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The Effects of Health Insurance Coverage on the Math Achievement Trajectories of School Children in Yuma County, Arizona: Implications for Education Accountability Policy

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Abstract: U.S. Federal and state education policies place considerable emphasis on assessing the effects that schools and teachers have on student test score performance. It is important for education policy makers to also consider other factors that can affect student achievement. This study finds that an exogenous school factor, discontinuous health insurance coverage, leads to a deficit in math achievement over time. A sample of Yuma County, Arizona public school students who experienced an illness or injury and whose health insurance coverage status was known were selected for inclusion into the study over five consecutive school years (1999 – 2003). The longitudinal math achievement trajectory of students who had private health insurance coverage was compared to students who had discontinuous coverage. Net of a student's poverty status and other background characteristics the findings suggest that students who experienced a health event when they had no healthcare insurance had the same growth rate but lower overall math achievement. The average achievement gap was a constant -8.84 scale score points. However, separate analyses for specific types of illness/injury suggest the achievement deficit varied considerably and is typically larger.

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Other important findings from the study suggest that students who maintained continuous health insurance coverage through the SCHIP/Medicaid program had steeper, positive achievement gains than either those with private coverage or those who experience coverage gaps.
Keywords: Education policy; Mathematics achievement; Academic achievement; Health insurance coverage; Uninsured; SCHIP/Medicaid; Longitudinal panel data; Low-income minority sample

Los efectos de la cobertura de seguro de salud en las trayectorias de logros en matemáticas de los escolares en el Condado de Yuma, Arizona: Implicaciones para la política de rendición de cuentas la educación.

Resumen: políticas educativas federales y estatales en los EE.UU ponen mucho énfasis en la evaluación de los efectos que las escuelas y los profesores tienen en el rendimiento de académico de los estudiantes. Es importante que los responsables de las políticas educativas consideren otros factores que pueden afectar el rendimiento de los estudiantes. Este estudio revela que un factor exógeno a la escuela, la cobertura de seguro de salud discontinua, conduce a un déficit en el rendimiento en matemáticas. Se analizan los datos de una muestra de estudiantes de escuelas públicas en el Condado de Yuma, Arizona que experimentaron una enfermedad o lesión, y con una cobertura de seguro de salud identificada. El estudio accedió a datos durante cinco años consecutivos (1999-2003) y se compararon los logros en matemáticas de los estudiantes que tenían cobertura de seguro médico privado con aquellos que tenían una cobertura discontinua. Considerando las condiciones de pobreza y otras características relevantes, los resultados sugieren que los estudiantes que experimentan problemas de salud cuando no tenían seguro tenían la misma tasa de crecimiento, pero el rendimiento en matemáticas era en general inferior. La brecha promedio de logro fue una constante de -8,84 puntos. Sin embargo, un análisis complementario para los tipos específicos de enfermedades/lesiones sugieren que el déficit de rendimiento varió considerablemente, con tendencia a aumentar. Otras consideraciones importantes son que los estudiantes que mantienen una cobertura de seguro de salud continua a través del programa SCHIP/Medicaid tenían mejoras más pronunciadas de logros positivos comparados con los que tienen cobertura privada o los que experimentan cobertura discontinuada.
Palabras clave: política de la educación; Matemáticas logro; logro académico; la cobertura de seguro de salud; sin seguro; SCHIP/Medicaid; datos de panel longitudinales; muestra de minorías de bajos ingresos

Os efeitos de ter cobertura de seguro saúde nas trajetórias de aprendizagem de matemática dos alunos do Condado de Yuma , Arizona: Implicações para as políticas de prestação de contas na educação.

Resumo: políticas educacionais federais e estaduais em os EUA tem muita ênfase na avaliação dos efeitos que as escolas e os professores têm no desempenho acadêmico dos alunos. É importante para os formuladores de políticas educacionais considerar outros fatores que podem afetar o desempenho do aluno. Este estudo mostra que um fator exógeno à escola , uma cobertura descontínua de seguro de saúde, leva a um déficit no desempenho em matemáticas. Foram analisados dados de uma amostra de alunos de escolas públicas no Condado de Yuma , Arizona experimentou uma doença ou lesão, com níveis da cobertura de seguro de saúde identificados. O estudo acesso dados por cinco anos consecutivos (1999-2003) e comparou os logros em matemática dos alunos que tiveram a cobertura de seguro de saúde privado com aqueles com cobertura descontínua. Considerando-se as condições de pobreza e outras características relevantes, os

resultados sugerem que os alunos que apresentam problemas de saúde quando tem cobertura de saúde tem a mesma taxa de crescimento, mas o desempenho em matemática era geralmente mais baixo. A diferença média foi uma constante de -8,84 pontos. No entanto, uma análise adicional para tipos específicos de doenças / lesões sugerem que a diferença de rendimento variaram consideravelmente, com tendência a aumentar. Outras considerações importantes são para estudantes que mantêm um programa de cobertura de seguro de saúde continua através SCHIP / Medicaid tiveram maiores melhorias em comparação com aqueles com cobertura privada ou cobertura descontinua.
Palavras-chave: política de educação; realização matemática; o desempenho acadêmico; a cobertura de seguro de saúde; seguro; SCHIP/Medicaid; dados em painel longitudinais; amostra de minoria de baixa renda

Introduction

School accountability and value-added education policies have been part of a longstanding effort in the U.S. to develop methods for assessing the effects of school and teacher quality on student learning and achievement. The best conceived value-added rating systems have attempted to statistically separate school and teacher quality effects from their students' background characteristics to produce an unbiased assessment. However, the reliability and the validity of the derived scores have often been questioned especially in the circumstance where results were used in high-stakes, definitive decisions about teacher and school quality (Amrein-Beardsley 2008; Berliner 2013; Rothstein 2010). Critics had previously demonstrated that there was substantial variability in the rating scores of the same teachers from year to year (Amrein-Beardsley & Collins 2012; Newton, Darling-Hammond, Haertel & Thomas 2010; Rothstein 2010).

To deflect criticism and demonstrate the utility of the value-added approach some have suggested (Harris 2009) that the scope of application could be broadened so that the measures produced need not necessarily be used only in high stakes situations. Other policy options have been proposed including using value-added modeling as one part of the high stakes assessment or more benignly identifying teachers who are effective and even providing an incentive for improving instruction (Harris 2009). Increasingly, as a response to the limitations of value added methodology, many states and districts are no longer solely reliant on value-added systems. Instead they employ multiple measures of teacher effectiveness that can include both principal evaluations and assessments of teachers' credentials and experience.

Irrespective of the policy debate concerning appropriate applications of value-added methodology, studies including those that have been supportive of these systems have shown the influence of student background and community-level factors on student learning and achievement that have not usually been accounted for. They include factors like individual-level (Garcy 2009) and aggregate-level student health status (Stone & Jung 2008), whether a student was homeless (Meyer & Dokumaci 2010), or other exogenous, non-school, aggregate-level factors such as the community crime and violence rates, the degree of home ownership, or the level of area, marital dissolution (Berliner 2009, Berliner 2013). This study continues in the same vein testing the hypothesis that an outside-of-school factor i.e., discontinuous health insurance coverage, can lead to a deficit in math achievement.

To link health insurance coverage status to student health and student health to math achievement, the paper begins with a review which establishes a probable, causal relationship between health insurance coverage and better adult and child health. The pathways that produce the relationship for both are briefly mentioned. Discussion then turns to the negative health effects of discontinuous health insurance coverage particularly for children. Finally, evidence is presented that relates student health to academic achievement.

Review of the Literature

Does health insurance produce a health benefit?

There are several studies and recent reviews that have suggested a causal relationship between health insurance coverage and health (Brown et al., 1998; Institute of Medicine 2009; Levy & Meltzer 2004; McWilliams 2009; U.S. Congress 1992). To date, there is only one randomized, experimental study called the Health Insurance Experiment (HIE) that tested the impact of free health insurance on individual-level health in the United States. The HIE study included numerous measures of health status for 7,700 individuals under the age of 65. The most important finding demonstrated that free health insurance improved the control of blood pressure. The most indigent patients experienced the greatest reduction. They also experienced marginally better vision, were more likely to seek needed dental care, and they had a lower prevalence of serious symptom reporting (Brook et al., 1983; Brook et al., 2006; Keeler et al., 1985).

A number of older, larger, quasi-experimental studies have also shown consistent positive effects of health insurance on health. Many were conducted as natural experiments when there were enactments or expansions of public health insurance programs. Researchers who have studied Medicaid eligibility expansions in the U.S. have shown a decline in the incidence of low birth weight babies, infant mortality, and an increase in the child health-care utilization rate (Currie & Gruber 1996a; Currie & Gruber 1996b). A related eligibility expansion study found that low-income, pregnant women living closer to neonatal ICUs increased their use of fetal monitoring, ultrasound technology, labor induction, and cesarean section. This, in turn, reduced the incidence of infant mortality and low birth weight (Currie & Gruber 1997). Similarly, a study of the enactment of the Canadian National Insurance Program (1962-1972) found reductions in infant mortality and the percentage of low birth weight infants (Hanratty 1996).

Several smaller, dated, quasi-experimental studies have found no effect of public health insurance on birth outcomes when Healthy Start was expanded to cover women at 100 to 185 percent of the U.S. federal poverty level (Haas et al., 1993a; Haas et al., 1993b). In turn, a study of privately and publically-covered individuals that accounted for baseline health status found no beneficial health effects of private coverage and worse health among those with publically-sponsored insurance (Ross & Mirowsky 2000).

Contemporary Studies

While most recent studies have suggested a beneficial effect of health insurance on health there is at least one study that has produced mixed findings. This longitudinal, quasi-experimental study used data from the Health and Retirement Study (HRS) and tracked self-reported general health trajectories and mortality before and after Medicare eligibility in the same pre and post-elderly participants (Polsky et al., 2009). Although the authors concluded that there was no statistically significant effect of gaining health insurance coverage on the health of the previously uninsured, there were several counterfactual findings that suggested some limited health imparting effects. Those who were previously uninsured who gained Medicare coverage experienced a larger decline in active depression relative to those who had been previously insured. Additionally, there was some evidence that suggested that health declines slowed for Medicare recipients irrespective of prior health insurance coverage status.

Other recent studies that have used longitudinal data to assess whether gained Medicare coverage at age 65 improved the health of adults in the U.S. who had been previously uninsured have produced positive findings. Analyses of survey data from the HRS suggested that those adults who had been continuously or discontinuously insured, but had later gained coverage at age 65, reported improved health. This was particularly the case for those who had diabetes and cardiovascular disease (McWilliams et al., 2007). An additional, earlier study that also used longitudinal data from the HRS examined the effects of private insurance on a composite measure of health status. After accounting for baseline health status, health behaviors, and participant characteristics, results suggested that health insurance produced small but statistically significant increments in the health score of those who gained insurance coverage. A number of different modeling techniques including the use of a state-level instrumental variable approach produced consistent findings and substantially larger estimates of the health insurance effect (Dor et al., 2006).

Studies which include those utilizing a mix of different research designs have also shown positive effects of health insurance coverage. Two large, quasi-experimental studies using data from the National Health Interview Survey in the U.S. found a 20% lower 7-day mortality risk among those hospitalized with a serious, acute condition (e.g., stroke, myocardial infraction) (Card et al., 2009), and improvement in both general self-reported health and functional status (Card et al., 2004). These health gains were demonstrated to have occurred in individuals who were previously uninsured but had gained public coverage at age 65. The study ruled out other potential sources of health gains including changes in marital status, employment, geographical location, and family income.

Finally, a quasi-experimental study that used cross-sectional, general health data from the U.S. and Canada estimated the effect of near universal Medicare coverage in the U.S. on self-reported health disparities between low and high-income adults under 65, and among those 65 and older (Decker & Remler 2004). Two important findings emerged. Among adults under 65, reported relative health disparities between low and high-income groups in Canada were about half as large as those reported between low and high income groups in the U.S. This implied that universal health coverage in Canada had reduced these estimated health disparities. A second, related finding among those 65 and older suggested that the U.S./Canadian low-to-high-income, self-reported health gap was half the size of the under 65 group. The authors suggested that near universal Medicare coverage that became available to the American elderly at age 65 likely accounted for this reduction.

How Does Health Insurance Improve Health?

A different set of process studies have demonstrated how health insurance was likely to improve or maintain health. Increased health-care utilization, increased medical care/prescription spending, less delay in seeking medical treatment, more frequent use of preventative care, and greater continuity of health-care are suggested pathways (Davidoff et al., 2005; Olsen et al., 2005). Concerning preventative care, parents who had health insurance could more easily afford treatments or, obtain prescription medication which controlled or alleviated the symptoms of illness in children (Olsen et al., 2005). Health-care utilization has also been shown to increase among adults and children when health insurance was made available to individuals or families who were previously uninsured (Currie & Gruber 1997; 1996a; 1996b; Keane et al., 1999; Lave et al., 1998a; 1998b). Access to health-care is particularly important to individuals with chronic conditions who may require preventative care e.g., dental care to control the effects of diseases like diabetes (Davidoff et al., 2005).

The Negative Effects of Discontinuous Health Insurance Coverage for Children

While accumulating evidence continues to build support for the existence of a causal relationship between health insurance and improved health, an increasing number of other studies that have utilized a variety of research designs and methods have consistently shown that no health insurance coverage/gaps in coverage with no access to medical care is especially damaging to the health of children. Studies have suggested a litany of unaddressed health-care needs including delayed medical care, unmet health-care, unfilled prescriptions, a lack of a usual place for health-care, no well-child visits, and no doctor office visits (Keane et al., 1999; Lave et al., 1998a; Newacheck et al., 1998; Olsen et al., 2005; Satchell & Pati 2005).

Preventative care may also be compromised or is not sought. Several studies have found that the rate of immunization among very young, uninsured children was lower when compared to those who had coverage (Allred et al., 2007; Becton et al., 2008). In a survey study of children who had asthma, those who were uninsured at the baseline had poorer access to asthma care when compared to their insured counterparts (Szilagyi et al., 2006). A cohort study of children who had been newly diagnosed with type 1 diabetes found that uninsured children had substantially higher odds ratios of presenting with any form of ketoacidosis and severe ketoacidosis relative to children who had private or public insurance (Maniatis et al., 2005). The authors speculated that the uninsured children were more likely to have delayed seeking treatment, resulting in more serious symptoms. An additional study found that parents who lacked coverage were also more likely to report that their children's mental health needs went unmet (DeRigne et al., 2009). Perhaps as a result of delayed medical care uninsured children are also more likely to die. At least two very large, cross-sectional studies that utilized U.S. national hospital admission data have shown that mortality among uninsured, hospitalized children was greater when compared to those who were hospitalized but had coverage (Abdullah et al., 2010; Rosen et al., 2009). While negative health outcomes are a consequence of a lack of access to health-care, discontinuous health insurance coverage may also have consequences that extend beyond poor childhood health.

Health Effects on Academic Performance

There is substantial face validity for this hypothesis. Much of the recent evidence has suggested that illness or injury affects educational processes negatively. Research has shown that unhealthy children who miss school typically experience learning disruptions which result in lower academic achievement (Wolfe 1985; Schwartz & Lui 2000), difficulty staying on grade level (Klerman 1988), and slumps in academic performance (Mueller et al., 2006). Even those children who manage to stay in school with untreated illnesses are more disruptive and have poorer concentration, making learning more difficult (Currie 2005; Needham et al., 2004).

Other studies have suggested a link between poor, overall childhood health and substandard cognitive outcomes (Miller & Koreman 1994; O'Brien Caughy 1996; Palloni 2006), or specific health conditions (e.g., diabetes, sickle cell anemia) and lower cognitive outcomes, reduced intelligence, or ability (Brown et al., 2000; Hershey et al., 1999; Kral et al., 2003; Northam et al., 1999; Rovet et al., 1988; 1990). Researchers in different fields have focused narrowly on the relationship between specific health conditions and academic outcomes including scholastic achievement, and test performance (Taras & Potts-Datema 2005a, b, c). These studies have suggested that chronic conditions suffered during childhood and adolescence were correlated with lower achievement (Fowler 1988; Garcy 2009; Nabors & Freymuth 2002; Nettles 1994; McCarthy et al., 2003; Mo-suwan et al., 1999).

Additional evidence has suggested an association between substandard childhood health and other outcomes including greater absenteeism (Damiano et al., 2003; Howell & Trenholm 2007), reduced concentration, and more frequent emotional outbursts (Taras & Potts-Datema 2005a; Taras & Potts-Datema 2005b; Taras & Potts-Datema 2005c). Some researchers have assumed that the availability of health insurance coverage could moderate the effects of chronic illness or substandard health on school achievement (Schwartz & Lui 2000). Discontinuous health insurance coverage that has coincided with acute or chronic illnesses could be especially harmful to a child's school performance because it could increase the likelihood that prompt medical treatment cannot be sought, preventative care can be delayed or never received, and/or continuity of care for existing illnesses/injuries is disrupted or never established. This in turn could lengthen the duration of a school absence associated with the illness/injury. To date, there are few if any known studies that have established a relationship between health insurance coverage and children's academic performance. This study tests the specific hypothesis that discontinuous coverage is related to the development of a math achievement deficit.

To test the main hypothesis, this study focuses on student math achievement over other content areas because math learning is more likely to occur in school than at home (Bryk et al., 1993; Heyneman 2005). Hence, math achievement may be more adversely impacted by illness or school absence when compared to other content areas. For students who suffered from an illness/injury and lost their health insurance coverage prior to testing, two research questions are posed:

RQ1. How did their math achievement compare to students who had continuous health insurance coverage but similar illnesses/injuries?

RQ2. Do the rate of change and the overall gap in math achievement vary by illness/injury and by insurance coverage status?

Method

Participants

The study is situated in the rural county of Yuma, Arizona which shares borders with California and Mexico. It utilizes information on a group of students (n = 11,946) who had at least one or more test scores, suffered an illness/injury prior to testing on one or more occasions, had information on their source/s of health insurance coverage over time, and had no missing information on their background characteristics. These students were drawn from a larger database that included the majority of children enrolled in the county's public school districts who were tested at the 2nd through the 9th grade level during the 1999 through 2003 school years (n ≈ 34,000). Additional, comparative descriptive, information about this larger database was included in an earlier but related publication (Garcy 2009).

The majority of the children in this study are Hispanic (68%) (*Table 1*). Most received a free and reduced price lunch (FRPL – 54%). Yuma County Census estimates from 2003 indicated that childhood poverty rates for those 5-17 years of age were high (about one-third) and a large proportion of these children came from low to moderate income families. Unemployment in the County was also very high (29.8%). Several studies have shown that Hispanic and foreign-born children in the U.S. are more likely to be uninsured, have gaps in their coverage, and they utilize medical services less frequently (Guendelman et al., 2001; Patel 2001).

Two sources of data were used to construct the original, larger database. Five years (1999 to 2003) of consecutive, student-level, Stanford Achievement Test 9 (SAT 9) math assessment data obtained from the Arizona Department of Education (ADE) were matched to corresponding health encounter usage information from the Yuma County Health Query (YCHQ) database. Individual student/patient identification numbers were unique to each database. A character matching

Table 1
Health Insurance Status and Descriptive Characteristics of Students in Yuma County, Arizona Public School Districts, Tested at the 2^{nd} – 9^{th} grade level, 1999 to 2003 (n = 11,946)

	Mean	SD	Min.	Max.
Math scale score	639.38	53.45	425	839
Grade level	5.32	2.26	2	9
SCHIP/Medicaid	64.11%	47.97	0	1
Private	28.05%	44.93	0	1
Other public insurance	3.01%	17.09	0	1
Discontinuous coverage/Uninsured	2.55%	15.77	0	1
Other health insurance	2.06%	14.21	0	1
Medicare	0.19%	4.34	0	1
Worker's compensation	0.02%	1.41	0	1
Infectious & parasitic diseases (IPD)	18.76%	-	-	-
Endocrine, nutritional & metabolic diseases (ENM)	6.68%	-	-	-
Diabetes	0.27%	-	-	-
Mental health condition	10.61%	-	-	-
Diseases of the nervous system & sense organs (NSSO)	33.49%	-	-	-
Otitis media (OM)	10.14%	-	-	-
Respiratory diseases	38.29%	-	-	-
Asthma	3.45%	-	-	-
Digestive system diseases (DSD)	13.16%	-	-	-
Injuries & poisonings (IP)	31.87%	-	-	-
FRPL	54.28%	49.82	0	1
ELL status	38.45%	48.65	0	1
Male	50.45%	50.00	0	1
Special education	4.44%	20.60	0	1
Not mobile	88.54%	31.85	0	1
Hispanic	68.01%	46.65	0	1
White	25.43%	43.55	0	1
Other race/ethnicity	2.79%	16.48	0	1
African American	1.95%	13.84	0	1
Native American	1.23%	11.02	0	1
Asian	0.58%	7.62	0	1

algorithm that utilized the student's last and first name, date of birth, and gender linked test records to their patient records across the five panels.

Measures

Assessment Data and Model Control Covariates

Math assessment data were included from the nationally norm referenced SAT 9 exam if the math score was considered valid from the test administrator's perspective. A student's math scale score was the primary dependent variable used in the statistical analyses. SAT 9 student demographic and social background characteristic data were used to construct indicators for race/ethnicity, gender, grade level tested, English language learner (ELL) status, school mobility status, special education status (SPED), and FRPL status. FRPL was used as a proxy for a poverty status. With the exception of grade level tested, these student characteristics were entered into the multivariate analysis as binary variables. Students who had a Hispanic heritage were included in the contrast category, as were mobile, non-ELL, female, non-SPED and non-FRPL students.

Health Information

The YCHQ database contains health-care usage information for most Yuma County school aged children from 1999 to 2003. Database records include public Medicaid (Arizona Health Care Cost Containment System - AHCCCS, State Children's Health Insurance Program - SCHIP)/Medicare insurance claim records for all children enrolled in the program; private insurance claim data for Yuma County employers; inpatient, outpatient and emergency department data from the Yuma Regional Medical Center (YRMC), the County's only emergency department; YRMC school-based clinics; Yuma County's two largest pediatric practices; and Yuma County's federally qualified community health centers. These data were used to determine the sources of children's health insurance (the last known payer) or if they were uninsured when they received medical treatment.

The YCHQ database also includes medical diagnostic information codes (International Classification of Diseases codes (ICD - 9)). ICD-9 codes were used to examine the effects of three specific health conditions, diabetes, otitis media (OM) a type of middle ear infection, and asthma. Seven general categories of health conditions were incorporated into the final dataset including infectious and parasitic diseases (IPD), endocrine, nutritional or metabolic diseases and immunity disorders not including diabetes (ENM), a mental disorder, diseases of the nervous system and sense organs (NSSO), diseases of the digestive system (DSD), diseases of the respiratory system other than asthma, and injuries and poisonings (IP).

Student Health Insurance Variables

There were six sources of potential health-care insurance for children including SCHIP/Medicaid, other public insurance not offered via the SCHIP/Medicaid program, private health insurance, worker's compensation, Medicare, and any other health insurance from a different source. Those children who had received medical treatment but were not covered by any of these sources were classified as having had discontinuous health insurance coverage i.e., coverage gaps or being uninsured for some period during the school year. However, the data did not allow us to distinguish between students who were never insured, those uninsured for the entire year, or only part of the year. Binary indicators were created for each insurance source. Students were assigned a value of "1" if they had at least one uninsured health encounter within a school year. Students who were insured for every health encounter during a school year were given a code of "0". Students who had private health insurance were placed in the contrast category since employer sponsored coverage often offers the best benefits, lowest out of pocket expense, and greatest choice of health-care providers.

Data Analysis

Statistical Models

Multilevel growth trajectory models (GTM) are used to examine the relationship between different types of health insurance coverage and math achievement over time. For each of the eleven illness/injury groupings three sets of models were estimated that included a main effects model with two levels and a linear time trend. Additional models that added a quadratic and a cubic time trend were estimated to assess whether math achievement trajectories over time were non-linear. Cross-level interactions between the health insurance coverage groupings and the linear time trend were included to assess if the math achievement trajectories of students with different health insurance statuses were non-parallel across time. Finally, -2 log likelihood ratio (-2LL) testing was also conducted to determine if the addition of these terms and their associated covariance components improved global model fit. They were dropped from the model if there was no improvement.

The model with higher order polynomials had two levels. The within student model estimating a nonlinear change in math achievement of the jth student at the ith time point (1 to 5) is expressed as follows:

$$\text{Math scale score}_{ij} = \beta_{0j} + \beta_{1j}(\text{Time}_{ij}) + \beta_{2j}(\text{Time}_{ij}^{2}) + \beta_{3j}(\text{Time}_{ij}^{3}) + r_{ij}$$

where β_{0j} represents the overall intercept, β_{1j} is the average linear change in math scores, β_{2j} is the average quadratic change in math scores, β_{3j} is the average cubic change in math scores, and r_{ij} is the random error associated with the jth student at the ith time point.

In each model, β_{0j}, β_{1j}, β_{2j}, and β_{3j} are allowed to vary from student to student. This is expressed as deviation from the overall student intercept u_{0j}, deviation from the linear student math achievement trajectory u_{1j}, deviation from the average quadratic math achievement trajectory u_{2j}, and deviation from the average cubic math achievement trajectory u_{3j}. The between student model is expressed as follows:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{SCHIP/Medicaid}_{ij}) + \gamma_{02}(\text{Medicare}_{ij}) + \gamma_{03}(\text{Other public insurance}_{ij}) + \gamma_{04}(\text{Worker's Compensation}_{ij}) + \gamma_{05}(\text{Other health insurance}_{ij}) + \gamma_{06}(\text{Discontinuous coverage}_{ij}) + \gamma_{07}(\text{Grade}_{ij}) + \gamma_{08}(\text{English language learner status}_{j}) + \gamma_{09}(\text{FRPL status}_{ij}) + \gamma_{010}(\text{Special education status}_{j}) + \gamma_{011}(\text{Not mobile}_{ij}) + \gamma_{012}(\text{Male}_{j}) + \gamma_{013}(\text{White}_{j}) + \gamma_{014}(\text{Hispanic}_{j}) + \gamma_{015}(\text{Black}_{j}) + \gamma_{016}(\text{Native American}_{j}) + \gamma_{017}(\text{Other race/ethnicity}_{j}) + u_{0j}$$

and:

$$\beta_{1j} = \gamma_{10} + \gamma_{11}(\text{SCHIP/Medicaid}_{ij}) + \gamma_{12}(\text{Medicare}_{ij}) + \gamma_{13}(\text{Other public insurance}_{ij}) + \gamma_{14}(\text{Worker's compensation}_{ij}) + \gamma_{15}(\text{Other health insurance}_{ij}) + \gamma_{16}(\text{Discontinuous coverage}_{ij}) + u_{1j}$$

$$\beta_{2j} = \gamma_{20} + u_{2j}$$

$$\beta_{3j} = \gamma_{30} + u_{3j}$$

where β_{0j} is a function of the jth student's characteristics, and β_{1j} is a function of the deviation of each student from the overall linear math achievement trajectory u_{1j}, and the interaction between a student's time varying health insurance status and a linear math achievement trajectory i.e., γ_{11}, γ_{12}, γ_{13}, γ_{14}, γ_{15}, and γ_{16}.

Predicted average math achievement trajectories were plotted in a series of figures for each illness/injury group using the estimates generated from the multilevel GTMs net of student characteristics. This graphical presentation is well suited for displaying cross-level interactions between time and each of the health insurance coverage statuses. Post-hoc contrasts were calculated to assess the statistical significance ($\alpha \leq .05$) of the gaps in math achievement at each time point.

The predicted trajectories shown in each figure correspond to students who have a particular health insurance coverage status for all five academic years. However, the estimated models allowed for variation at the individual level between time points since health insurance coverage status can change over time. Thus, all of the models have been specified to allow for students to move from one achievement trajectory to another depending on their actual health insurance coverage status in a given year.

Results

Figure 1 presents the results for all students who have any health condition during the 1999-2003 period.

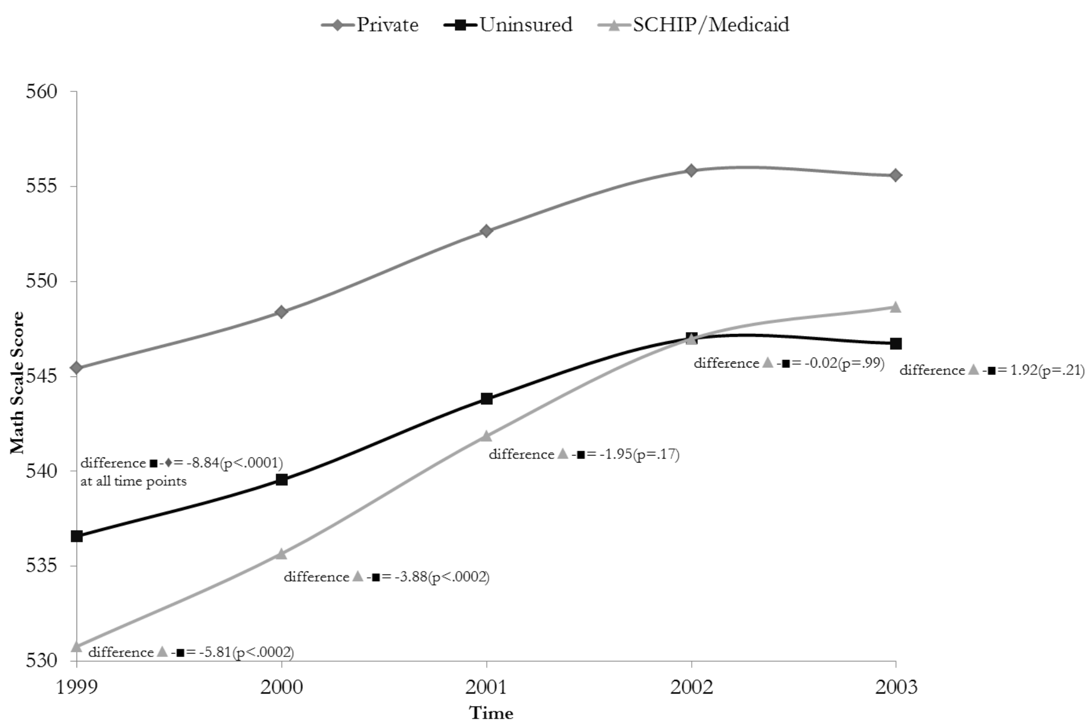

Figure 1. Average math achievement trajectories for students with any health condition (n. obs. = 20,182 from 11,946 students)

Students who were uninsured have the same growth rate (identical slopes) in math achievement over time but consistently lower overall achievement when compared to students who have continuous, private health insurance coverage. Over time, the achievement gap is a constant -8.84 ($p<.0001$) points. These results also imply that a student with any health condition, who had private coverage but then later had discontinuous coverage, would experience on average an almost 9 point decline in their predicted math achievement. If the same student re-gained private coverage, performance is predicted to match those in the private coverage group. If instead the student remains uninsured the earlier deficit would not disappear. Other trajectory profiles are also possible.

There is also a significant ($p<.0001$) statistical interaction between time and students who have continuous health insurance sponsored through the SCHIP/Medicaid program. The plot of the achievement trajectory suggests that students who have publicly sponsored health insurance do not perform as well as their privately insured peers. Importantly, these students have a steeper, positive rate of achievement. Almost half of the initial -14.65 point baseline deficit is closed between 1999 and 2003.

In contrast to the predicted trajectory of the students with discontinuous coverage, the achievement of students with SCHIP/Medicaid coverage is lower at four of the five time points and significantly different at the baseline and second time point. At the last time point, the path of the trajectory suggests that average math achievement for these students is marginally higher (difference = 1.92, p=.21).

The effect sizes (*Table 2*) of having private insurance coverage over being uninsured or having SCHIP/Medicaid coverage were computed at the baseline and the final time point of the study. The private coverage effect size over being uninsured is small (.29). However, it can be considered educationally significant (Wolf 1986). At the baseline, private coverage has a moderate effect size (.46) over SCHIP/Medicaid coverage. By the study's conclusion it becomes smaller (.25). This suggests that private coverage produces some small health imparting effect above the publically-sponsored coverage. At the same time, these results also provide evidence that continuous coverage through the SCHIP/Medicaid program reduces the negative effects of health events on math achievement.

Math achievement trajectories for students who have an IPD are not shown because -2LL testing does not suggest any improvement to global model fit with the addition of cross-level interactions between time and the different types of coverage. Hence, all achievement trajectories are parallel to one another. For students who experienced loss of coverage, a persistent -14.04 (p<.02) point deficit is observed in contrast to those students who have continuous private coverage (*Table 2*). Students with SCHIP/Medicaid coverage have a similar -14.69 (p<.0001) deficit over time. However, the .65 point difference between students with coverage gaps and students with publicly sponsored coverage is non-significant (p<.91). Finally, the effect size of private coverage is moderate relative to being discontinuously insured (.46) or continuously insured with SCHIP/Medicaid coverage (.48).

Figure 2 shows linear, longitudinal math achievement trajectories for students who have an ENM disease not related to diabetes. Global model fit did not improve with the addition of a quadratic time trend. Relative to students with continuous private coverage those who are uninsured are -9.12 points (p<.33) behind over time. Those with continuous SCHIP/Medicaid coverage are -24.25 (p<.0001) behind at the baseline. However, math achievement gains were much more rapid among the SCHIP/Medicaid students so that by the study's conclusion the deficit narrows to a statistically, non-significant -2.11 points (p<.65). At the baseline the effect size for continuous private coverage over discontinuous coverage is small (.30), and large (.80) for those who have continuous SCHIP/Medicaid coverage. By the last time point there is no discernible benefit (.09) of private coverage over the SCHIP/Medicaid group.

The results for students with diabetes are not presented because model estimates are unreliable. There is only a small number of students with diabetes (n=33) who have information on their health insurance coverage and math performance. Most students have only a single time point of data (n=20) and most are covered by SCHIP/Medicaid with only a very small number covered by private insurance (< 9). Additionally, there is only one child with diabetes who is uninsured during the 5 year time frame. This is not surprising given the potential implications of the disease if left untreated.

For students who have a mental disorder -2LL testing suggests that a model with a quadratic time trend and no cross-level interaction between time and the different coverage groupings fits best. All trajectories are parallel to one another with a convex trend. Students who have gaps in their health insurance coverage over time have the lowest achievement of any of the groups. Compared to

Table 2
Summary of Results, Mean Scale Score Point Differences and the Effect Sizes of Private Coverage Over Discontinuous Coverage, and SCHIP/Medicaid Coverage

	1999		2003	
	Mean Scale Score Point Difference	Effect size of Private Coverage[g]	Mean Scale Score Point Difference	Effect size of Private Coverage[g]
Any health condition				
Uninsured	-8.84[f]	0.29	-8.84[f]	0.29
SCHIP/Medicaid	-14.65[f]	0.46	-6.92[f]	0.25
IPD				
Uninsured	-14.04[c]	0.46	-14.04[c]	0.46
SCHIP/Medicaid	-14.69[f]	0.48	-14.69[f]	0.48
ENM				
Uninsured	-9.12[a]	0.30	-9.12[a]	0.30
SCHIP/Medicaid	-24.25[f]	0.80	-2.11[a]	0.09
Mental Health				
Uninsured	-26.23[d]	0.94	-26.23[d]	0.94
SCHIP/Medicaid	-9.92[e]	0.24	-9.92[e]	0.24
NSSO				
Uninsured	-19.47[e]	0.72	-19.47[e]	0.72
SCHIP/Medicaid	-18.29[f]	0.56	-10.48[f]	0.32
OM				
Uninsured	-39.86[f]	1.09	-39.86[f]	1.09
SCHIP/Medicaid	-22.61[f]	0.70	-5.13[a]	0.18
Respiratory				
Uninsured	-8.21[a]	0.40	-24.22[f]	0.71
SCHIP/Medicaid	-13.47[f]	0.43	-13.47[f]	0.43
Asthma				
Uninsured	-14.94[a]	0.33	-14.94[a]	0.33
SCHIP/Medicaid	-1.20[a]	0.03	-1.20[a]	0.03
DSD				
Uninsured	-9.20[b]	0.37	-9.20[b]	0.37
SCHIP/Medicaid	-7.16[e]	0.11	-7.16[e]	0.11
IP				
Uninsured	-7.90[d]	0.23	-7.90[d]	0.23
SCHIP/Medicaid	-17.10[f]	0.51	-7.51[f]	0.25

[a] $p>.15$ [b] $p\leq.10$ [c] $p\leq.05$ [d] $p\leq.01$ [e] $p\leq.001$ [f] $p\leq.0001$
[g] Cohen's d for mean difference between two independent groups with repeated measures.

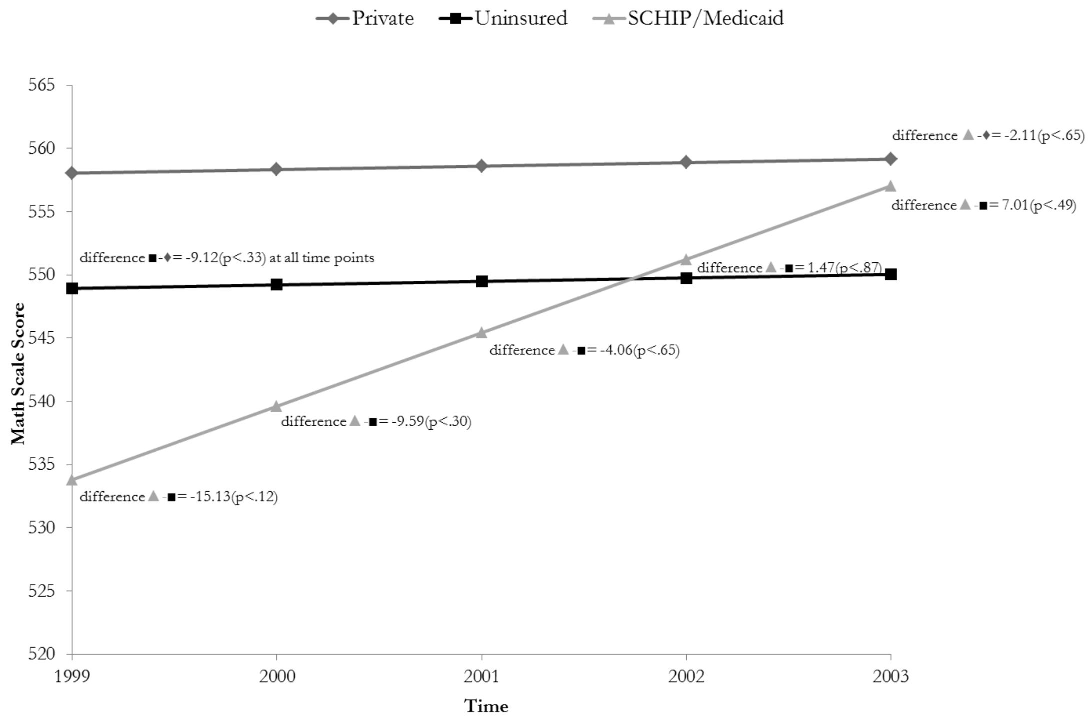

Figure 2. Average math achievement trajectories for students with ENM diseases not related to diabetes (n. obs. = 942 from 798 students)

the trajectory of students who have continuous private coverage, those who have discontinuous coverage experience a very large, persistent -26.23 (p<.006) point deficit in math achievement. Students who have continuous SCHIP/Medicaid coverage have a constant -9.92 (p<.0006) deficit when compared to students with private coverage. The achievement deficit between those with SCHIP/Medicaid coverage and discontinuous coverage was also large (-16.31) but marginally significant (p<.08). Computed effect sizes suggest a large benefit (.94) from continuous private coverage over discontinuous coverage and a small benefit (.24) above SCHIP/Medicaid coverage.

Achievement trajectory plots for students who have a disease of the NSSO are presented in Figure 3. When compared to students who have continuous, private insurance coverage, those who have gaps in coverage show the same growth rate but lower overall math achievement. Across time the deficit is a constant -19.47 (p<.0002) points. At the baseline, students with SCHIP/Medicaid coverage perform at about the same level as their uninsured peers. However, -2LL testing suggests a model that includes a quadratic time trend and an interaction between time and the continuous SCHIP/Medicaid coverage group improves global model fit. These students have a steeper, positive achievement gain. By the last time point, students in this group close nearly half of the initial -18.29 point gap. This achievement trajectory also diverges from that of students who experience gaps in their coverage. Post-hoc contrasts suggest that by the last time point the SCHIP/Medicaid students have marginally higher achievement when compared to students with discontinuous coverage (-8.99, p<.09).

Private coverage has a medium effect size above the other coverage groups (.72, .56) at the baseline. However, the effect size of private coverage over SCHIP/Medicaid diminishes in strength by the last time point (.32). This finding again, suggests there are health and achievement benefits that accompany continuous health insurance coverage.

Achievement trajectories for students who have OM are shown in Figure 4. A model with a

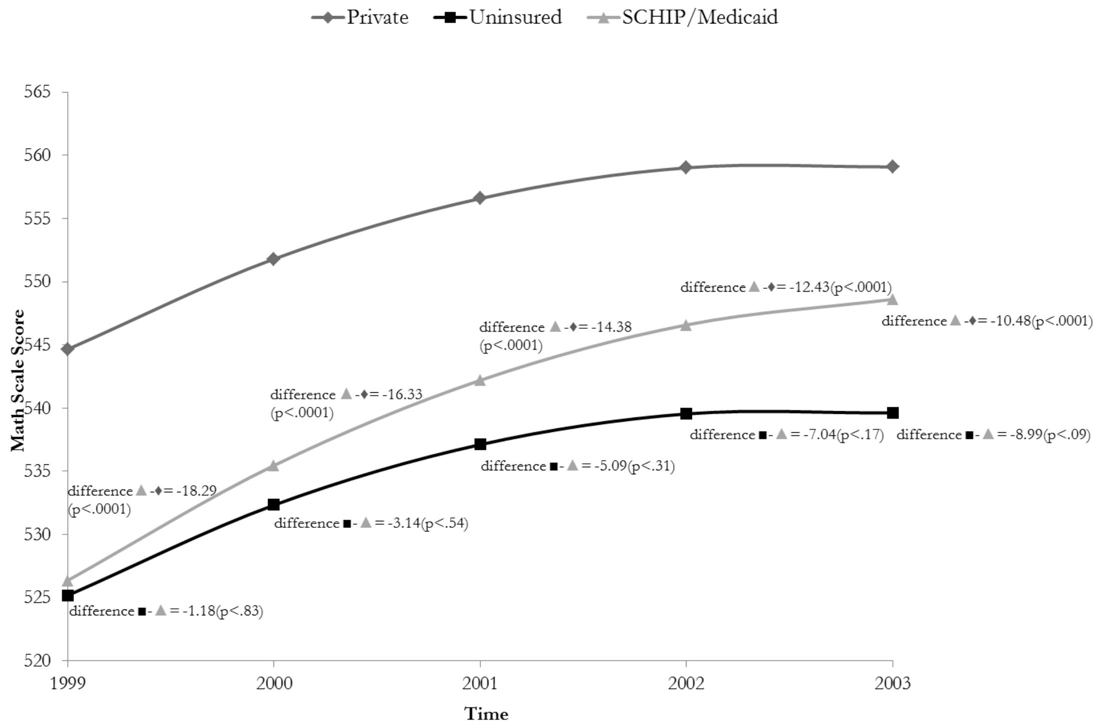

Figure 3. Average math achievement trajectories for students with a disease of the NSSO (n. obs. = 5,279 from 4,001 students)

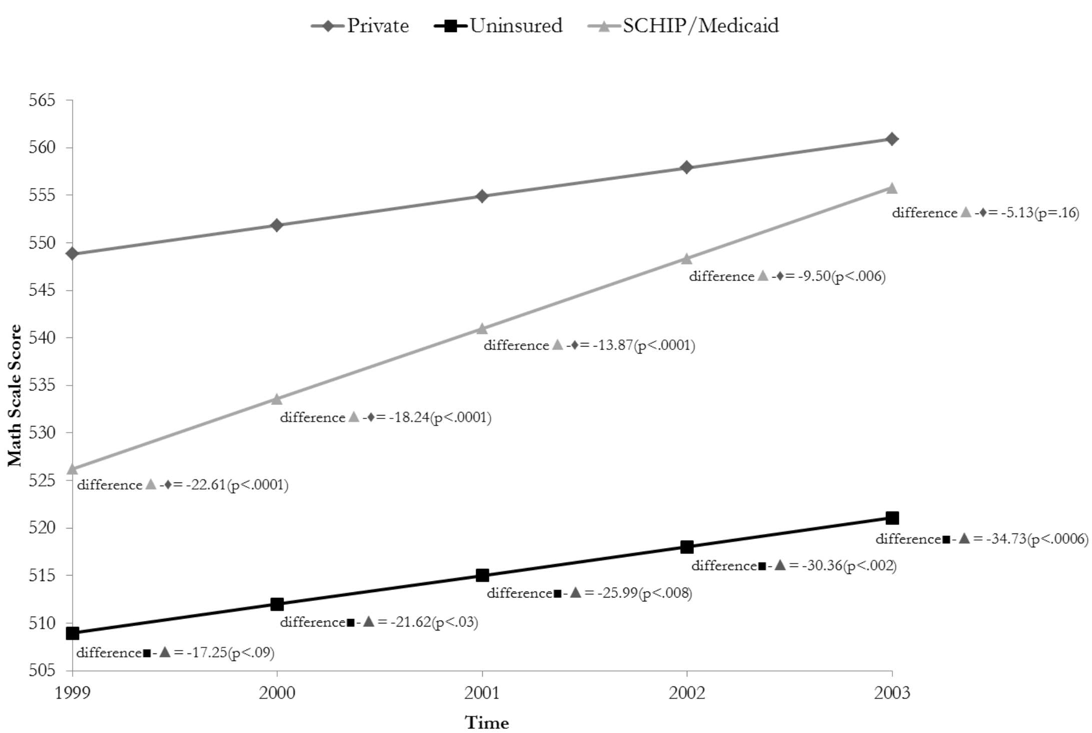

Figure 4. Average math achievement trajectories for students with OM (n. obs. = 1,383 from 1,211 students)

linear time-trend and a cross-level interaction between time and continuous SCHIP/Medicaid coverage fits best. Compared to those with private coverage, students who have this source of public coverage experience a substantial -22.61 point deficit in math achievement (p<.0001) at the baseline. By the last time point, the post-hoc contrast suggests the steeper rate of achievement gain reduces the deficit substantially (-5.13, p<.16). In turn, the effect size of continuous private coverage is moderate (.70) at the baseline but diminishes to a negligible size (.18) at the last time point.

Those students with gaps in coverage show a large -39.86 point deficit in achievement (p<.0001) when compared to those with private coverage. The corresponding effect size of continuous private coverage is quite large (1.09). In contrast, the steeper achievement gain shown by students with SCHIP/Medicaid coverage translates into a substantial 34.73 point advantage at the last time point of the study (p<.0006).

Figure 5 includes the math achievement trajectories of students who have a disease of the

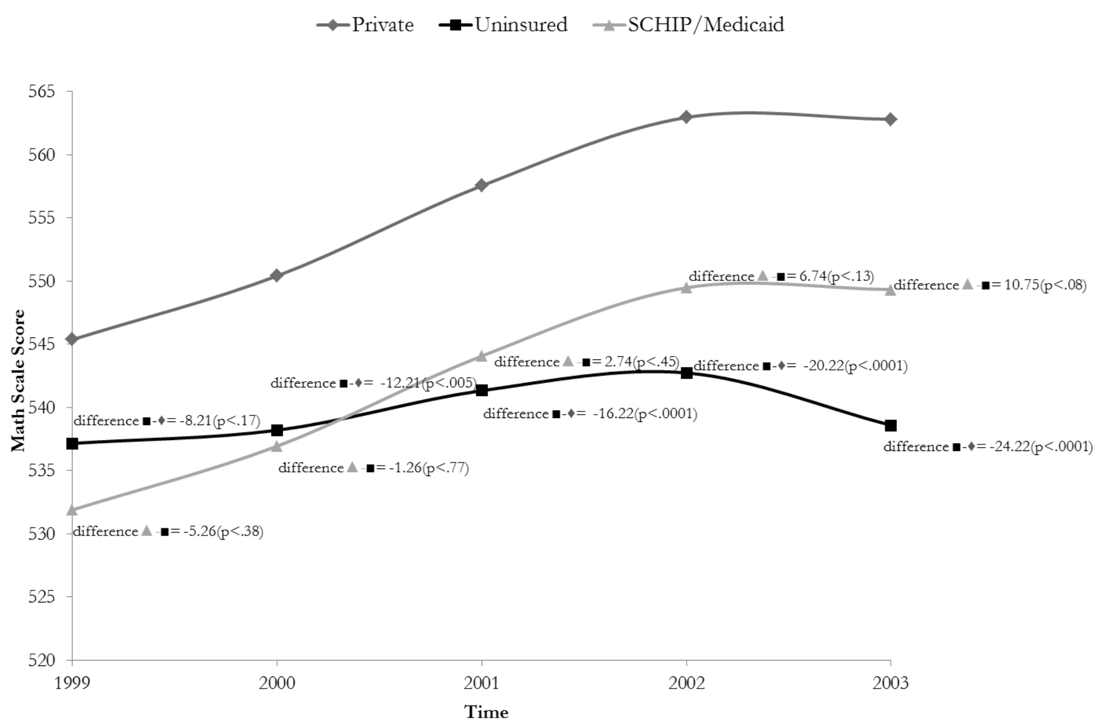

Figure 5. Average math achievement trajectories for students with diseases of the respiratory system unrelated to asthma (n.obs. = 6,311 from 4,574 students)

respiratory system unrelated to asthma. -2LL testing suggests an improvement to global model fit with the addition of a cubic time-trend and an interaction for those with discontinuous coverage over time. In contrast to students with private coverage, these students experience a considerable non-linear decline in their achievement. By the last time point the deficit increases three fold from -8.21 to -24.22 points. Similarly, the effect size of private coverage increases from a small size (.40) to a medium size (.71) over time.

For those with SCHIP/Medicaid coverage, a consistent -13.47 (p<.0001) point deficit is evident. The rate of gain was comparable to students who have continuous private coverage. These students also begin with the lowest, overall baseline achievement. However, by the final time point there is a nearly 11 point advantage over those who experience coverage gaps.

Math trajectories are not shown for those students who suffer from asthma or a DSD. Findings did not suggest statistically significant achievement differences between the various coverage groupings. The findings in the asthma analysis indicate that students who have gaps in their coverage are a consistent -14.94 points ($p<.23$) behind their continuously, privately covered counterparts. The effect size of private coverage is small (.33) but educationally significant. In contrast, a very small -1.20 point difference between the private coverage and SCHIP/Medicaid groups is evident over time. However, this difference is not statistically significant ($p<.83$). The effect size of private coverage is almost non-existent (.03).

Relative to students with continuous, private coverage, findings from the DSD analysis indicate a stable but marginally significant ($p<.10$) achievement deficit (-9.20) for students who had discontinuous coverage. The private insurance effect size was small (.37) but educationally significant. Students who have continuous SCHIP/Medicaid coverage have a slightly smaller, stable achievement gap (-7.16 $p<.0033$) in contrast to the private insurance grouping. The effect size of private coverage is smaller (.11) but not educationally significant.

Achievement trajectories of students who have an IP are shown in Figure 6. Predicted gains are linear for this set of students as global model fit did not improve with the addition of a quadratic or cubic time-trend. The achievement growth rate for students who have gaps in their insurance coverage matches that of students who have continuous private coverage. However, their total math achievement is consistently lower over time -7.90 ($p<.002$). There is a small but nearly educationally significant effect size (.23) of private coverage.

Findings also suggest a significant ($p<.0017$) statistical interaction between time and the group of students who have continuous health insurance through the SCHIP/Medicaid program.

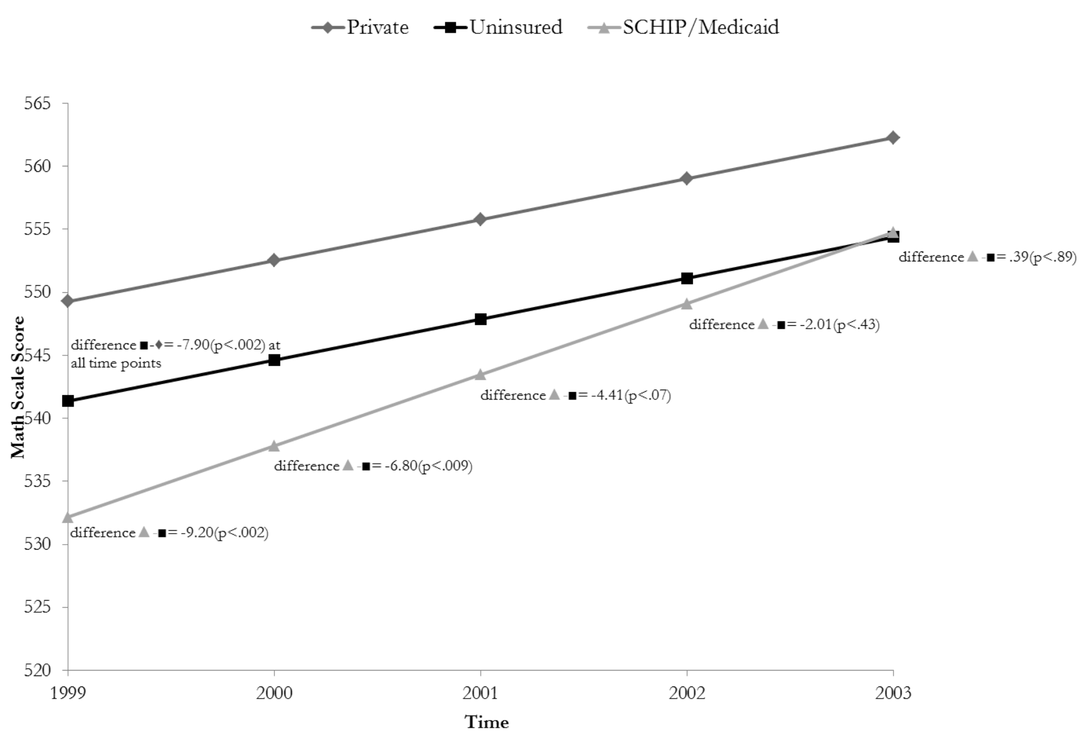

Figure 6. Average math achievement trajectories for students with an IP (n. obs. = 4,670 from 3,807 students)

Those with publicly sponsored health insurance do not perform as well as their privately insured peers. These students, however, show a steeper rate of achievement gain over time. At the study's conclusion more than half of the -17.10 ($p<.0001$) point baseline deficit has disappeared and the predicted math achievement of students with SCHIP/Medicaid coverage is statistically identical to those with discontinuous coverage. At the baseline the effect size of private coverage was medium (.51) but decreases in importance to a small (.25) but educationally significant size at the study's conclusion.

Discussion

The findings provide support for the central hypothesis of the study and answers to the research questions. When considering any type of health condition, discontinuous insurance coverage is associated with a deficit in math achievement. It is important to reiterate that the statistical models allow for the possibility that student coverage status can vary over time. Students may switch from one predicted mean achievement trajectory to another depending on their health insurance coverage status at a given time point. The math score difference between average students with coverage and those who have discontinuous coverage can also be interpreted as the decrement to an average student's math achievement score if they had coverage and then lost it. It is also evident that the type of injury/illness affects the magnitude of this deficit. The largest deficits are observed for students with a mental disorder or OM. Effect sizes of private coverage over discontinuous coverage are also large suggesting that loss of coverage is particularly harmful to the math achievement of students with these health conditions.

It is also worth noting that the achievement deficit between the coverage groupings could not be attributed to a poverty status or other demographic characteristics of the students since these effects were netted out statistically. While correlation coefficients clearly indicate that the percentage of students who had a poverty status was positively associated with SCHIP/Medicaid coverage (.30, $p<.0001$) and negatively associated with private health insurance coverage (-.26, $p<.0001$), the association between the percentage with a poverty status and having discontinuous health insurance coverage was very small but negative (-.02, $p<.02$). This suggests that students who have discontinuous health insurance coverage are less likely to come from the lowest income families. This is consistent with recent national level statistics that have shown an increasing proportion of uninsured children originate from families that are above the qualification threshold for public coverage or have recently lost their coverage because of a parent's job loss (Center on Budget and Policy Priorities 2007).

Taken together, this study's findings are consistent with a large number of other studies that have shown that discontinuous/lack of health insurance coverage increases the likelihood that prescriptions go unfilled, prompt medical treatment cannot be sought, preventative care can be delayed or never received, and/or continuity of care for existing illnesses/injuries is disrupted or never established (Keane et al., 1999; Lave et al., 1998a; Newacheck et al., 1998; Olsen et al., 2005; Satchell & Pati 2005). In turn, this may increase the duration of a health problem which is likely to increase the number of school days that are missed by students who don't receive timely or appropriate medical intervention. Absence from school is likely to translate into missed learning opportunities and reduced achievement (Klerman 1988).

However, the rate of math learning does not appear to be affected by sequential coverage gaps. Students with a respiratory condition unrelated to asthma are the exception where the predicted deficit in math achievement increases with multiple gaps in coverage over time. This finding is consistent with the idea that deficits in math learning resulting from missed school could compound as additional school is missed.

It may then seem surprising that the majority of the analyses predict a stable, longitudinal achievement deficit for students who are likely to have missed the most school. But in fact, the total number of children in the study who experience multiple, consecutive periods where they have discontinuous coverage is quite small. There are, fortunately, even fewer children in the database who experience sequential gaps in coverage over more than two time points. Viewed in this light, the uninsured achievement trajectory is predominantly estimated with data from students who have one or two time points of information. This suggests that uninsured periods were generally short for most students.

Further support for the idea that continuous health coverage (whether publicly or privately sponsored) positively affects student health and, in turn, beneficially affects academic performance is seen in the math achievement of the SCHIP/Medicaid coverage group. These students generally show more rapid achievement gains than either the private coverage group or those students with discontinuous coverage. Importantly, several of the analyses (any health condition, ENM, NSSO, OM, and IP) suggest the steepness of the SCHIP/Medicaid achievement trajectory minimally matches the math achievement of students who have continuous, private health insurance coverage. This is confirmed by plotting forward the predicted SCHIP/Medicaid trajectory for several, additional academic years. While the effect sizes of private coverage over publically-sponsored insurance are negligible to small in size at the study's conclusion, in most cases any achievement advantage associated with private coverage is predicted to disappear over the longer term. It may also be cautiously suggested that SCHIP/Medicaid is generally effective in promoting health among most Yuma County public school students. These students then appear to benefit academically.

Limitations

Because of international border proximity and the composition of the sample it is possible that some of the students received health-care services elsewhere. We are unaware of any data that could be used to assess how frequently this might have occurred. Additionally, Native American health-care usage in Yuma County is not likely to be fully captured in the YCHQ. Two small tribes, the West Cocopah and Fort Yuma-Quechan, have reservations in the county. Only those Native American patients who require obstetric care/surgery are likely to have records in the YCHQ database because the Indian Health Services operates a hospital for both tribes. Finally, we did not have within year information on children's health insurance coverage status. It is possible that some children experienced more complex patterns of discontinuous health insurance coverage than is reflected in these analyses.

Conclusion

This study demonstrates a clear connection between discontinuous health insurance coverage and a deficit in math achievement utilizing a large, longitudinal sample of students. There is also evidence suggesting a positive achievement effect of the SCHIP/Medicaid program particularly for continuously covered students who experience an ENM disease unrelated to diabetes, a disease of the NSSO, OM, and an IP. One of the major strengths of this study is that the injury/illness and health insurance data collected on students came from administrative records. Therefore, recall bias is not a concern. Finally, this is one of the first studies to simultaneously examine illness/injury, health insurance coverage status, and the effect they have on math achievement.

Policy Implications

Education policy makers need to consider these results and other similar findings in relation to school and teacher quality ratings systems. This study demonstrates that student math achievement, which is more likely to occur in school and less likely to be influenced by home factors, can be affected both positively and negatively by a child's health insurance coverage status. Although access to health insurance has not previously been linked to the performance of the nation's public schools, policy makers might consider ways in which to account for these non-school factors in their ratings systems, or consider a more diverse set of methods for assessing school and teacher quality rather than relying on a single, high-stakes assessment. In the current context of high, long-term, unemployment and a health-care system that still does not provide guaranteed health-care coverage to all children or to those under the age of 65, it is highly probable that schools and teachers located in communities that experience greater material and social disadvantages are likely to be mistakenly blamed for low student achievement when other intervening factors may also be partially responsible.

In terms of broader social policy, the findings from this study suggest an effective response may in part need to address underlying, existing inequalities in American society. In relation to this study, access to health-care is a pressing concern. The SCHIP/Medicaid program has helped the nation's lowest income children to obtain health-care. But children who are from families that are just above the qualification threshold for SCHIP/Medicaid sponsored health-care or those who have lost their coverage through parental job loss still face the prospect of insurance coverage gaps (Center on Budget Priorities 2007). An expansion of the SCHIP program could help to reduce the impact of health related events on math achievement.

While an expansion of SCHIP/Medicaid alone is not likely to increase the enrollment of children who are already eligible but fail to enroll (Currie 2005), researchers have proposed that alternative programs might be more efficacious in reducing the effects of health related events that interfere with learning (Currie 2005; Rothstein 2004). Rothstein suggested that in-school health clinics could provide health services to children for a nominal cost. Currie suggested that programs such as Head Start, Women, Infants, and Children (WIC), home visiting and family centered health programs might be better contexts in which to provide needed and preventative health-care. Coupled with streamlined/expanded SCHIP enrollment, such programs could help to reduce deficits in academic achievement that are the result of health related events and missed schooling for those children who have limited access to health-care.

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