Course Taking Effect on Postsecondary Enrollment of Deaf and Hard of Hearing Students

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Abstract

Data from the National Longitudinal Transition Study-2 were used to examine the effect of academic and career or technical education course taking in high school on deaf or hard of hearing (DHH) youth's postsecondary enrollment in 2-year, 4-year, and career or technical education (CTE) institutions. The analyses included a nationally representative cohort of 440 youth who were deaf or hard of hearing. This study examined the impact of academic course taking in high school—percentage of credits earned in academic courses and completion of algebra coursework—on the enrollment of DHH students in 2- and 4-year colleges and CTE schools, as well as the impact of CTE course taking—percentage of credits earned in CTE courses and completion of an occupationally specific course of study—on the enrollment of DHH students in 2- and 4-year colleges and CTE schools. Propensity model analyses, a quasi-experimental method, indicated that completing an algebra course in high school was a significant predictor of DHH students' future enrollment in postsecondary programs and completing a greater proportion of academic courses significantly increased the likelihood of DHH students' enrolling in 2-year and 4-year colleges and CTE programs, however, neither completing a greater proportion of CTE courses nor being a CTE concentrator in a specific occupational course of study contributed to DHH students' enrolling in postsecondary programs, including CTE programs. The results provide important implications for policy and practice. The finding that completing an algebra course was associated with a significantly greater likelihood of enrollment in CTE as well as 2- and 4-year postsecondary education programs emphasizes the generality of the gateway character of that course as demonstrated in previous studies involving the general (hearing) student population. The findings also demonstrate that the role of taking an algebra course as a predictor of postsecondary enrollment holds for DHH students as it does for hearing students, despite their generally lower prior mathematics achievement. Other research indicate that a factor in specific academic outcomes for DHH students is lack of prior preparation and content knowledge. The present findings are consistent with empirical research indicating the need for DHH students to take more, or perhaps more rigorous, courses if they are to enroll in and complete postsecondary programs. Such findings need to be considered early on during transition planning in a way that is appropriate to the DHH student's strengths and needs and points to the secondary transition planning staff both encouraging DHH students who have a goal of future postsecondary attendance to take a rigorous, academically focused high school curriculum and providing students with the supports needed to complete these courses. (Contains 3 tables).

Effect of Course Taking on Postsecondary Enrollment of Deaf and Hard of Hearing Students

The high level of both practical and academic knowledge and skills necessary for educational and employment success in the 21st century makes their acquisition difficult for many individuals. This is particularly true for those individuals, like deaf and hard-of-hearing (DHH) students, who traditionally have struggled to gain proficiency in literacy, mathematics, and other academic domains**.** Achievement testing over the past 40 years has indicated that DHH students generally leave high school underprepared for the transition to postsecondary education relative to hearing peers (Pitiyanuwat & Phattharayuttawat, 1991; Qi & Mitchell, 2012). Allen (1994), for example, analyzed data on DHH school leavers from the 1992-1994 Gallaudet Research Institute Annual Survey of Deaf and Hard-of-Hearing Children and Youth, finding that only about 25% of those destined for postsecondary education were reading at the grade 5 level or above. He concluded that “it is fairly obvious that a large number of deaf students are enrolling in colleges with very limited skills.” Kelly (2008) described five cohorts of DHH students entering postsecondary education between 2002 and 2006 and who had taken the American College Test (ACT). He reported that 20% met the ACT College Readiness Benchmarks for English and Reading; only 15% met the benchmark for mathematics.

More recently, Marschark, Shaver, Nagle, and Newman (2015) examined DHH students’ high school academic performance as indexed by the Woodcock Johnson III (WJ III) passage comprehension, mathematics calculation, science, and social studies achievement tests. Using National Longitudinal Transition Study-2 (NLTS2) data for approximately 500 DHH high school students, they found test scores markedly lower than those of peers in the general population in all four benchmark areas. They also found that some groups within the DHH high school population were particularly at risk for poor academic performance: those with an additional diagnosis of a learning disability and those with greater hearing loss and less spoken language abilities than other DHH youth. In addition, being African American or Hispanic was negatively associated with DHH students' academic performance. Other studies have produced similar results. In short, DHH students, as a group, are exiting high school with low academic achievement relative to students in the general population, and the gap for some DHH subgroups is especially concerning.

The academic underachievement evidenced in DHH throughout the school years (Qi & Mitchell, 2012) is likely both a (partial) cause and an effect of their taking less rigorous courses relative to their peers in the general high school population. Nagle, Newman, Shaver, and Marschark (in press) found that academic credits accounted for a smaller proportion of overall credits for DHH high school students than for their peers. DHH students earned, on average, fewer credits than their peers in science, social studies, and foreign language. DHH students and their peers earned a similar number of credits in mathematics courses; however, a higher proportion of DHH students' credits were in basic mathematics, and they had fewer in midlevel mathematics courses, such as Algebra I, and fewer advanced mathematics courses. The latter finding is particularly important, as Adelman (2006) reported increasing proportions of bachelor degree attainment for each year of mathematics taken in secondary school and Adelman (1999) found that the highest level of mathematics courses taken in high school was the best predictor of bachelor degree completion. Less rigor in course-taking at the secondary level thus leaves DHH (and hearing) students less prepared for postsecondary education and less likely to gain a postsecondary degree (Adelman, 2006; Kelly, 2008; Long, Conger, & Iatarola, 2012).

Mathematics as Gateway and Predictor

Commonly taken by students in the first year of high school, Algebra I is considered a gateway course to higher mathematics, a key course for admittance to university, and a significant predictor of employment success for youth in the general population (ACT, 2005; Adelman, 1999; Adelman, Daniel, & Berkovits, 2003; Csikszentmihalyi & Schneider, 2000; Riegle-Crumb, 2006). The lower frequency of DHH students' taking Algebra I may reflect differing academic abilities and thus different course needs of DHH students (Qi & Mitchell, 2012) or differing expectations on the part of students, parents, and teachers about readiness for higher level mathematics courses (e.g., Kelly, Lang, & Pagliaro, 2003; Pagliaro & Kritzer, 2005). Both of these explanations would be reflective of the differing educational trajectories and settings experienced by DHH learners relative to hearing peers (Pagliaro & Kritzer, 2013), cognitive differences or delays (e.g., in memory and visual-spatial processing) among DHH students, reflected in mathematics problem solving (Gottardis, Nunes, Lunt, 2011; Zarfaty, Nunes, & Bryant, 2004), and the importance of utilizing DHH students' visual and spatial skills in mathematics instruction and interventions (Zarfaty et al., 2004). Either explanation also would be consistent with the findings of Shaver, Newman, Huang, Yu, and Knokey (2011) and Marschark et al. (2015) that DHH students' scores were significantly below those of their peers in the general population on the WJ III mathematics calculation and applied problems subtests.

Riegle-Crumb (2006) noted that mid-level and higher level mathematics courses not only serve as indicators of high school achievement, but also provide fundamental tools for later success by exposing students to cognitively demanding material and offering opportunities to interact with teachers and classmates. These opportunities are important for DHH students' academic success but often are limited because of communication barriers in the classroom (Lang, 2002). Further, many DHH students already are delayed in their mathematics and number knowledge by the time they reach high school, a disadvantage that begins as early as preschool and is seen through the postsecondary years (Bull, Marschark, Sapere, Davidson, Murphy, & Nordmann, 2011; Bull, Marschark, & Blatto-Vallee, 2005; Kritzer, 2009), regardless of parental hearing status. This qualification is noteworthy because it frequently is assumed that DHH children of deaf parents are better prepared for school, relative to those with hearing parents, by virtue of having access to (sign) language from birth. Kritzer (2009), however, found that among 4- to 6-year-olds, 71% of those with at least one deaf parent were functioning “below average” on a standardized, age-appropriate mathematics assessment. Twenty-nine percent of the children with deaf parents were in the lowest performing group. Marschark et al. (2015) found that neither having deaf parents nor using sign language were significant predictors of mathematics achievement at the high school level. Clearly, the issue is far more complex than a cultural-linguistic perspective on educating deaf learners might imply.

Traxler (2000) found that the gap in mathematics achievement between DHH and hearing students tends to widen through middle school and high school. Knoors and Marschark (2014) argued that findings of DHH students’ difficulties in mathematics reflect differences in more fundamental mathematics-related skills, such as mental calculation and speed of number comparison, areas in which they have been found less proficient than hearing peers (Bull et al., 2005, 2011). Lesser proficiency in such skills also has been found to be related to their lesser exposure to the concepts and proc esses of mathematics, both at home and at school (e.g., (Convertino, Borgna, Marschark, & Durkin, 2014; Kelly et al., 2003; Kritzer, 2009; Pagliaro & Kritzer, 2005).

Loveless (2008) contended that efforts in the United States over the past 20 years to enroll all students in an algebra course by eighth grade were based on an argument for equity rather than empirical evidence. That is, students who take algebra earlier in high school later demonstrate greater mathematics skills, but those returns do not accrue solely from the mathematics courses themselves, independent of student characteristics and prior experiences (Riegle-Crumb, 2006). Attewell and Domina (2008), for example, found that although all students benefit from more rigorous high school curricula, the returns are smaller for those with lower prior achievement. Gamoran and Hannigan (2000) obtained similar results specifically on the benefits from high school algebra, reporting that returns are smaller for those with lower mathematics abilities, the situation of most DHH students. Differences in cognitive functioning as well as background knowledge in mathematics between DHH and hearing learners (Knoors & Marschark, 2014) may mean that DHH students struggle more with courses like algebra and gain less from them. It therefore remains unclear whether Algebra I serves as the same gateway for DHH students as it does for their hearing peers or whether it and higher level courses in mathematics (or any other area) have the same predictive value regarding postsecondary readiness and achievement or employment (Long, Iatarola, & Conger, 2009).

CTE Course Taking

Career technical education (CTE) programs offer students career-focused technical and academic skills. Beyond discipline appropriate content, CTE for both DHH and hearing students typically also includes programming aimed at fostering problem-solving and decision-making skills, job search and interviewing skills, and knowledge of business practices (Albertini et al., 2011; Danek & Busby, 1999). Such programming often is included in transition planning at the secondary level and to a lesser extent at the postsecondary level.

CTE programming at both the secondary and postsecondary levels long has been emphasized for DHH students who did not have the credentials for more academically-oriented programs, were not perceived by others to be ready for such programs, or who simply were following a long tradition of DHH individuals' excelling in technical fields (Lang, 2011). Using data from the National Longitudinal Transition Study and NLTS2, Wagner, Newman, and Cameto (2004) reported that during the intervening 15 years between NLTS and NLTS2 (1985–87 to 2001–02), 14- to 18-year-olds DHH students' enrollment in academic courses increased significantly. However, they observed that one result of the general increase in academic rigor in high school (e.g., ACT, 2005; Adelman, 1999) was a concurrent 10 percentage-point decrease in DHH students' enrollment in CTE courses. The National Center for Education Statistics (Hudson, 2013) reported a similar decrease for students in the general population, with a decline in the average number of CTE credits earned by U.S. public high school graduates between 1990 and 2009.

Bishop and Mane (2004) found that students going into high school with poorer academic credentials were more likely to enroll in CTE courses than students with better previous performance, suggesting that motivation and/or ability may play a central role in decision-making regarding CTE versus academic programming. Nevertheless, depending on an individual's career goals, CTE courses may be seen as appropriate alternatives to traditional academic courses, a decision best made as part of broader transition planning. Bishop and Mane's analysis of 12 years of international longitudinal data revealed that countries that enroll a large proportion of high school students in CTE programs have significantly higher rates of school attendance and program completion, and that CTE coursework did not negatively affect scores on college entrance examinations.

Rationale for the Present Study

Given the historic underachievement and delays in academically-relevant cognitive and noncognitive academic skills among DHH high school students, this group is especially vulnerable to not being sufficiently prepared to succeed at the postsecondary level (Albertini, Kelly, & Matchett, 2011; Allen, 1994; Kelly, 2008). Both the rigor and level of courses taken have been shown to be predictors of entry, persistence, and degree attainment among hearing students (e.g., Dougherty, Mellor, & Jian, 2006; Karp, Calcagno, Hughes, Jeong, & Bailey, 2007; Roderick, Nagaoka, & Coca, 2009). However, many DHH high school students, appropriately or not, are channeled into CTE or lower-level academic courses, frequently leaving them unprepared for postsecondary education.

In order to examine the relationship of postsecondary educational preparation in terms of high school course taking with postsecondary enrollment of DHH students, we used the nationally representative longitudinal NLTS2 database, which contains extensive academic and demographic information on DHH youth in the United States. Although others have examined the impact of course taking on postsecondary enrollment, that work focused on other populations (e.g., Rojewski, Lee, & Gregg, 2013—students with high incidence disabilities, and Wagner, Newman & Javitz, 2015—students with learning disabilities) or youth in the general population (e.g., ACT, 2005; Attewell & Domina, 2008; Gamoran & Hannigan, 2000; Long et al., 2009). Still to be determined is the extent to which various types of high school courses prepare DHH students for postsecondary education when other factors are controlled.

Of interest in this study was the content of high school courses as predictive of enrollment in postsecondary education. Based on the hypothesis that more rigorous academic course work, including algebra coursework would be related to higher enrollment rates at 2- and

4-year colleges and that more intensive CTE course taking would be related to higher CTE school enrollment rates, the present study addressed two research questions:

1. What was the impact of academic course taking—percentage of credits earned in academic courses and completion of algebra coursework—on the enrollment of DHH students in 2- and 4-year colleges and CTE schools?
2. What was the impact of CTE course taking—percentage of credits earned in CTE courses and completion of an occupationally specific course of study—on the enrollment of DHH students in 2- and 4-year colleges and CTE schools?

We used propensity score modeling, a quasi-experimental method that creates statistical experimental and control groups and allows for the estimation of a treatment effect in a case where a randomized controlled trial is not possible (Becker & Ichino, 2002). Such rigorous analysis enables researchers to move beyond description and begin to draw conclusions about interventions, a component of research that is needed in the field of secondary education and that can support identification of evidence-based practices that lead to improved outcomes for students with disabilities (Test, Mazzotti, Mustian, & Fowler, 2009).

Conceptual Framework

This study was guided by the NLTS2 conceptual framework (Wagner & Marder, 2003), which posited that youths' experiences—in this case course taking and postsecondary enrollment—are shaped not only by the immutable characteristics of students (e.g., disability functioning, gender, race/ethnicity), their households (e.g., household income, mother's education level), and their schools (primarily schools/programs designed for DHH students or regular "mainstream" schools), but also by factors that are fluid and can change over time (e.g., communication skills, academic achievement). Research has shown that demographic factors, such as gender, race/ethnicity, and household income, are significantly related to variations in course taking and postsecondary enrollment (Newman et al., 2012; Newman et al., 2011). Additionally, school type has been linked both to differences in achievement at secondary level (Marschark et al., 2015) and course taking and outcomes at the postsecondary level (Nagle et al., in press) as have differences in the nature and severity of youth's disabilities (Antia, Reed, Jones, & Kreimeyer, 2009; Newman et al., 2012; Newman et al., 2011). For youth in the general population, academic performance also has been shown to be significantly related both to course taking and to postsecondary enrollment (Bishop & Mane, 2004).

Method

Sample

The findings in this paper are based on secondary analyses of data from NLTS2, funded by the U.S. Department of Education. NLTS2 is the largest and richest data set available that generalizes nationally to youth with disabilities transitioning from high school to early adulthood. The NLTS2 two-stage sampling strategy was first to randomly sample local educational agencies (LEAs) and state-supported special schools (e.g., schools for the deaf) stratified by geographic region, district enrollment, and wealth. Then students receiving special education services were randomly selected from the rosters of the LEAs or special schools. Each student's eligibility for special education services and the designated disability category were determined by the LEA or special school contributing the student roster. The initial NLTS2 sample comprised more than 11,000 high school students ages 13–16 receiving special education services in December 2000 and included students in each of the 12 federally recognized disability categories, including DHH students. In the NLTS2 database are data from phone interviews and/or surveys of parents and youth across five waves of data collection (conducted every other year beginning in 2001 and ending in 2009), high school transcripts, surveys of students' high school teachers, and direct assessments of students' academic achievement. By the final data collection wave, youth were 21 to 25 years old. Sample selection, sample attrition, and representativeness were more fully described by SRI International (2000) and Javitz and Wagner (2003, 2005). NLTS2 data yield nationally representative estimates of students with disabilities as a whole and in each disability category, including DHH students. Weights were computed by taking into account the various youth and school characteristics used in stratifying variables in the sampling and nonresponse in those strata. Details on the weighting strategy can be found in Newman et al. (2012) and Valdes et al. (2013).

The present study included youth who had (a) been identified by their school district as receiving special education services for a primary disability of hearing impairment,[1] (b) at least one parent or youth interview/survey after leaving high school that reported postsecondary school attendance or nonattendance, and (c) a high school transcript from which course taking could be determined. Approximately, 440 youth met these criteria. Unweighted sample sizes were rounded to the nearest 10, as required for restricted-use data by the U.S. Department of Education.

NLTS2 Data Sources

Parent/young adult interviews/surveys. Interviews were conducted with parents in English and Spanish using Computer Assisted Telephone Interview every other year between

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[1] Students were sampled under the federal disability category of *hearing impairment*. In this paper, we refer to this population as *deaf and hard-of-hearing*, the convention used following the 1991 joint statement by the World Federation of the Deaf and the International Federation of Hard of Hearing People.

2001 and 2009. Interviews also were attempted with sample members who were at least 18 years old and who were reported by parents to be able to respond for themselves by phone. Mail questionnaires were sent to parents who could not be reached by phone and to young adults who were reported to be able to answer questions for themselves but not by telephone.

High school transcripts. Eight waves of transcript requests for NLTS2 sample members were sent to secondary schools between March 2002 and September 2009. A transcript was considered complete if it indicated that a student had graduated, completed the high school program, aged out, or dropped out and included information for all grading periods the student had been in high school.

School surveys. School staff most knowledgeable about the student's school program completed the school program survey. Secondary school staff completed surveys about the characteristics of students' secondary schools. For details on all data sources, see Newman et al. (2011).

Measures

Treatment: High school course taking. Four measures of course taking in two domains, academic and CTE, were the subject of analyses, specifically: (a) the percentage of overall credits earned in academic education courses, (b) whether a student had completed an algebra course, (c) the percentage of overall credits earned in CTE courses, and (d) whether a student had completed an occupationally focused course of study. The data source for the five variables was students' final high school transcripts.

Overall course taking in academic and CTE courses was included in the analyses as percentages of overall earned credits rather than as the number of earned credits to control for high school dropouts; those who had dropped out would have completed fewer credits. The percentage of credits earned in each of the two areas (academic and CTE courses) was dichotomously coded (1 = *above the mean*, 0 = *below the mean*). Completion of at least one algebra course was also dichotomously coded (1 = *yes*, 0 = *no*). Completion of a concentration of occupationally specific CTE courses, defined as whether students had earned 4 or more credits of occupationally specific courses (i.e., courses in business, trades) (Wagner, Newman, Javitz, 2015), was dichotomously coded (1 = *yes*, 0 = *no*).

Outcomes: Enrollment in postsecondary school. The outcome measures in the analyses were enrollment in each of three types of postsecondary schools—2-year or community college, 4-year college or university, and CTE schools. Enrollment data came from the Waves 2 through 5 post-high school parent/youth telephone interviews and mail surveys. A dichotomous variable (1 = *yes*, 0 = *no*) was created for enrollment in each of the types of postsecondary schools. Youth were coded as a 1 = *yes* if they were reported ever to have enrolled in that type of school since leaving high school. Those who had never enrolled in any postsecondary school were coded as 0 = *no*. The sample for each set of analyses was limited to those who had enrolled in that specific type of postsecondary school and those who had never enrolled in any postsecondary school (e.g., the sample for the analyses on enrollment in 2-year college comprised those who ever enrolled in 2-year college and those never enrolled in any postsecondary school; it did not include students who had enrolled in 4-year or CTE schools).

Covariates. Covariate selection is critical to the propensity modeling approach, a primary purpose of which is to achieve the optimal balance between comparison groups on specified covariates that influence the decision to both participate in a treatment and an outcome (Caliendo & Kopeing, 2008; McCaffrey, Ridgeway, & Morral, 2004; Rojewski et al., 2013). As indicated earlier, covariate selection was informed by the NLTS2 conceptual framework

(Wagner & Marder, 2003). The specific factors within the framework's larger constructs included in the analyses reported here were selected on the basis of this conceptual framework and prior research on factors related to course taking and postsecondary enrollment, which were more fully described in the literature review section. These covariates, shown in Table 1, are described below.

Demographic covariates came from the Wave 1 parent interview/survey and were the following dichotomous variables: youth's gender (1 = *male*, 0 = *female*), race/ethnicity (1 = *other than White*, 0 = *White*), household income (1 = *<$50,000*, 0 = *≥$50,000*), and mother's education (1 = *high school graduate/GED or less*, 0 = *all other education categories*).

Indicators of the nature and severity of youth's disabilities were level of hearing loss, whether the student had an additional disability, speech clarity, use of sign language, and affected functional domains. Level of hearing loss was reported in the Wave 1 school program surveys and infilled with information from the Wave 2 school program survey for those missing the Wave 1 survey; for those missing both school surveys, level of loss was based on parent report. This variable was dichotomously coded (1=*deaf*, 0 = *hard of hearing*). Wave 1 parent interview/surveys, infilled with information form the Wave 2 interviews if Wave 1 data were missing, provided the remaining severity indicators. To determine clarity of speech, Parents were asked to indicate how clearly the youth spoke on a scale ranging from 1 (*has no trouble speaking clearly*) to 4 (*does not speak at all*). Use of sign language and whether youth had any additional disabilities were each included as dichotomous variables (1 = *yes*, 0 = *no*). Parents also reported whether youth had any problems with seeing, speaking, conversing, understanding language, appendage use, or health. The number of problem domains mentioned ranged from zero to six; these then were dichotomously coded as 1 (*0 to 2 problems*) and 0 (*3 or more problems*).

Type of secondary school attended was characterized based on the school characteristics survey and the Waves 1 through 4 parent interview/survey. Students were identified as having attended regular secondary schools (those that serve a wide variety of students, as well as magnet, charter, alternative, and vocational schools), special schools that serve only students with disabilities, or a mix of both regular and special secondary schools. The type of secondary school covariate was then dichotomized as 1 (*regular secondary schools only*) and 0 (*special schools or a mix of secondary school types*).

Academic performance was measured on the basis of students' high school transcript grade point average (GPA) in academic coursework in grades 9 and 10.

Missingness rates for variables ranged from 0 to 9%. As required by the What Works Clearinghouse (WWC) standards for designing quasi-experiments, none of the variables in these analyses have been imputed (What Works Clearinghouse, 2015).

Propensity Score Methodology

Propensity score techniques (Becker & Ichino, 2002) are increasingly being used in observational studies with cohort designs to reduce selection bias in estimating treatment effects when randomized controlled trials are not feasible or ethical (Rosenbaum & Rubin, 1983, 1984, 1985). Researchers strive to create balance on observed covariates between treatment and comparison groups using these statistical methods instead of randomization. The goal is to achieve a valid test of the treatment effect while statistically balancing treatment participants and nonparticipants on measured covariates that might be confounders, thus disentangling confounding effects from treatment effects. We used propensity score methods in this study to test the effects of course taking on the odds of students enrolling in postsecondary school.

The analyses presented here estimated the average treatment effect on students in the treatment condition in the population (PATT) represented by NLTS2 students—i.e., the effect of course taking on students who took those types of courses. We used the analysis approach recommended by DuGoff, Schuler, and Stuart (2014) to adjust for potential confounding (i.e., differences between the treated and untreated students in the sample other than the treatment itself, which might have affected the outcome).

Logistic regressions to generate propensity scores were performed. Data were weighted using the NLTS2 cross-wave, cross-instrument weight, "wt_anyPYPHSsch" (Valdes et al., 2013), so that findings are nationally representative of DHH students in the NLTS2 age range and time frame. The dependent variable was one of the course taking treatments, and the independent variables were the covariates. These regressions generated the estimated probability (propensity score) that each student implicate belonged to the course taking treatment group. The survey weights for control students were adjusted by multiplying the NLTS2 weight by the quantity $p/(1-p)$ where p is the propensity score. Propensity scores were truncated at 0.99 to avoid excessively large adjustment factors. Treatment students' survey weights were not adjusted.

To estimate the treatment effect, we conducted separate weighted logistic regressions using the propensity-adjusted survey weights where the dependent variable was one of the three postsecondary enrollment outcomes and the independent variables included course taking variables. All covariates were included in these analyses to further adjust for any differences due to covariates. Regression results generated odds ratios (*OR*s), which can be interpreted as measures of relative probabilities of enrollment in each of three types of postsecondary schools by the treatment group and comparison group, controlling for the observed covariates and their respective propensity to have experienced treatment. Effect size for the *OR*s can be calculated using the Cox Index $LOR_{Cox} = \ln(OR)/1.65$ (Cox, 1970).

The propensity scoring approach weighted the treatment group to the national population and the control group to the distribution of the treatment group in the population. This approach essentially weighted the comparison group to create balance with the treatment group on observed covariates and thus facilitated estimation of the effect of specified types of course taking for participants. We selected weighting over other approaches, such as matching, because of its good performance in this data set and because it retains all subjects in the analysis.

Adequacy of Adjustment for Treatment and Control Differences

To ensure that the propensity score method created balanced treatment and comparison groups, we compared the standardized mean differences (SMDs) between the two groups on each covariate using survey weights and the propensity score-adjusted survey weights, respectively, before and after propensity score weighting. The SMD is the difference in means between the groups, divided by their pooled standard deviation. The WWC established a 0.25 cutoff for baseline equivalence for quasi-experimental studies (What Works Clearinghouse, 2014), a standard also supported by other analysts (e.g., Ho, Imai, King, & Stuart, 2007). Baseline equivalence of the treatment and comparison group SMDs was compared using the 0.25 criterion. SMDs were required to be less than 0.25 to demonstrate equivalence of the analytical sample.

Eleven covariates were included in the four propensity models. Before propensity score weighting, the SMDs were above the WWC cutoff for three covariates in the model comparing proportions of academic credits (Table 1), three covariates in the model comparing completion of algebra with noncompletion (Table 1), four covariates in the model comparing proportions of

CTE credits (Table 2), and three covariates in the model comparing completion of an occupationally focused course of study (Table 2). After propensity score weighting, with one exception, all SMDs were below the WWC cutoff, indicating that the two groups were balanced on the covariates and that propensity modeling was warranted. In the analyses comparing completion of an occupationally focused course of study, use of sign language remained slightly above the cutoff (0.26 difference) after propensity weighting. All covariates also were included in all subsequent models to further account for any possible differences between treatment and comparison groups due to covariates.

<Tables 1 and 2>

Results

Approximately half the DHH youth represented by the analysis sample were male (53.5%), 63.3% were White, 14.1% were African American, and 18.6% were Hispanic. About one-quarter (26.0%) lived in households with incomes of $25,000 or less, and 50.3% had mothers with a high school diploma or less education. Approximately 4 of 5 DHH students represented by the analysis sample (80.6%) had attended only regular secondary schools that served a wide variety of students; the rest had attended just special secondary schools that served only students with disabilities (e.g., schools for the deaf) or a combination of regular and special schools during their secondary school years.

On average, academic courses accounted for 60% and CTE courses accounted for 18% of the total credits DHH students earned. Approximately 62% of DHH high school students had successfully completed an Algebra 1 course, and 43% had completed a concentration of occupationally specific CTE courses. Nagle et al. (in press) provided more comprehensive information about DHH high school students' course taking. Within 8 years of leaving high school, 52% of DHH youth had attended a 2-year college, 34% had attended a 4-year college or university, and 43% had attended a CTE school.

Research Question 1: Effects of Academic Course Taking on Postsecondary Enrollment

Propensity-adjusted results supported the hypothesis that academic course taking affects postsecondary school enrollment (Table 3). Completion of a higher proportion of academic credits significantly increased the odds of DHH students enrolling in 2-year and 4-year colleges (*OR*s = 4.99 and 5.37, $p < .001$ for both), and CTE schools ($OR = 7.45$, $p < .001$). Of those who had earned a higher proportion of academic credits, 77% had enrolled in a 2-year college, 79% had enrolled in a 4-year college, and 66% had enrolled in a CTE school, compared with propensity-adjusted enrollment rates (where the control group matched the treatment group on all covariate means) of 40%, 42%, and 21%, respectively, for those who earned fewer academic credits. DHH students who had completed an algebra course were more likely to enroll in the three types of postsecondary schools as well—2- year ($OR = 2.87$, $p < .05$), 4-year ($OR = 3.57$, $p < .01$), and CTE schools ($OR = 3.69$, $p < .05$). As translated into percentages, 79%, 75%, and 71% of students who had earned algebra credits had enrolled in the three types of postsecondary programs, respectively, as compared with propensity-adjusted enrollment rates of 56%, 45%, and 40% for those who had not successfully completed algebra coursework.

<Table 3>

Research Question 2: Effects of CTE Course Taking on Postsecondary Enrollment

In contrast to the findings on academic course taking, neither completion of a higher proportion of CTE courses nor having completed an occupationally specific course of study contributed to higher odds for enrollment of DHH students in postsecondary institutions, including CTE schools (Table 3). Students who had a higher proportion of CTE coursework in their overall credits were less likely to have enrolled in a 4-year college or university ($OR = 0.26$, $p < .01$).

Discussion

In this study, we used propensity score modeling, a quasi-experimental method, to examine the relationship between academic and CTE course taking and postsecondary school enrollment for DHH students, based on secondary analysis of NLTS2. Findings indicated that (1) completing an algebra course in high school was a significant predictor of DHH students' future enrollment in postsecondary programs, (2) completing a greater proportion of academic courses significantly increased the likelihood of DHH students' enrolling in 2-year and 4-year colleges and CTE programs compared with propensity-adjusted enrollment rates, but (3) neither completing a greater proportion of CTE courses nor being a CTE concentrator in a specific occupational course of study contributed to DHH students' enrolling in postsecondary programs, including CTE programs.

The first finding demonstrates that the role of taking an algebra course as a predictor of postsecondary enrollment holds for DHH students as it does for hearing students, despite their generally lower prior mathematics achievement (Qi & Mitchell, 2012). The algebra benchmark is remarkably robust in that having completed an algebra course remains a predictor for both groups of students despite differences in the strategies used in mathematical problem solving (Blatto-Vallee, Kelly, Gaustad, Porter, & Fonzi, 2007; Bull et al., 2005; Marschark, Morrison, Lukomski, Borgna, & Convertino, 2013). Further, the finding that completing an algebra course was associated with a significantly greater likelihood of enrollment in CTE as well as 2- and 4-year postsecondary education programs emphasizes the generality of the gateway character of that course as demonstrated in previous studies involving the general (hearing) student population.

Findings indicate that the proportion of academic courses, but not of CTE courses, predicted DHH students' enrollment in postsecondary education. Academic credits accounted for a smaller proportion of overall credits for DHH students than for their peers in the general population (Nagle et al., 2015). As Nagle and colleagues indicated, DHH students earned significantly fewer credits in science, social studies, and mid-level and advanced math than their peers. That finding may account for some of the lag in academic achievement seen among DHH students relative to hearing peers across the curriculum (Marschark et al., 2015; Qi & Mitchell, 2012). This situation often has been attributed to communication barriers in the classroom, but recent research indicates that a greater factor in specific academic outcomes for DHH students is lack of prior preparation and content knowledge (see Albertini et al., 2011; Kelly, 2008; Marschark, Machmer, & Convertino2016, for a review). The present findings from secondary analyses of the NLTS2 data thus are consistent with empirical research indicating the need for DHH students to take more, or perhaps more rigorous, courses if they are to enroll in and complete postsecondary programs (Allen, 1994; Kelly, 2008). Such findings need to be considered early on during transition planning in a way that is appropriate to the DHH student's strengths and needs.

DHH students still may be more likely than peers in the general population to attend CTE-oriented programs and enter nonprofessional occupations (Boutin & Wilson, 2009), but that proportion is likely to shrink as more DHH students take more academic courses at the secondary level and successfully complete baccalaureate and higher degrees. The challenge for all stakeholders in educating DHH students thus becomes ensuring that they are appropriately prepared at each stage of their academic careers, whatever their occupational destinations.

Implications for Practice

The reauthorized Individuals with Disabilities Education Act (IDEA) requires that beginning at age 16 or younger, each student with a disability has a transition plan that specifies post-high school goals regarding training, education, employment, and, where appropriate, independent living skills, as well as the courses of study and other transition services are needed to assist the student in reaching those goals (U.S. Department of Education, 2007). Transition plans of approximately 60% of DHH high school students include 2- or 4-year college attendance as a primary goal, and the post-high school goal for 33% of the DHH students was CTE program attendance (Cameto, Levine, & Wagner, 2004). Clearly, given the present findings, it is important that secondary transition planning staff both encourage DHH students who have a goal of future postsecondary attendance to take a rigorous, academically focused high school curriculum and to provide those students with the supports to complete these courses. Almost half of DHH students (47%) had failed one or more graded courses in high school (Newman et al., 2012). Both transition planning and individualized education program (IEP) meetings thus should include discussion of the supports DHH students need to succeed in their academic courses and graduate as well as to prepare for postsecondary education.

Limitations

This study has provided evidence of the importance of course taking to postsecondary enrollment for DHH students, particularly academic course taking. Nonetheless, the study has several limitations. Some analyses were based on self-reported data; we could not independently verify income levels, mother’s education level, or postsecondary enrollment. Measures of the functional and hearing-related covariates also were based on parents' reports, which cannot be equated with the results of professional evaluations. Course taking measures were based on high school transcript data, which provided limited course information (e.g., course title, earned credits, grades), and did not include course information, such as specific content, rigor, teaching modality, or provision of accommodations. In addition, as a secondary analysis, this study was constrained by the NLTS2 design and the items available in the data set.

Finally, unobserved confounding is a concern in nonexperimental studies such as this, where student course taking could not be randomized. The propensity score approach adjusts for observed covariates but does not necessarily balance on unobserved factors. Bias may arise if there is unobserved confounding, that is, if an unmeasured factor is correlated with both course taking and postsecondary school enrollment. However, sensitivity analysis indicated that results were unlikely to overstate effects. A sensitivity analysis (Lin, Psaty, & Kronmal, 1988) was conducted to determine how strongly a single unmeasured binary variable would need to be associated with both postsecondary enrollment and course taking to render the effect of the treatment statistically nonsignificant if that binary variable had been entered as a covariate into the propensity score analysis. For example, such a variable would need to have an *OR* of 6.6 with both the dependent variable and treatment in the model exploring the effect of academic course taking on 4-year college enrollment, which is a relatively high hurdle. This suggests that an unobserved confounder would need to be very powerful (i.e., tripling the college enrollment rate) before it would render the current findings not statically significant.

Areas for Future Research

This study provides a strong foundation for further examination of DHH students' course taking, including evaluating the rigor of the courses they take, the rigor of evaluation relative to hearing classmates, and returns on the level, rigor, and grades obtained in coursework. The present findings and those of Nagle et al. (in press) indicate that DHH students earn a similar number of overall academic credits as their general high school peers and yet they continue to score below those peers in achievement testing. Further research needs to consider the extent to which achievement tests and course grades/credits reflect different aspects of learning or different evaluation standards. That is, do DHH students take less rigorous courses than their hearing peers? Are they evaluated less rigorously in courses they take at different levels? Are the characteristics and heterogeneity of DHH students such that various metrics of academic outcomes are less valid for them than they are for the general population?

We did not find a relationship between CTE course taking and postsecondary enrollment. However, findings from other studies suggest that concentrating CTE course taking in an occupationally specific area can be effective in helping students with learning disabilities and other high-incidence disabilities be career ready when they leave high school and be better able to achieve their employment goal (Rojewski et al., 2013; Wagner et al., 2015). Encouraging students to sample such areas offers the opportunity to match employment to their strengths while avoiding barriers associated with their needs. Further investigation is needed to determine whether concentrated CTE course taking aided DHH students in becoming career ready.

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Table 1

Treatment and Control Balance Statistics on Covariates after Propensity Score Weighting (PSW) for Academic Course Taking

	% Overall Credits Earned in Academic Courses			Competed Algebra Coursework		
	Treatment *M*	SMD[a]		Treatment *M*	SMD[a]	
Covariates		Pre-PSW	Post-PSW		Pre-PSW	Post-PSW
Demographics (%)						
Male	47.06	0.29	-0.02	52.75	-0.05	-0.02
Race/ethnicity (not White)	34.22	-0.11	-0.12	33.59	-0.17	-0.02
Household income <$50,000	53.28	-0.16	-0.02	54.31	-0.14	0.10
Mother’s education (high school graduate or less)	42.44	-0.33	-0.10	39.59	-0.58	-0.05
Disability functioning and type of school attended (%)						
Deaf vs. hard of hearing	45.10	-0.11	-0.10	48.86	0.08	-0.03
Has additional disability	43.78	-0.30	0.05	43.64	-0.39	-0.09
Clarity of speech	1.94	-0.21	-0.15	1.916	-0.34	-0.10
Uses sign language	57.93	-0.14	-0.21	59.51	-0.08	-0.07

Number functional domains impaired (% with 0-2)	67.59	0.14	0.09	66.99	0.14	0.10
Attended a regular secondary school only	81.07	0.01	0.09	84.39	0.23	-0.07
Academic achievement in grades 9 & 10						
Academic courses GPA	2.76	0.09	0.12	2.59	0.19	0.00
Sample size	380			370		

[a]Pre-PSW standardized mean difference (SMD) is calculated as the treatment mean minus the control mean (both means calculated using survey weights), with the difference divided by the pooled standard deviation. The Post-PSW SMD is calculated as the treatment mean (calculated using survey weights) minus the control mean (calculated using PSW-adjusted survey weights), with the difference divided by the pooled standard deviation.

Table 2

Treatment and Control Balance Statistics on Covariates after Propensity Score Weighting (PSW) for Career/Technical Education Course Taking

	% Overall Credits Earned in CTE Course			Competed Occupationally Focused Course of Study		
	Treatment *M*	SMD[a]		Treatment *M*	SMD[a]	
Covariates		Pre-PSW	Post-PSW		Pre-PSW	Post-PSW
Demographics (%)						
Male	67.06	0.55	0.15	67.34	0.52	0.09
Race/ethnicity (not White)	35.14	-0.07	0.07	34.35	-0.08	0.03
Household income <$50,000	66.09	0.36	0.07	58.06	0.03	0.11
Mother's education (high school graduate or less)	59.45	0.38	0.072	54.66	0.16	0.15
Disability functioning and type of school attended (%)						
Deaf vs. hard of hearing	50.35	0.12	0.10	51.14	0.13	0.11
Has additional disability	52.99	0.10	0.05	57.05	0.23	0.06
Clarity of speech	2.10	0.11	0.10	2.24	0.35	0.15
Uses sign language	65.07	0.17	0.16	68.86	0.29	0.26

Number functional domains impaired (% with 0-2)	63.39	-0.05	0.05	64.77	0.00	-0.11
Attended a regular secondary school only	75.10	-0.29	0.06	76.22	-0.20	-0.01
Academic achievement in grades 9 & 10						
GPA in academic courses	2.51	-0.04	-0.05	2.55	0.06	-0.08
Sample size	370			370		

Note. CTE = career or technical education.

[a]Pre-PSW standardized mean difference (SMD) is calculated as the treatment mean minus the control mean (both means calculated using survey weights), with the difference divided by the pooled standard deviation. The Post-PSW SMD is calculated as the treatment mean (calculated using survey weights) minus the control mean (calculated using PSW-adjusted survey weights), with the difference divided by the pooled standard deviation.

Table 3

PATT Effect of Course Taking on Postsecondary Education Enrollment for Deaf or Hard of Hearing Students, by Type of Postsecondary School

	School Type Youth Enrolled In								
	2-Year or Community College			4-Year College or University			CTE School		
Treatment	Treatment Group[a] (%)	Adjusted Control Group[b] (%)	Propensity-Adjusted *OR*[c] (95% CI)	Treatment Group[a] (%)	Adjusted Control Group[b] (%)	Propensity-Adjusted *OR*[c] (95% CI)	Treatment Group[a] (%)	Adjusted Control Group[b] (%)	Propensity-Adjusted *OR* (95% CI)
Academic course taking									
% overall credits earned in academic education courses above the mean	77.1	40.3	4.99*** (2.08,11.96)	79.4	41.8	5.37*** (2.21,13.04)	66.5	21.0	7.45*** (3.13,17.70)
Completed algebra coursework	78.7	56.3	2.87* (1.19, 6.92)	74.7	45.3	3.57** (1.40,9.14)	71.2	40.1	3.69* (1.34,10.16)
CTE course taking									

% overall credits earned in CTE courses above the mean	61.1	74.4	0.54 (0.25, 1.28)	40.6	72.4	0.26** (0.11,0.64)	54.9	57.0	0.92 (0.37,2.30)
Completed an occupationally specific course of study	62.6	62.4	1.01 (0.42, 2.46)	53.6	54.6	0.96 (0.36,2.57)	55.4	48.1	1.34 (0.55, 3.29)

Note. PATT= population average treatment effect on the treated. *OR* = odds ratio. CI = confidence interval. CTE = career or technical education. *p <. 05. ** p < .01. *** p < .001.

[a] Treatment group percentage, using survey weights.

[b] Percentage positive for a control group that would yield the propensity adjusted *OR* if it matched the treatment group on all covariate means; calculated 100 * Pt / [*OR* (1-Pt) + Pt], where Pt is the survey-weighted percentage of the treatment group with a positive outcome and *OR* is the propensity- and covariat- adjusted OR.

[c] Effect size for dichotomous outcomes can be calculated using the Cox Index: LOR_{Cox} =ln(OR)/1.65, where *LOR* is the logged [c]odds ratio, ln() is the natural logarithm function, and *OR* is the odds ratio. D. R. Cox, 1970, *Analysis of Binary Data,* New York, NY: Chapman & Hall/CRC.