | 108894 | 3       | 30       | 37              | 13              |
| 13       | 10      | 565      | 2977   | 5       | 76       | 37              | 7               |
| 14       | 9       | 1095     | 6478   | 5       | 61       | 38              | 8               |
| Summary  | 410     | 83318    | 621058 | 52      | 50*      | 46 <sup>†</sup> | 18 <sup>†</sup> |

Note: \* total † pooled estimate

and mathematics college readiness benchmarks. Additionally, the proportion of students taking the ACT varied across districts with 76% of students taking the ACT in District 13 and 19% of students taking the ACT in District 11. On average, across all 14 districts, more than half of the graduating class completed the ACT during high school. The counts for MAP Mathematics are highly comparable.

Are districts comparable and how well do they collectively “represent” typical middle school students in the US? The data suggest, not surprisingly, that students performed quite differently on MAP and ACT among the districts. It is clear that some districts have more higher performing students than others. In addition, districts are compared in terms of the average SCI. As Table 2 shows, participating districts have average SCIs from 35 to 60, values that cluster around the national average of 50. It seems reasonable to infer that the participating district schools collectively serve a spectrum of public school students clustered at the national SCI average. Consequently, these results are representative of districts in this more limited sense of the term, rather than being statistically representative of public schools across the US.

## Missing Data and Selection

In this study, each district provides all the ACT data from district archives. NWEA receives permission to extract all available MAP scores for use in the study. As a result, ACT data are in

Table 3: Sample Size and Correlation between ACT and MAP for a Single Cohort from District 11

|             |       | 6    |      | 7    |      | 8    |      | 9    |      | ACT  |
|-------------|-------|------|------|------|------|------|------|------|------|------|
|             |       | Fa   | Sp   | Fa   | Sp   | Fa   | Sp   | Fa   | Sp   |      |
| Mathematics | N     | 594  | 611  | 639  | 648  | 678  | 687  | 171  | 688  | 801  |
|             | Corr. | 0.71 | 0.73 | 0.72 | 0.76 | 0.75 | 0.78 | 0.67 | 0.77 |      |
| Reading     | N     | 593  | 611  | 1117 | 1127 | 1180 | 1201 | 206  | 1159 | 1375 |
|             | Corr. | 0.66 | 0.66 | 0.67 | 0.65 | 0.70 | 0.68 | 0.64 | 0.65 |      |

truth “complete” except for those students who have not taken the college test during high school. Recently, Thum and Matta (2015) found that only about a third of recent graduates in a medium-sized district take either the ACT or the SAT. This pattern is echoed in Table 2. While on average, those who take the ACT also have stronger MAP score trends than those who have not taken the ACT, there is a good proportion of students who do not take the ACT but show MAP score trends that are comparable to students who have taken the college admissions test. Neglecting the MAP scores of these students (that is, ignoring self-selection in test-taking) may lead to biases in the estimated benchmarks. MAP scores are also missing for some students, although in much smaller proportion and appear to be haphazard in their occurrence. Missing MAP data, therefore, are not expected to bias the results and may be ignored.

Correlations between MAP and ACT scores provide the basis for relating one scale to another. Table 3 shows the sample correlations of seniors from one cohort in District 11 who have taken the ACT and MAP scores they received when they attended middle school. The sample correlations are moderately high (from 0.65 to 0.78) but they do not show a trend towards higher values in the higher grades as one expects. Not only do the counts reflect self-selection from the start, there is a pattern of “reverse attrition” in the number of scores available that makes information from bivariate analyses weak. These patterns in the observed data are the very reason why selection needs to be factored into any reasonable approach. It also suggests that growth modeling of longitudinal data is superior to bivariate or cross-sectional analyses. With a longitudinal design, shared information across the grades and terms is maximized and estimates of the links between early MAP scores and ACT are improved.

## Linking Method

Many methods are available for relating scores from any two scales for a population of examinees. A delineation of the factors leading to each plausible approach and the significance of its results are beyond the scope of this brief. The interested reader should consult, for example, Kolen (2004). According to the framework shared by Mislevy (1992) and Linn (1993), this application is best



considered a projection to the extent that the tests do not tap the same construct and regression is key for constructing the benchmarks. However, several considerations regarding the data are unique to this application.

First, the study seeks to relate scores from two scales (MAP, ACT) obtained over an extended period (grades 5-12), as is also the case with the Illinois ISAT described above. Most applications involve two scales measuring two similar constructs and the scores are obtained at about the same time-frame for a known examinee population. A frequently cited example is the effort to estimate the concordance of scores between the ACT and SAT, but concordance is unsuitable for use in what turns out to be essentially a projection or prediction problem. In relating MAP scores to the ACT however, instead of studying the bivariate relationship using conventional regressions between, for example, the 5<sup>th</sup> grade MAP mathematics scores with the ACT scores for the population of *all* examinees, the approach in this study considers the entire score trajectory of every individual member of the student population in order to maximize the shared information across time points.

Second, the study recognizes that not all members of a graduating class take a college entrance examination. Scale relationships based only on the data of examinees who have taken a college entrance exam are likely to contain an element of selection bias that generally makes the relationship obtained for college entrance examinees unsuitable for predictive use among the entire student population. For example, it is hard to predict if a 5<sup>th</sup> grader will opt to take a college entrance examination during high school. Instead, what is needed is information, derived from the available data, about the likelihood of a student taking a college entrance exam in order to identify a relevant benchmark for the grade. Given the challenges posed by the need to employ longitudinal test scores from multiple scales, a special analysis is required to achieve sound results.

The core of the analysis is built on a multilevel growth model that allows examination of multiple sequential age-cohorts of students and jointly considers the impact of selection on the results. From the growth curve estimates, the joint distribution of a set of MAP and ACT scores from multiple age-cohorts of examinees is determined. Inferences for the individual student at any grade and term are based on the estimated multivariate-normal distributions of MAP scores. These distributions are conditional on selected ACT benchmarks and a stated probability of a student taking the college entrance exam in high school (by grade and term). Many elements of the approach are discussed in the literature on statistical inference for longitudinal data in the presence of missing data and selection (e.g., Albert & Follmann, 2009; Hedeker & Gibbons, 1997; Little, 2008).

Following Thum (2011), the recent paper by Thum and Matta (2015) provides the methodological basis for the analyses performed in this study. They successfully deployed this approach for obtaining back-mapped college readiness benchmarks for MAP mathematics and reading based on both the ACT and SAT scores that were available. Appendix A provides a summary of the approach. Recognizing the potential for seasonal bias (and hence auto-correlated errors), a new functional form – constructed from an additive polynomial describing between grade features of within grade

level changes – is introduced in place of the more conventional polynomial regression model. In addition, adjustment is also made to reflect the measurement error in MAP and ACT scores. It is important to note that, due to the presence of selection effects, the estimated benchmarks are dependent on the probability that a student takes the college test in high school. This probability is set at 0.5 throughout to represent the very reasonable situation where the user wishes to suppress any such knowledge, even if it is available subjectively, when evaluating the college readiness of middle school students. Finally, the approach demonstrated by Thum (2011) and Thum and Matta (2015) for data from a single district is extended in this study to produce a set of benchmarks from pooling the benchmarks of individual districts.

## Results

Exploratory analysis of the data for each of the 14 districts consistently suggested that high school students whose MAP scores on reading or mathematics are higher than the district average achievement in the spring of the 8<sup>th</sup> grade are more likely to take the ACT. The selection model is then specified in a manner to exploit this information. The resulting model estimates are used to derive the college readiness benchmarks (see Appendix A).

### Benchmarks

To set the MAP college readiness benchmark for mathematics and reading at each grade and term, given an ACT score of 22 or 24 and a 0.5 probability<sup>8</sup> that a student will opt to take a college test, are examined. Using the estimated bivariate relationships between each MAP assessment and the ACT, benchmarks are identified by considering two classification accuracy standards. The first is the *true positive rate* (TPR) and the second is the *false positive rate* (FPR)<sup>9</sup>. The true positive rate is the proportion of students who are considered college ready based on a given MAP score for a grade and term and who are actually college ready (based on a score of 24 (or 22) or better on the ACT during high school), among all those students who scored a 24 (or 22) or better on the ACT. The false positive rate is the proportion of students who are considered college ready based on a given MAP score but do not score a 24 (or 22) or higher on the ACT among all those students who did not score a 24 (22) or better on the ACT. Locating a MAP score that balances high true positive rate with low false positive rate is key to determining a benchmark for each term and grade.

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<sup>8</sup>This probability value merely reflects the situation in which the reader has no specific knowledge about how likely a student will be taking the ACT in high school.

<sup>9</sup>In the wider research literature on decision quality, false positive rate is the Type I error rate and false negative rate is the Type II error rate.

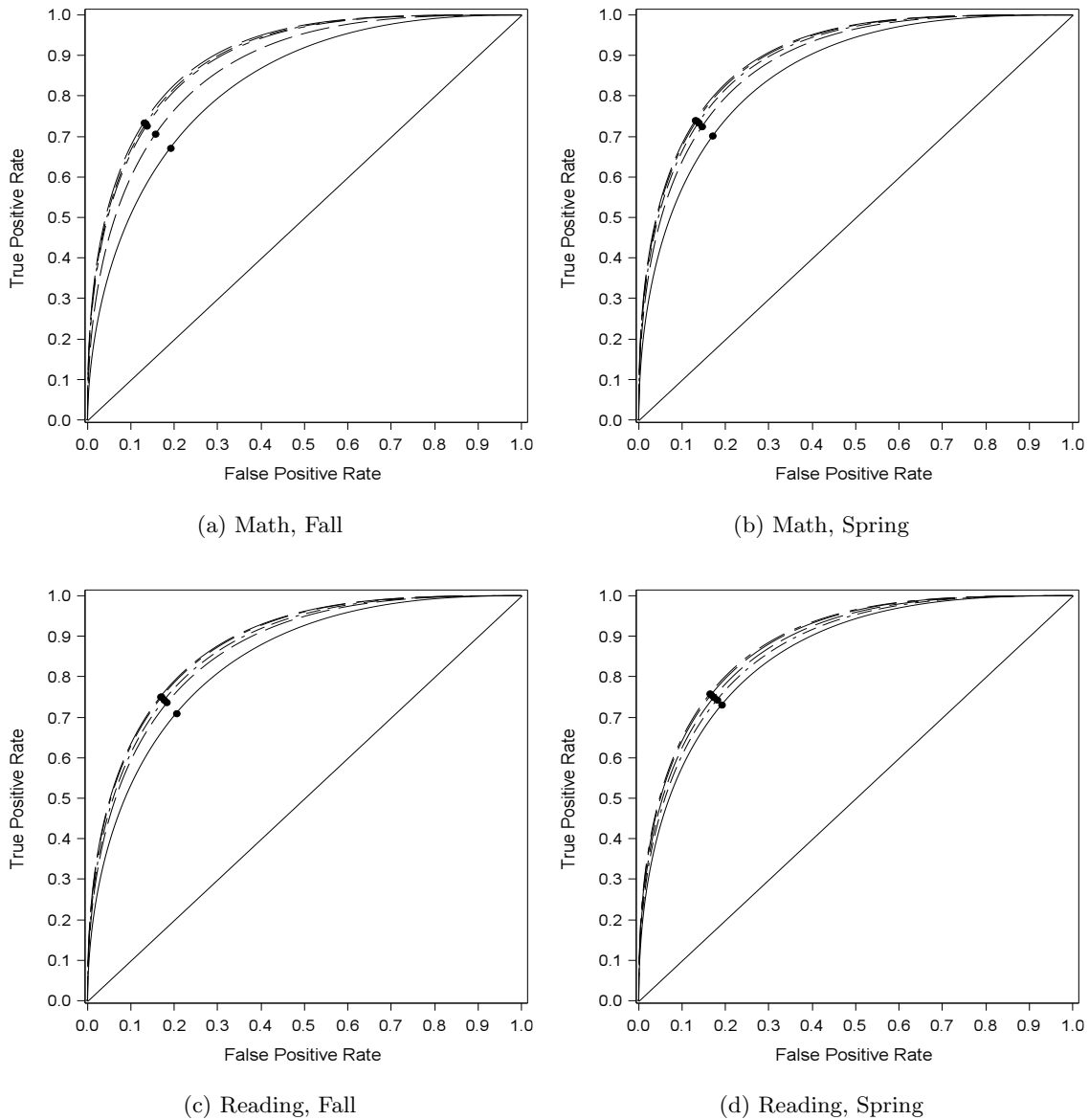


Figure 1: ACT = 22 ROC Plots for Mathematics and Reading Benchmarks, Grades 5 - 9

Plotting the true positive rate against the false positive rate for all possible MAP benchmarks for a given grade and term generates an ROC curve<sup>10</sup>. The area under the ROC curve (AUC) is a well-known measure of predictive power, where a straight 45-degree line represents no predictive power (or 50-50 chance) and an AUC of 1 is perfect prediction<sup>11</sup>. As is shown in Table 4, AUC estimates for all benchmarks are relatively high, indicating predictions are well calibrated (or reliable).

<sup>10</sup>A “receiver operating characteristic” or ROC curve is a graphical device representing the trade-off between the hit and false alarm rates of a binary decision rule; here, the proposed benchmark for college readiness. See, *e.g.*,

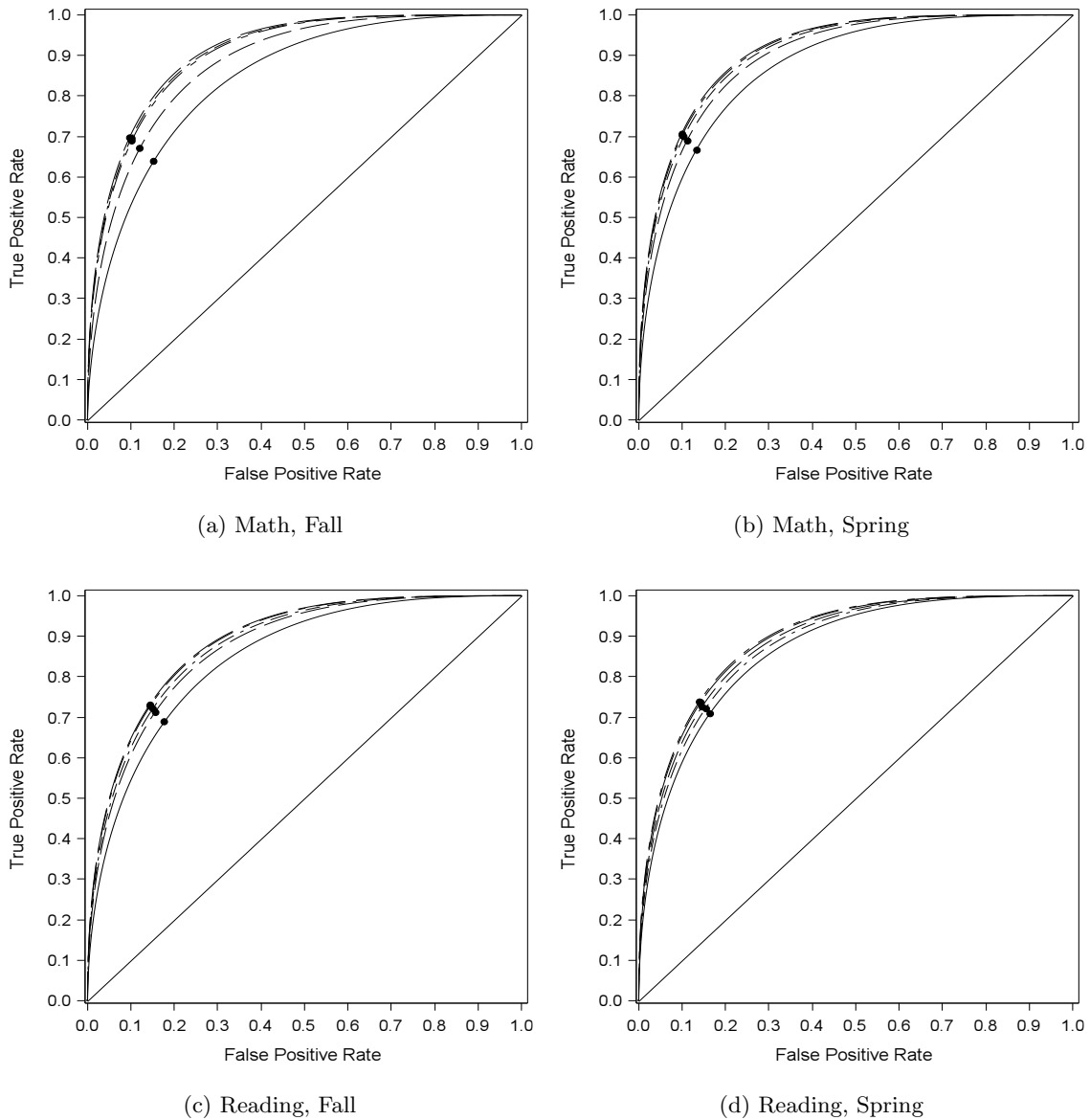


Figure 2: ACT = 24 ROC Plots for Mathematics and Reading Benchmarks, Grades 5 - 9

Figure 1 provides four graphs, each one containing the ROC curves for grades 5 through 9 for different subjects (mathematics and reading) and terms (fall and spring) on assuming the ACT benchmark of 22. Figure 2 displays the same graphs if we assume the more stringent ACT college readiness benchmark of 24. Graph (a) illustrates the ROC curves for fall term mathematics, Graph (b) illustrates spring term mathematics, Graph (c) illustrates fall term reading, and Graph (d) represents spring term reading. In each graph, the grade 5 scores are the shallowest (smaller AUC)

Swets, Dawes, and Monahan, (2000).

<sup>11</sup>The AUC is also called a “concordance” statistic.

Table 4: Area Under the Curve (AUC) for MAP College Readiness Benchmarks

| Subject     | ACT | Grade | 5     |       | 6     |       | 7     |       | 8     |       | 9     |       |
|-------------|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|             |     | Term  | f     | s     | f     | s     | f     | s     | f     | s     | f     | s     |
| Reading     | 22  |       | 0.873 | 0.886 | 0.892 | 0.901 | 0.902 | 0.908 | 0.904 | 0.906 | 0.897 | 0.896 |
|             | 24  |       | 0.879 | 0.893 | 0.898 | 0.907 | 0.909 | 0.914 | 0.910 | 0.912 | 0.904 | 0.902 |
| Mathematics | 22  |       | 0.866 | 0.887 | 0.896 | 0.906 | 0.912 | 0.917 | 0.917 | 0.919 | 0.914 | 0.914 |
|             | 24  |       | 0.877 | 0.897 | 0.906 | 0.916 | 0.922 | 0.926 | 0.927 | 0.928 | 0.924 | 0.923 |

and are represented by the solid curved line. As the grade level increases, the AUC becomes larger and the curve approaches the top-left corner of the plot. This indicates, as expected, that benchmarks at 8<sup>th</sup> and 9<sup>th</sup> grade are more predictive of college readiness than benchmarks in 5<sup>th</sup> grade. On the whole, use of the benchmarks leads to highly accurate predictions. The point plotted on each curve is the MAP benchmark with the given true positive rate and false positive rate in Table 5.

In addition to the pooled benchmarks for each grade, term and subject listed in Table 5 are their standard errors, 2015 normative percentiles, true positive, and false positive rates. The standard errors indicate that the benchmarks are well-estimated. As expected, benchmarks increase with grade level and they also appear to be more stringent, as they approach high school. For example, the mathematics benchmark (corresponding to the ACT score of 24) for fall term of grade 7 is 236.84 which corresponds with the 79<sup>th</sup> percentile based on the 2015 NWEA MAP national norms. Using this benchmark will correctly classify students who are college ready 68% of the time while falsely classifying students who are not college ready as college ready only 10% of the time. The true positive rate for mathematics ranges from 0.63 (fall, grade 5) to 0.70 (spring, grade 7; fall, grade 8; spring, grade 8; spring, grade 9). The false positive for mathematics benchmarks ranges from 0.15 (fall, grade 5) to 0.10 (fall, grade 7 and on). The true positive rates for reading benchmarks range from 0.70 to 0.73 and the false positive rates range from 0.18 to 0.13. Table 5 also gives the results corresponding to the ACT benchmark of 22.

## Applications

Rather than use a cut-score to make a simple pronouncement of whether a student is college ready or not, inference statements that provide a suitable normative context and acknowledges that data quality precludes such deterministic characterization are to be preferred (Maruyama, 2012). Specifically, two types of inferences are useful based on the estimated benchmarks for students: comparison with peers and evaluating college readiness.

Table 5: Normative Stringency and Classification Accuracy of Pooled Benchmarks for MAP Mathematics and Reading Tests

| Grade | Term   | Mathematics, ACT=22 |      |     |      |      | Mathematics, ACT=24 |      |     |      |      |
|-------|--------|---------------------|------|-----|------|------|---------------------|------|-----|------|------|
|       |        | Benchmark           | SE   | Pct | TPR  | FPR  | Benchmark           | SE   | Pct | TPR  | FPR  |
| 5     | Fall   | 217.31              | 0.04 | 65  | 0.67 | 0.19 | 221.33              | 0.04 | 74  | 0.63 | 0.15 |
| 5     | Spring | 225.58              | 0.04 | 61  | 0.70 | 0.16 | 229.74              | 0.04 | 70  | 0.67 | 0.14 |
| 6     | Fall   | 225.30              | 0.04 | 68  | 0.70 | 0.15 | 229.63              | 0.04 | 79  | 0.68 | 0.13 |
| 6     | Spring | 232.34              | 0.03 | 66  | 0.72 | 0.14 | 236.82              | 0.03 | 76  | 0.68 | 0.11 |
| 7     | Fall   | 232.20              | 0.03 | 71  | 0.72 | 0.13 | 236.84              | 0.03 | 81  | 0.68 | 0.10 |
| 7     | Spring | 238.06              | 0.03 | 70  | 0.73 | 0.13 | 242.85              | 0.03 | 79  | 0.70 | 0.10 |
| 8     | Fall   | 238.00              | 0.03 | 74  | 0.73 | 0.13 | 242.96              | 0.03 | 83  | 0.70 | 0.10 |
| 8     | Spring | 242.73              | 0.04 | 74  | 0.73 | 0.13 | 247.83              | 0.04 | 81  | 0.70 | 0.10 |
| 9     | Fall   | 242.72              | 0.04 | 76  | 0.73 | 0.13 | 247.99              | 0.04 | 84  | 0.69 | 0.10 |
| 9     | Spring | 246.35              | 0.04 | 74  | 0.73 | 0.13 | 251.76              | 0.04 | 83  | 0.70 | 0.10 |

| Grade | Term   | Reading, ACT=22 |      |     |      |      | Reading, ACT=24 |      |     |      |      |
|-------|--------|-----------------|------|-----|------|------|-----------------|------|-----|------|------|
|       |        | Benchmark       | SE   | Pct | TPR  | FPR  | Benchmark       | SE   | Pct | TPR  | FPR  |
| 5     | Fall   | 209.31          | 0.04 | 59  | 0.71 | 0.20 | 212.62          | 0.04 | 69  | 0.70 | 0.18 |
| 5     | Spring | 214.70          | 0.04 | 59  | 0.72 | 0.18 | 217.94          | 0.04 | 66  | 0.72 | 0.17 |
| 6     | Fall   | 214.97          | 0.04 | 61  | 0.73 | 0.18 | 218.32          | 0.04 | 68  | 0.72 | 0.16 |
| 6     | Spring | 219.59          | 0.03 | 61  | 0.74 | 0.17 | 222.87          | 0.03 | 69  | 0.73 | 0.15 |
| 7     | Fall   | 219.83          | 0.03 | 64  | 0.74 | 0.17 | 223.21          | 0.03 | 71  | 0.73 | 0.15 |
| 7     | Spring | 223.73          | 0.03 | 65  | 0.75 | 0.16 | 227.04          | 0.03 | 72  | 0.73 | 0.13 |
| 8     | Fall   | 223.88          | 0.03 | 67  | 0.75 | 0.16 | 227.31          | 0.03 | 73  | 0.73 | 0.14 |
| 8     | Spring | 227.10          | 0.03 | 67  | 0.75 | 0.16 | 230.46          | 0.03 | 74  | 0.73 | 0.14 |
| 9     | Fall   | 227.14          | 0.04 | 67  | 0.74 | 0.17 | 230.61          | 0.04 | 75  | 0.73 | 0.16 |
| 9     | Spring | 229.72          | 0.04 | 69  | 0.74 | 0.17 | 233.11          | 0.04 | 75  | 0.72 | 0.15 |

Note: SE = Std. Error Pct = Percentile TPR = True Positive Rate FPR = False Positive Rate

*How Do I Compare With My Peers?* The student's observed score may be used to characterize his performance, in terms of a percentile, among his peers who are expected to meet or exceed the ACT college readiness benchmark of 24. Such percentile ranks can be helpful to the efforts to keeping the student on-track for college. Predicted MAP scores,  $\hat{y}$ , corresponding to selected percentile ranks for MAP benchmarks for reading at grades 5 through 9, for both the fall and spring terms, are given in Table 2. They are easily obtained from the equation

$$\hat{y} = \mu + \sigma \times \Phi^{-1}(P/100),$$

where  $P$  is the desired percentile, under the assumption that scores are normally distributed with cumulative function  $\Phi(\mu, \sigma^2)$  with benchmark  $\mu$  and variance  $\sigma^2$ . Tables 6, 7, 8, and 9 in Appendix B give the results for mathematics and reading, assuming an ACT of 22 and 24, respectively. The predicted standard deviations reported in these tables are based on conditional distributions given by Equation 5 in Appendix A.

As a more concrete example, the mathematics benchmarks keyed on ACT = 24 (229.63) in Table 7 are used to determine that a 6<sup>th</sup> grade student who scores a 236 on the fall administration of MAP (6 points higher than the benchmark) would be in the 75<sup>th</sup> percentile amongst 5<sup>th</sup> graders in terms of being on-track for college. Similarly, a student who scores a 228 (2 points lower than the benchmark) is at the 45<sup>th</sup> percentile. The student who scores a 230, right at the fall 6<sup>th</sup> grade MAP college readiness benchmark, would be in the 50<sup>th</sup> percentile.

*Am I College Ready?* Direct numerical comparisons are seldom justifiable when working with imperfect information. Probability statements, on the other hand, provide a suitable normative context and acknowledges data quality. The student's observed score and standard error support a simple evaluation, one that takes into account the imprecision of an observed score to determine whether or not his performance meets or exceeds the relevant MAP college readiness threshold. The probability that an observed score  $y$  with an SEM<sup>12</sup>  $s_y$  meets or exceeds a given benchmark  $\mu$  is

$$p = \Phi [(y - \mu)/s_y] .$$

Table 10, 11, 12, and 13 in Appendix B give the results for mathematics and reading, assuming an ACT of 22 and 24, respectively, where the default SEM values of 3.2 (for mathematics) and 3.4 (for reading) are employed.

Continuing with the previous example involving the fall administration of 6<sup>th</sup> grade MAP and ACT = 24, Table 11 shows that the student who scored a 236, when considering the standard error of measurement (SEM=3.2), would have a 98% chance of meeting the benchmark. At the same time, the student who scored a 228 would have a 31% chance of meeting the fall 6<sup>th</sup> grade benchmark given the same standard error of measurement. The student who scored 230 would have a 55% chance of meeting the benchmark.

## Summary

This study identifies some limitations of conventional approaches to linking multiple scales for deriving a set of accurate MAP benchmarks for identifying the college readiness of middle grade students. The method developed by Thum (2011) and Thum and Matta (2015) are employed, and are further extended to include a strategy for pooling the results from multiple districts. The approach successfully addressed serious challenges stemming from the fact that the linked tests do not measure the same construct to begin with, that the tests are less and less likely to do so as the time separating them increases, and that some of the test scores are unobserved due to significant

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<sup>12</sup>SEM stands for standard error of measurement. It is a positive number, and scores with smaller SEMs have greater precision. The typical SEMs for MAP mathematics and reading have been found to be 3.2 and 3.4, respectively.

and non-ignorable effects of student self-selecting to take the ACT in high school.

Using over a half million test events from 83,318 4<sup>th</sup> to 12<sup>th</sup> graders from 410 schools in 14 districts across the US, pooled college readiness benchmarks for fall and spring terms of 5<sup>th</sup> through 9<sup>th</sup> graders on MAP mathematics and reading, which are statistically anchored on ACT's college readiness cut-scores of 22 and 24, are obtained. The true positive classification rates are sufficiently high, suggesting that, when such benchmarks are used, educators and parents can be confident that students are accurately identified as being college ready, or not. At the same time, the false positive classification error rates appear sufficiently low so that students requiring assistance to get back on track to being college ready are also accurately identified.



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## Appendix A

### A Growth Model with Selection

For each examinee  $i$ , the probability  $p(\cdot)$  that they take a college entrance exam ( $r_i = 1$ ) during high school is

$$\Pr(r_i = 1 | \boldsymbol{\nu}_i^o) \sim \text{Bernoulli}(f(\boldsymbol{\nu}_i^o)), \quad (1)$$

where  $\boldsymbol{\nu}_i^o \in \boldsymbol{\nu}_i$  are residuals from the growth model

$$\Pr(\mathbf{y}_{1i}, \mathbf{y}_{2i} | \mathbf{X}_i, \boldsymbol{\gamma}, \boldsymbol{\nu}_i, \boldsymbol{\Sigma}_i) \sim \text{Normal}(\mathbf{X}_{1i}\boldsymbol{\gamma} + \mathbf{X}_{2i}\boldsymbol{\nu}_i, \boldsymbol{\Sigma}_i) \quad (2)$$

The product of the marginal distribution of the data under Equation 2 and the conditional probability of a student who takes a college entrance test in high school from Equation 1 defines the shared-parameter model

$$f_y(\mathbf{y}_{1i}, \mathbf{y}_{2i} | \mathbf{X}_i, \boldsymbol{\gamma}, \boldsymbol{\nu}_i, \boldsymbol{\Sigma}_i) \times f_r(r_i | \boldsymbol{\nu}_i^o) \quad (3)$$

Let  $\hat{p}$  be a suitably chosen probability that a student would take a college entrance examination when he reaches high school. For a given probability  $\hat{p}$ ,

$$(\hat{\mathbf{y}}_{1i}, \hat{\mathbf{y}}_{2i} | \hat{p}) \sim \text{MVN} \left( [\hat{\boldsymbol{\mu}}_1, \hat{\boldsymbol{\mu}}_2], \left[ \hat{\boldsymbol{\Sigma}}_{11}, \hat{\boldsymbol{\Sigma}}_{21}, \hat{\boldsymbol{\Sigma}}_{22} \right] \right) \quad (4)$$

is a conditional distribution of predicted student MAP and college entrance examination scores by term and grade-level. The benchmarks on MAP for every term and grade-level, which correspond to the benchmarks  $\mathbf{y}_2^c$  on the college entrance examinations, are obtained from Equation 4 by further conditioning on  $\hat{\mathbf{y}}_{2i} = \mathbf{y}_2^c$ , giving

$$(\hat{\mathbf{y}}_{1i} | \hat{\mathbf{y}}_{2i} = \mathbf{y}_2^c, \hat{p}) \sim \text{MVN} \left( \hat{\boldsymbol{\mu}}_1 + \hat{\boldsymbol{\Sigma}}_{12} \hat{\boldsymbol{\Sigma}}_{22}^{-1} [\hat{\boldsymbol{\mu}}_2 - \mathbf{y}_2^c], \hat{\boldsymbol{\Sigma}}_{11} - \hat{\boldsymbol{\Sigma}}_{21} \hat{\boldsymbol{\Sigma}}_{22}^{-1} \hat{\boldsymbol{\Sigma}}_{21} \right). \quad (5)$$

A set of pooled benchmarks is estimated by weighting district-specific benchmarks, represented by Equation 5, by the information provided by the students who contributed their data to each district analysis.

## Appendix B

Table 6: Predicted Benchmark for MAP Mathematics by Grade/Term and Percentile Ranks for HS Seniors Expected to Meet the Mathematics ACT=22 Benchmark

|                             | Grade | 5      |        | 6      |        | 7      |        | 8      |        | 9      |        |
|-----------------------------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                             | Term  | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring |
| Benchmark                   |       | 217.31 | 225.58 | 225.30 | 232.34 | 232.20 | 238.06 | 238.00 | 242.73 | 242.72 | 246.35 |
| SD                          |       | 11.46  | 10.38  | 10.01  | 9.59   | 9.41   | 9.40   | 9.61   | 9.87   | 10.53  | 10.99  |
| Pct                         |       | 65     | 61     | 68     | 66     | 71     | 70     | 74     | 74     | 76     | 74     |
| Conditional Percentile Rank | 10    | 203    | 212    | 212    | 220    | 220    | 226    | 226    | 230    | 229    | 232    |
|                             | 15    | 205    | 215    | 215    | 222    | 222    | 228    | 228    | 233    | 232    | 235    |
|                             | 20    | 208    | 217    | 217    | 224    | 224    | 230    | 230    | 234    | 234    | 237    |
|                             | 25    | 210    | 219    | 219    | 226    | 226    | 232    | 232    | 236    | 236    | 239    |
|                             | 30    | 211    | 220    | 220    | 227    | 227    | 233    | 233    | 238    | 237    | 241    |
|                             | 35    | 213    | 222    | 221    | 229    | 229    | 234    | 234    | 239    | 239    | 242    |
|                             | 40    | 214    | 223    | 223    | 230    | 230    | 236    | 236    | 240    | 240    | 244    |
|                             | 45    | 216    | 224    | 224    | 231    | 231    | 237    | 237    | 241    | 241    | 245    |
|                             | 50    | 217    | 226    | 225    | 232    | 232    | 238    | 238    | 243    | 243    | 246    |
|                             | 55    | 219    | 227    | 227    | 234    | 233    | 239    | 239    | 244    | 244    | 248    |
|                             | 60    | 220    | 228    | 228    | 235    | 235    | 240    | 240    | 245    | 245    | 249    |
|                             | 65    | 222    | 230    | 229    | 236    | 236    | 242    | 242    | 247    | 247    | 251    |
|                             | 70    | 223    | 231    | 231    | 237    | 237    | 243    | 243    | 248    | 248    | 252    |
|                             | 75    | 225    | 233    | 232    | 239    | 239    | 244    | 244    | 249    | 250    | 254    |
|                             | 80    | 227    | 234    | 234    | 240    | 240    | 246    | 246    | 251    | 252    | 256    |
|                             | 85    | 229    | 236    | 236    | 242    | 242    | 248    | 248    | 253    | 254    | 258    |
|                             | 90    | 232    | 239    | 238    | 245    | 244    | 250    | 250    | 255    | 256    | 260    |

Note: Pct = Percentile

Table 7: Predicted Benchmark for MAP Mathematics by Grade/Term and Percentile Ranks for HS Seniors Expected to Meet the Mathematics ACT=24 Benchmark

|                             | Grade | 5      |        | 6      |        | 7      |        | 8      |        | 9      |        |
|-----------------------------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                             | Term  | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring |
| Benchmark                   |       | 221.33 | 229.74 | 229.63 | 236.82 | 236.84 | 242.85 | 242.96 | 247.83 | 247.99 | 251.76 |
| SD                          |       | 11.58  | 10.49  | 10.16  | 9.73   | 9.59   | 9.57   | 9.83   | 10.07  | 10.78  | 11.23  |
| Pct                         |       | 74     | 70     | 79     | 76     | 81     | 79     | 83     | 81     | 84     | 83     |
| Conditional Percentile Rank | 10    | 206    | 216    | 217    | 224    | 225    | 231    | 230    | 235    | 234    | 237    |
|                             | 15    | 209    | 219    | 219    | 227    | 227    | 233    | 233    | 237    | 237    | 240    |
|                             | 20    | 212    | 221    | 221    | 229    | 229    | 235    | 235    | 239    | 239    | 242    |
|                             | 25    | 214    | 223    | 223    | 230    | 230    | 236    | 236    | 241    | 241    | 244    |
|                             | 30    | 215    | 224    | 224    | 232    | 232    | 238    | 238    | 243    | 242    | 246    |
|                             | 35    | 217    | 226    | 226    | 233    | 233    | 239    | 239    | 244    | 244    | 247    |
|                             | 40    | 218    | 227    | 227    | 234    | 234    | 240    | 240    | 245    | 245    | 249    |
|                             | 45    | 220    | 228    | 228    | 236    | 236    | 242    | 242    | 247    | 247    | 250    |
|                             | 50    | 221    | 230    | 230    | 237    | 237    | 243    | 243    | 248    | 248    | 252    |
|                             | 55    | 223    | 231    | 231    | 238    | 238    | 244    | 244    | 249    | 249    | 253    |
|                             | 60    | 224    | 232    | 232    | 239    | 239    | 245    | 245    | 250    | 251    | 255    |
|                             | 65    | 226    | 234    | 234    | 241    | 241    | 247    | 247    | 252    | 252    | 256    |
|                             | 70    | 227    | 235    | 235    | 242    | 242    | 248    | 248    | 253    | 254    | 258    |
|                             | 75    | 229    | 237    | 236    | 243    | 243    | 249    | 250    | 255    | 255    | 259    |
|                             | 80    | 231    | 239    | 238    | 245    | 245    | 251    | 251    | 256    | 257    | 261    |
| 85                          | 233   | 241    | 240    | 247    | 247    | 253    | 253    | 258    | 259    | 263    |        |
| 90                          | 236   | 243    | 243    | 249    | 249    | 255    | 256    | 261    | 262    | 266    |        |

Note: Pct = Percentile

Table 8: Predicted Benchmark for MAP Reading by Grade/Term and Percentile Ranks for HS Seniors Expected to Meet the Reading ACT=22 Benchmark

|                             | Grade | 5      |        | 6      |        | 7      |        | 8      |        | 9      |        |
|-----------------------------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                             | Term  | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring |
| Benchmark                   |       | 209.31 | 214.70 | 214.97 | 219.59 | 219.83 | 223.73 | 223.88 | 227.10 | 227.14 | 229.72 |
| SD                          |       | 11.92  | 10.55  | 10.47  | 9.5    | 9.75   | 9.09   | 9.76   | 9.36   | 10.44  | 10.32  |
| Pct                         |       | 59     | 59     | 61     | 61     | 64     | 65     | 67     | 67     | 67     | 69     |
| Conditional Percentile Rank | 10    | 194    | 201    | 202    | 207    | 207    | 212    | 211    | 215    | 214    | 216    |
|                             | 15    | 197    | 204    | 204    | 210    | 210    | 214    | 214    | 217    | 216    | 219    |
|                             | 20    | 199    | 206    | 206    | 212    | 212    | 216    | 216    | 219    | 218    | 221    |
|                             | 25    | 201    | 208    | 208    | 213    | 213    | 218    | 217    | 221    | 220    | 223    |
|                             | 30    | 203    | 209    | 209    | 215    | 215    | 219    | 219    | 222    | 222    | 224    |
|                             | 35    | 205    | 211    | 211    | 216    | 216    | 220    | 220    | 223    | 223    | 226    |
|                             | 40    | 206    | 212    | 212    | 217    | 217    | 221    | 221    | 225    | 224    | 227    |
|                             | 45    | 208    | 213    | 214    | 218    | 219    | 223    | 223    | 226    | 226    | 228    |
|                             | 50    | 209    | 215    | 215    | 220    | 220    | 224    | 224    | 227    | 227    | 230    |
|                             | 55    | 211    | 216    | 216    | 221    | 221    | 225    | 225    | 228    | 228    | 231    |
|                             | 60    | 212    | 217    | 218    | 222    | 222    | 226    | 226    | 229    | 230    | 232    |
|                             | 65    | 214    | 219    | 219    | 223    | 224    | 227    | 228    | 231    | 231    | 234    |
|                             | 70    | 216    | 220    | 220    | 225    | 225    | 228    | 229    | 232    | 233    | 235    |
|                             | 75    | 217    | 222    | 222    | 226    | 226    | 230    | 230    | 233    | 234    | 237    |
|                             | 80    | 219    | 224    | 224    | 228    | 228    | 231    | 232    | 235    | 236    | 238    |
|                             | 85    | 222    | 226    | 226    | 229    | 230    | 233    | 234    | 237    | 238    | 240    |
| 90                          | 225   | 228    | 228    | 232    | 232    | 235    | 236    | 239    | 241    | 243    |        |

Note: Pct = Percentile

Table 9: Predicted Benchmark for MAP Reading by Grade/Term and Percentile Ranks for HS Seniors Expected to Meet the Reading ACT=24 Benchmark

|                             | Grade | 5      |        | 6      |        | 7      |        | 8      |        | 9      |        |
|-----------------------------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                             | Term  | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring |
| Benchmark                   |       | 212.62 | 217.94 | 218.32 | 222.87 | 223.21 | 227.04 | 227.31 | 230.46 | 230.61 | 233.11 |
| SD                          |       | 11.95  | 10.53  | 10.49  | 9.50   | 9.76   | 9.08   | 9.77   | 9.35   | 10.45  | 10.32  |
| Pct                         |       | 69     | 66     | 68     | 69     | 71     | 72     | 73     | 74     | 75     | 75     |
| Conditional Percentile Rank | 10    | 197    | 204    | 205    | 211    | 211    | 215    | 215    | 218    | 217    | 220    |
|                             | 15    | 200    | 207    | 207    | 213    | 213    | 218    | 217    | 221    | 220    | 222    |
|                             | 20    | 203    | 209    | 209    | 215    | 215    | 219    | 219    | 223    | 222    | 224    |
|                             | 25    | 205    | 211    | 211    | 216    | 217    | 221    | 221    | 224    | 224    | 226    |
|                             | 30    | 206    | 212    | 213    | 218    | 218    | 222    | 222    | 226    | 225    | 228    |
|                             | 35    | 208    | 214    | 214    | 219    | 219    | 224    | 224    | 227    | 227    | 229    |
|                             | 40    | 210    | 215    | 216    | 220    | 221    | 225    | 225    | 228    | 228    | 230    |
|                             | 45    | 211    | 217    | 217    | 222    | 222    | 226    | 226    | 229    | 229    | 232    |
|                             | 50    | 213    | 218    | 218    | 223    | 223    | 227    | 227    | 230    | 231    | 233    |
|                             | 55    | 214    | 219    | 220    | 224    | 224    | 228    | 229    | 232    | 232    | 234    |
|                             | 60    | 216    | 221    | 221    | 225    | 226    | 229    | 230    | 233    | 233    | 236    |
|                             | 65    | 217    | 222    | 222    | 227    | 227    | 231    | 231    | 234    | 235    | 237    |
|                             | 70    | 219    | 223    | 224    | 228    | 228    | 232    | 232    | 235    | 236    | 239    |
|                             | 75    | 221    | 225    | 225    | 229    | 230    | 233    | 234    | 237    | 238    | 240    |
|                             | 80    | 223    | 227    | 227    | 231    | 231    | 235    | 236    | 238    | 239    | 242    |
|                             | 85    | 225    | 229    | 229    | 233    | 233    | 236    | 237    | 240    | 241    | 244    |
| 90                          | 228   | 231    | 232    | 235    | 236    | 239    | 240    | 242    | 244    | 246    |        |

Note: Pct = Percentile

Table 10: Predicted Probability of an Observed MAP Mathematics Score Meeting or Exceeding Selected MAP Benchmarks by Grade/Term for HS Seniors Expected to Meet the Mathematics ACT=22 Benchmark

| Grade          | 5      |        | 6      |        | 7      |        | 8      |        | 9      |        |
|----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring |
| Benchmark      | 217.31 | 225.58 | 225.30 | 232.34 | 232.20 | 238.06 | 238.00 | 242.73 | 242.72 | 246.35 |
| SD             | 11.46  | 10.38  | 10.01  | 9.59   | 9.41   | 9.40   | 9.61   | 9.87   | 10.53  | 10.99  |
| Pct            | 65     | 61     | 68     | 66     | 71     | 70     | 74     | 74     | 76     | 74     |
| Observed Score | 210    | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 212    | 5      | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 214    | 15     | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 216    | 34     | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 218    | 59     | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 220    | 80     | 4      | 5      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 222    | 93     | 13     | 15     | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 224    | 98     | 31     | 34     | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 226    | 99     | 55     | 59     | 2      | 3      | 1      | 1      | 1      | 1      |
|                | 228    | 99     | 78     | 80     | 9      | 9      | 1      | 1      | 1      | 1      |
|                | 230    | 99     | 92     | 93     | 23     | 25     | 1      | 1      | 1      | 1      |
|                | 232    | 99     | 98     | 98     | 46     | 48     | 3      | 3      | 1      | 1      |
|                | 234    | 99     | 99     | 99     | 70     | 71     | 11     | 11     | 1      | 1      |
|                | 236    | 99     | 99     | 99     | 87     | 88     | 27     | 27     | 2      | 2      |
|                | 238    | 99     | 99     | 99     | 96     | 97     | 50     | 50     | 7      | 7      |
|                | 240    | 99     | 99     | 99     | 99     | 99     | 73     | 73     | 20     | 20     |
|                | 242    | 99     | 99     | 99     | 99     | 99     | 89     | 89     | 41     | 41     |
|                | 244    | 99     | 99     | 99     | 99     | 99     | 97     | 97     | 65     | 66     |
|                | 246    | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 85     | 85     |
| 248            | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 95     | 95     |        |
| 250            | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     |        |
| 252            | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     |        |
| 254            | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     |        |
| 256            | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     |        |

Note: SEM = 3.2; Pct = Percentile



Table 11: Predicted Probability of an Observed MAP Mathematics Score Meeting or Exceeding Selected MAP Benchmarks by Grade/Term for HS Seniors Expected to Meet the Mathematics ACT=24 Benchmark

| Grade          | 5      |        | 6      |        | 7      |        | 8      |        | 9      |        |
|----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring |
| Benchmark      | 221.33 | 229.74 | 229.63 | 236.82 | 236.84 | 242.85 | 242.96 | 247.83 | 247.99 | 251.76 |
| SD             | 11.58  | 10.49  | 10.16  | 9.73   | 9.59   | 9.57   | 9.83   | 10.07  | 10.78  | 11.23  |
| Pct            | 74     | 70     | 79     | 76     | 81     | 79     | 83     | 81     | 84     | 83     |
| Observed Score | 214    | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 216    | 5      | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 218    | 15     | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 220    | 34     | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 222    | 58     | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 224    | 80     | 4      | 4      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 226    | 93     | 12     | 13     | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 228    | 98     | 29     | 31     | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 230    | 99     | 53     | 55     | 2      | 2      | 1      | 1      | 1      | 1      |
|                | 232    | 99     | 76     | 77     | 7      | 7      | 1      | 1      | 1      | 1      |
|                | 234    | 99     | 91     | 91     | 19     | 19     | 1      | 1      | 1      | 1      |
|                | 236    | 99     | 97     | 98     | 40     | 40     | 2      | 1      | 1      | 1      |
|                | 238    | 99     | 99     | 99     | 64     | 64     | 6      | 6      | 1      | 1      |
|                | 240    | 99     | 99     | 99     | 84     | 84     | 19     | 18     | 1      | 1      |
|                | 242    | 99     | 99     | 99     | 95     | 95     | 39     | 38     | 3      | 3      |
|                | 244    | 99     | 99     | 99     | 99     | 99     | 64     | 63     | 12     | 11     |
|                | 246    | 99     | 99     | 99     | 99     | 99     | 84     | 83     | 28     | 27     |
|                | 248    | 99     | 99     | 99     | 99     | 99     | 95     | 94     | 52     | 50     |
|                | 250    | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 75     | 74     |
|                | 252    | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 90     | 90     |
| 254            | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 97     | 97     |        |
| 256            | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     |        |
| 258            | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     |        |
| 260            | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     |        |

Note: SEM = 3.2; Pct = Percentile

Table 12: Predicted Probability of an Observed MAP Reading Score Meeting or Exceeding Selected MAP Benchmarks by Grade/Term for HS Seniors Expected to Meet the Reading ACT=22 Benchmark

| Grade          | 5      |        | 6      |        | 7      |        | 8      |        | 9      |        |
|----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring |
| Benchmark      | 209.31 | 214.70 | 214.97 | 219.59 | 219.83 | 223.73 | 223.88 | 227.10 | 227.14 | 229.72 |
| SD             | 11.92  | 10.55  | 10.47  | 9.50   | 9.75   | 9.09   | 9.76   | 9.36   | 10.44  | 10.32  |
| Pct            | 59     | 59     | 61     | 61     | 64     | 65     | 67     | 67     | 67     | 69     |
| Observed Score | 200    | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 202    | 2      | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 204    | 6      | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 206    | 17     | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 208    | 35     | 2      | 2      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 210    | 58     | 8      | 7      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 212    | 79     | 21     | 19     | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 214    | 92     | 42     | 39     | 5      | 4      | 1      | 1      | 1      | 1      |
|                | 216    | 98     | 65     | 62     | 15     | 13     | 1      | 1      | 1      | 1      |
|                | 218    | 99     | 83     | 81     | 32     | 30     | 5      | 4      | 1      | 1      |
|                | 220    | 99     | 94     | 93     | 55     | 52     | 14     | 13     | 2      | 2      |
|                | 222    | 99     | 98     | 98     | 76     | 74     | 31     | 29     | 7      | 7      |
|                | 224    | 99     | 99     | 99     | 90     | 89     | 53     | 51     | 18     | 18     |
|                | 226    | 99     | 99     | 99     | 97     | 97     | 75     | 73     | 37     | 37     |
|                | 228    | 99     | 99     | 99     | 99     | 99     | 90     | 89     | 60     | 60     |
|                | 230    | 99     | 99     | 99     | 99     | 99     | 97     | 96     | 80     | 80     |
|                | 232    | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 93     | 92     |
| 234            | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 98     | 98     |        |
| 236            | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     |        |
| 238            | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     |        |

Note: SEM = 3.4; Pct = Percentile

Table 13: Predicted Probability of an Observed MAP Reading Score Meeting or Exceeding Selected MAP Benchmarks by Grade/Term for HS Seniors Expected to Meet the Reading ACT=24 Benchmark

| Grade          | 5      |        | 6      |        | 7      |        | 8      |        | 9      |        |
|----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring | Fall   | Spring |
| Benchmark      | 212.62 | 217.94 | 218.32 | 222.87 | 223.21 | 227.04 | 227.31 | 230.46 | 230.61 | 233.11 |
| SD             | 11.95  | 10.53  | 10.49  | 9.50   | 9.76   | 9.08   | 9.77   | 9.35   | 10.45  | 10.32  |
| Pct            | 69     | 66     | 68     | 69     | 71     | 72     | 73     | 74     | 75     | 75     |
| Observed Score | 204    | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 206    | 3      | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 208    | 9      | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 210    | 22     | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 212    | 43     | 4      | 3      | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 214    | 66     | 12     | 10     | 1      | 1      | 1      | 1      | 1      | 1      |
|                | 216    | 84     | 28     | 25     | 2      | 2      | 1      | 1      | 1      | 1      |
|                | 218    | 94     | 51     | 46     | 8      | 6      | 1      | 1      | 1      | 1      |
|                | 220    | 99     | 73     | 69     | 20     | 17     | 2      | 2      | 1      | 1      |
|                | 222    | 99     | 88     | 86     | 40     | 36     | 7      | 6      | 1      | 1      |
|                | 224    | 99     | 96     | 95     | 63     | 59     | 19     | 16     | 3      | 3      |
|                | 226    | 99     | 99     | 99     | 82     | 79     | 38     | 35     | 10     | 9      |
|                | 228    | 99     | 99     | 99     | 93     | 92     | 61     | 58     | 24     | 22     |
|                | 230    | 99     | 99     | 99     | 98     | 98     | 81     | 79     | 45     | 43     |
|                | 232    | 99     | 99     | 99     | 99     | 99     | 93     | 92     | 68     | 66     |
|                | 234    | 99     | 99     | 99     | 99     | 99     | 98     | 98     | 85     | 84     |
|                | 236    | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 95     | 94     |
| 238            | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     |        |
| 240            | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     |        |
| 242            | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     | 99     |        |

Note: SEM = 3.4; Pct = Percentile