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Office of Behavioral and Social Sciences Research

Education and Health: New Frontiers

Meeting Summary

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Abbreviations and Acronyms

Acronym	Acronym Definition
ADHD	Attention Deficit Hyperactivity Disorder
EDI	Early Development Inventory
FTO	fat-mass and obesity associated gene
GED	General Educational Development
GWAS	genome-wide association study
GxE	gene-environment interaction
HRS	Health and Retirement Study
IES	Institute of Education Sciences
IQ	intelligence quotient
MIDUS	Midlife in the United States: A Longitudinal Study of Health and Well-Being
NHIS-LMF	National Health Interview Survey-Linked Mortality Files
NIH	National Institutes of Health
NLSY97	National Longitudinal Survey of Youth 1997
OBSSR	Office of Behavioral and Social Sciences Research
PSID	Panel Study of Income Dynamics
RISE	Reducing Inequities through Social and Educational Change
SES	socioeconomic status

Executive Summary

Education and health are issues of national importance that affect the ability of the United States to remain competitive in a global environment. Educational policies might be the most promising avenue of any social policy in improving the health of the nation because there is broad evidence of the causal impact on a broad range of health outcomes and because they are likely to be politically feasible and cost-effective. However, it may take decades for the final impact of educational interventions to be realized. Research on the relationship between education and health requires a cooperative, multidisciplinary approach in order to develop effective interventions and social policy measures.

The Office of Behavioral and Social Sciences Research (OBSSR) seeks to stimulate behavioral and social research across the Institutes and Centers of the National Institutes of Health (NIH) in order to promote the understanding, treatment, and prevention of disease. Part of OBSSR's mission is to convene workshops, seminars, and symposia on state-of-the-art issues in the behavioral and social sciences.

OBSSR convened a workshop at the National Academies Keck Center on June 4, 2014 in Washington, DC. The meeting brought together clinicians and researchers in education and health in order to identify opportunities and gaps in the field and to develop strategies to ensure that education and health research remains a national priority. Among the most pressing areas of research: developing better measures of health outcomes, improving study designs, identifying mechanisms underlying the relationship between education and health, and considering contextual issues. There must also be attention to longitudinal research to understand long-run implications of early interventions and replication of studies to verify results. Themes evident throughout the meeting included the nature of the causal relationship between education and health, contextual issues, the need for more and better data, and interventions in education and health.

Themes

Nature of the Causal Relationship between Education and Health

The causal mechanisms behind the relationship between education and health are difficult to sort out, yet are an important consideration in developing effective social policies. Three possible reasons for what appears to be a causal relationship between education and health are: education increases resources, increases access to and use of information, and changes preferences, norms, and behaviors. Confounders temper the outcomes of health and education policies and should be considered whenever possible.

Contextual Issues Involved in the Relationship between Education and Health

Presentations from this meeting demonstrated that the relationship between education and health is complex and dynamic. Education and health influence each other in positive ways, but not equally, and not for everyone. Historical contexts, geographic location, social policies, and demographics all affect the extent to which education can mediate beneficial health outcomes.

The Need for More and Better Data in Education and Health

Researchers in the fields of education and health must work together in order to make the most efficient use of existing data and to develop new methods of data collection. Privacy issues and limited access to datasets prohibit extensive analysis of medical records and state educational

data; however, access to this kind of information is necessary to understand to what extent and under what conditions education can improve health. Real-time data collection also is critical for the development of responsive and effective interventions in education and health, and requires cooperation on a local, state, and national level.

Measures of personality might be added to further explicate the relationship between education and health. For example, conscientiousness is stable but not immutable and is a powerful factor on educational attainment. Childhood self-control predicts later health and wealth and partially explains educational and health outcomes.

Interventions in Education and Health

There is sufficient evidence for the role of education in health; therefore, interventions should not be delayed but should be implemented in parallel to ongoing research. Early childhood interventions are an investment in improved adult health; however, the effects of these early interventions should be examined throughout the life course to understand their full impact.

There are many characteristics of health, biology, and education that can contribute to understanding the relationship between education and health and must inform the development of effective interactions. These factors will enable researchers to implement an efficacious intervention at the right time to the right person and in the right way in order to optimize education and health outcomes and improve overall well-being.

The spillover effects of educational attainment to the family or household, across generations, among peers, and to the community must also be considered. Interventions must be targeted at malleable systems in various contexts, toward children, parents, and communities.

Next Steps

Leaders in the fields of education and health research must cooperate to make the most effective use of existing data resources and to encourage growth in this multidisciplinary area. Education and health researchers really need to work together with common vocabulary, measures and methods to make gains. Continued communication of the message that “education policy is health policy” will ensure that policymakers and funding institutions continue to make education and health national priorities.

Meeting Summary

Introduction

The United States currently spends more than \$2.9 trillion in health care, yet routinely appears last in comparisons of life expectancy among developed nations.¹ Health behaviors (40 percent) and other factors (50 percent) are the main determinants of health; health care itself plays a relatively minor role (10 percent).² Despite these results, the United States currently allocates 97 percent of what is spent on being healthy towards improving health care outcomes, and only 3 percent towards behavioral and other interventions.

The health and education research literature has repeatedly demonstrated that educational attainment is one of the strongest correlates of increased life expectancy.³ Compared to other countries, the United States has lower preschool enrollment than in most high-income countries and while students in grade school score above average, they have average or below average scores in math, science, and reading by age 15.⁴ Educational attainment was the strongest correlate of recent decreases in life expectancy for women (1992-1996) and health disparities by state have indicated a significant association between academic success by grade four and life expectancy. Furthermore, children of different races, ethnicities, and socioeconomic status (SES) have significantly disparate levels of educational attainment.⁵

Previous research has demonstrated an association between the lack of educational attainment and decreased life expectancy; furthermore, the United States has consistently ranked last among developed countries in international studies of educational attainment, morbidity, and mortality.⁶ Life expectancy is related to educational attainment, even after controlling for biological and behavioral risk factors. The number of added years of life expectancy gained by completing an advanced degree is greater than the years added from not smoking, low blood pressure, normal cholesterol, and mammography combined. In his welcome remarks, Dr. Robert Kaplan emphasized that the benefit of education on health and life expectancy is too big to ignore and that the United States must implement evidence-based practices to produce young adults who are “ready-for-life.”

To further investigate this topic, the NIH OBSSR convened a meeting of clinicians and scientists from diverse fields of health and education in order to identify research gaps and opportunities, foster collaborative research, and promote the development of effective interventions in health and education. OBSSR’s mission is to stimulate behavioral and social research across NIH in order to prevent and treat disease, enhance health, and lengthen life. The meeting agenda and list of invited participants are included as appendices 1 and 2, respectively.

¹ See collectivehealth.net

² Ibid.

³ David A Kindig and Erika R Cheng, “Even as Mortality Fell in Most US Counties, Female Mortality Nonetheless Rose in 42.8 Percent of Counties from 1992 to 2006,” *Health Affairs (Project Hope)* 32, no. 3 (March 2013): 451–58, doi:10.1377/hlthaff.2011.0892.

⁴ *U.S. Health in International Perspective: Shorter Lives, Poorer Health*, accessed June 10, 2014, http://www.nap.edu/catalog.php?record_id=13497.

⁵ S Jay Olshansky et al., “Differences in Life Expectancy Due to Race and Educational Differences Are Widening, and Many May Not Catch Up,” *Health Affairs (Project Hope)* 31, no. 8 (August 2012): 1803–13, doi:10.1377/hlthaff.2011.0746.

⁶ *U.S. Health in International Perspective: Shorter Lives, Poorer Health*, accessed June 10, 2014, http://www.nap.edu/catalog.php?record_id=13497.

Meeting participants presented their research in a series of 30-minute talks followed by 30-minute commentaries. Four breakout sessions addressed additional topics such as where along the age spectrum should investments be targeted, global perspectives, the availability and strengths of Institute of Education Sciences (IES) data, and interventions. Full summaries of the four breakout discussions are included as appendices 3-6. A final discussion session allowed participants to comment on the presentations and recommend future research and policy avenues. Dr. Kaplan thanked meeting participants for their time and participation and acknowledged the dedication of the OBSSR meeting organizers, Drs. Michael Spittel and Tia Zeno.

The remainder of this report highlights main themes from the presentations and discussion at the meeting. A bibliography of relevant references is included as appendix 7.

Keynote Address

Education, Information, and Investments in Children **Flávio Cunha, PhD, Rice University**

Previous research has demonstrated an association between family SES and a child's vocabulary at age 3. Hart and Risley conducted an assessment of children from 40 families of different socioeconomic backgrounds and counted the number of words in their vocabulary from ages 10-36 months.⁷ The vocabulary of children from families of low SES was consistently smaller than that of children from families of high SES. The child's vocabulary was associated with the number of words addressed to the child by the parent; parents with a high SES spoke more words to their children than parents of low SES.

An economic model for the rate of return on parental investment in child development

Dr. Cunha's economic model assessed the relationship between the number of words addressed to the child (parental investment) and the outcomes of increased vocabulary and child development. Dr. Cunha hypothesized that the parents' objective is to optimize a child's development. However, two parental constraints, the family budget and the production function (i.e., the limit on the health output), combine to define the choice set and limit the possibilities for a child's development.

This economic model explains the heterogeneity in parental investments in child development in several ways:

- 1. Parents are heterogeneous in their preferences for optimal child development.**
Economists do not frequently emphasize this social factor. People's preferences are difficult to change and policies to change preferences in child development would most likely be difficult to implement. An open area of investigation is whether education affects parental preferences.
- 2. Parents have heterogeneous amounts of resources.**
Wealthier parents have more choices with regards to optimizing their child's development. The increase in parental resources changes the choice set and possibly the parental preferences in Dr. Cunha's economic model. There is large evidence that

⁷ Todd R. Risley, Betty Hart, and Louis Bloom, *Meaningful Differences in the Everyday Experience of Young American Children* (Baltimore: Paul H. Brookes Publishing Co., 1995).

education affects economic resources through higher employment rates and higher earnings conditional on employment.

3. Parents are heterogeneous in productivity.

Educated parents are more informed on the best developmental practices for their children.

4. Parents are heterogeneous in their beliefs about the returns on early investments in children.

Early learning opportunities are an effective way to improve the development of a child. There is no data on parental expectations about the returns on investing in a child's early development. How parental education correlates with parental beliefs is also not known.

Dr. Cunha is particularly interested in the heterogeneity of parental beliefs about early investments in children. He believes providing information is an important step to changing parental attitudes and behaviors in early child development, leading to better-educated and healthier children. Several studies have provided evidence on the importance of information in improving parental behaviors that optimize child development.^{8 9 10} An example of information changing parental behavior was the decrease in maternal smoking following the Surgeon General's report on the health consequences of smoking; this decrease in smoking was more pronounced in more educated and better-informed mothers.

Previous research has calculated the return on investment of a health behavior as follows:

$$\text{Health outcome at the end of the period} = \text{Health outcome at the beginning of the period} + (\text{health measure}) \times (\text{health behavior})$$

Dr. Cunha noted that this equation holds true for large datasets with a randomization of health behaviors. In particular, when applying this equation to dimensions of child development, Dr. Cunha presented data suggesting that if a family doubled investments in children, then child development would increase by 20 to 45 percent.

Current economic theory assumes that individuals know the existence of such an equation as well as the range of values of the returns. In contrast, Dr. Cunha is developing an economic model that does not assume that individuals know this equation or the implied returns. Instead, different individuals may have different beliefs and, thus, different returns. In particular, Dr. Cunha is interested in measuring the beliefs that parents have about the process (i.e., the equations) that describe child development.

⁸ Anna Aizer and Laura Stroud, *Education, Knowledge and the Evolution of Disparities in Health*, Working Paper (National Bureau of Economic Research, March 2010), <http://www.nber.org/papers/w15840>.

⁹ "Behind the Scenes: Managing and Conducting Large Scale Impact Evaluations in Colombia," *Monitoring and Evaluation NEWS*, accessed June 10, 2014, <http://mande.co.uk/2012/uncategorized/behind-the-scenes-managing-and-conducting-large-scale-impact-evaluations-in-colombia/>.

¹⁰ James Heckman, Rodrigo Pinto, and Peter Savelyev, "Understanding the Mechanisms through which an Influential Early Childhood Program Boosted Adult Outcomes," *The American Economic Review* 103, no. 6 (October 2013): 2052–86, doi:10.1257/aer.103.6.2052.

Study design and results

Dr. Cunha hypothesized that parents who believe returns on investments in child development are low also talk less to their children. The study involved measuring the vocabulary of the child and the speech patterns with a device worn by 960 mothers participating in the study.

Standard measures of child development were modified to account for maternal beliefs on child development by asking mothers what is the youngest and oldest age a certain milestone can be reached by a child. Dr. Cunha then averaged the ages across different milestones. The results indicated that the mean parental belief on the return on investment in a child's development is 8 percent; furthermore, this return on investment was associated with the mother's educational level. The lower the educational level of the mother, the lower her expectations about the return on investments. For example, mothers who failed to complete high school believed that the returns are only 4 percent, while evidence presented by Dr. Cunha indicates that these returns are actually in the range of 20 to 45 percent.

Suskind and Leffel conducted just such an educational intervention highlighting the importance of information and parental feedback in child development.¹¹ Researchers recorded the number of words used by parents and children and told them where their child stood in relation to their peers. In response to feedback, parents increased speaking to their children by 50 percent. This 50 percent increase in investment by the parents resulted in a 50 percent increase in child vocalization. Dr. Cunha noted that this simple feedback intervention yielded a 100 percent rate of return on the investment.

Conclusions

Dr. Cunha described a research agenda that aims to document the importance of parental beliefs and how they correlate with education. Preliminary results have suggested that parental beliefs contribute to the return on investment in child development. These data have important consequences for the development of effective interventions in early childhood education.

Plenary Presentations

Epidemiology of Education and Health

James House, PhD, The University of Michigan

Dr. House presented an epidemiological perspective on how SES and behavior contribute to education and health.

What is education?

In most research on education and health, education is defined as the number of years of formal schooling or the highest degree attained. Dimensions of the content, quality, and other aspects of the educational experience are rarely investigated. While beyond the scope of this meeting, Dr. House emphasized the importance of these factors in defining the educational components that contribute to health. However, this limitation is not a major problem. The number of years of schooling and degrees attained are robustly related to health outcomes and other domains such as SES and labor force attainment.

How is education related to health?

Studies have shown that education is robustly related to health across a wide range of health outcomes, with some variation in strength depending on the health outcome and social context.

¹¹ "Team | Thirty Million Words," accessed June 10, 2014, <http://tmw.org/research/>.

Previous research has suggested a causal effect of education on health, although this effect is not equal in all times, places, or populations. Education is more important than income in postponing the onset of health problems and less important than income in halting the progression of health problems.

Education has been shown to have significant benefits in extending life expectancy; by age 25, individuals with advanced degrees can expect 12-16 more years of life compared to individuals with less than a high school degree.¹² Previous studies demonstrated that the relationship between years of education and health is mostly linear; however, there are additional benefits for completion of high school and college, which result in a significant decrease in mortality.¹³

Education has beneficial effects on morbidity as well. Smoking rates drop dramatically after high school graduation and rates of colorectal screening, wearing seat belts, and having smoke detectors increase. However, there are biological limitations to the benefits of education for some health outcomes. More education is generally associated with decreases in functional limitations throughout life. However, at some point, almost all individuals are biologically frail, regardless of their educational attainment. Education has also been shown to influence psychosocial and behavioral health; more education is associated with lower hostility and higher self-efficacy.¹⁴

Who manifests the relationship of education to health?

Education confers health benefits across multiple populations, including adults and children, men and women, and all racial and ethnic groups.¹⁵ There are also beneficial health effects from education across people in households or social networks (e.g., effects on spouses on each other, parents on young children, and children on older parents). Data from the National Health Interview Survey—Linked Mortality Files (NHIS-LMF) show life expectancy is approximately 3 years greater for those who are married and having an educated spouse provides a comparable advantage of an additional 3 years of life expectancy.¹⁶

Contextual issues are important in determining who receives health benefits of education. Data from the Chicago Community Adult Health Study (2002) on blood pressure in Hispanics and African-Americans revealed a greater risk of hypertension compared to whites; however, this difference disappeared in comingled neighborhoods. Environmental measures such as

¹² Brian L. Rostron and National Center for Health Statistics (U.S.), *Education Reporting and Classification on Death Certificates in the United States*, Vital and Health Statistics. Series 2, Data Evaluation and Methods Research, no. 151 (Hyattsville, Md. : Washington, DC: U.S. Dept. of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics ; For sale by the U.S. G.P.O., Supt. of Docs, 2010), <http://purl.fdlp.gov/GPO/gpo27616>.

¹³ Jennifer Karas Montez, Robert A Hummer, and Mark D Hayward, "Educational Attainment and Adult Mortality in the United States: a Systematic Analysis of Functional Form," *Demography* 49, no. 1 (February 2012): 315–36, doi:10.1007/s13524-011-0082-8.

¹⁴ James S. House, and David R. Williams. 2001. "Understanding and Reducing Socioeconomic and Racial/Ethnic Disparities in Health." In *Promoting Health: Intervention Strategies from Social and Behavioral Research* edited by B.D. Smedley and S.L. Syme. Pp. 81-124. Washington D.C.: National Academy Press.

¹⁵ Commission to Build a Healthier America Robert Wood Johnson Foundation, "Education Is Linked with Health Regardless of Racial or Ethnic Groups," n.d., http://www.commissiononhealth.org/PDF/fig3ed_a.pdf.

¹⁶ Dustin C. Brown, "Life Expectancy Differentials by Marital Status, Individuals' Own Education, and Spousal Education in the United States." Paper submitted for presentation at the Annual Meeting of the Population Association of America, May 1-3, 2014, Boston, MA.

affluence, gentrification, education level, and employment rates can all affect the health outcomes of education.

Where and when is education related to health?

The relationship between education and health is generally robust across geographic location (domestic and international), historical time, and the life-course or developmental stage. However, there is some variation in the degree to which education enhances access to resources that are health protective. For example, education has been shown to have less of an impact against less preventable diseases or extreme biologic frailty.¹⁷ Education also has been shown to have less of an impact in times or locations where SES resources, health care, and insurance are less stratified by education.

There is much interest in the long-term impacts of early childhood education. However, there is evidence that investments in early childhood education must be maintained and reinforced. Gains in education at later ages are important and remain so over most of the life course, except perhaps oldest ages. Educational and other socioeconomic disparities in health are smallest in late adolescence/early adulthood (as a function of biological robustness) and later old age (as a function of frailty).

Why is education related to health?

Dr. House gave several reasons why education contributes to improved health outcomes, although the relative contribution of these factors may vary from person to person:

- **Education improves socioeconomic status.**
 - Improved socioeconomic status can account for one-third to two-thirds of the effect of education on health through better access to health care and better conditions of life and work.
- **Education improves cognitive skills leading to disease prevention.**
 - Improved cognitive skills increases health literacy and better utilization of health care.
- **Education informs health preferences and values.**
 - Education improves an individual's ability to delay gratification and increases risk aversion.
- **Education decreases an individual's exposure to environmental psychosocial factors.**
 - Individuals with higher education have lower levels of stress, better social relationships, and better coping skills.
- **Education improves an individual's rank.**
 - However, Dr. House was skeptical about the role of rank (or placement within 'the pecking order') and health outcomes. Rank may play a more important role in certain points of the life course compared to others.

Policy and directions for future research

Dr. House noted the need to assess the health impacts of educational policies and their economic value need to be assessed. Educational policies might be the most promising avenue of any social policy in improving the health of the nation. Dr. House identified six criteria for

¹⁷ Jo C. Phelan et al., "Fundamental Causes' of Social Inequalities in Mortality: A Test of the Theory," *Journal of Health and Social Behavior* 45, no. 3 (September 1, 2004): 265–85, doi:10.1177/002214650404500303.

identifying and prioritizing areas of social and economic policy as key components of health policy and noted that educational policies fit all six criteria:

- The social policy must be in a **large, established policy area**.
- There must be **broad evidence on the causal impact** on a broad range of health outcomes.
- The social policy must be **cost-effective**.
- The social intervention must be **feasible**.
- The social policy must have **many positives and few negatives**.
- The policy must be **politically feasible**.

Conclusions

Future research directions should include evaluating health consequence measures of education in addition to the years of schooling or highest degree attained. In order to achieve this, there needs to be further research to learn the causal nature of the connection between education and health, the differential impacts of education on health *vis a vis* impacts of other socioeconomic factors, and the role of genetics and education in jointly shaping health. These areas need to be investigated across population subgroups and at group versus individual levels. These research questions can be informed by examining the conditions (time, place, and developmental phase) where education is more or less strongly related to health, delineating variations in health impacts of education across different diseases, and examining variations of impacts of education at different points in the lifespan. Finally, Dr. House noted it is necessary to explore and explain the pathways and mechanisms linking education and health to understand education as a “fundamental cause” of improved health.

Discussion

David Kindig, MD, MPH, The University of Wisconsin-Madison

Dr. Kindig began the discussion by referencing renowned health economist Victor Fuchs who wrote in 1974: “How much, then, should go for medical care and how much for other programs affecting health, such as pollution control, fluoridation of water, accident prevention and the like. There is no simple answer, partly because the question has rarely been explicitly asked.”¹⁸

According to Dr. Kindig, now is the time to develop interventions to improve education and health outcomes. It will be critical to determine which programs are the most cost-effective in improving education and health outcomes. Fairness in education is equality of opportunity and there is political common ground for programs that improve educational opportunities.

Dr. Kindig proposed an informational system that provides county-level data on educational and health factors, including rates of high school and college graduation, levels of poverty, violent crime rates, and levels of social support. This data could then be compared across counties within each state for comparative and informational purposes. Levels of investment could be connected to educational and health outcomes to determine the rate of return on investments. This kind of data would provide guidance for policy makers regarding areas in health and education that require more investment.

¹⁸ Victor Fuchs. *Who Shall Live?* New York: Basic Books, 1974.

What Demographic Data and the Big-Picture Examination of Patterns and Trends Adds to Our Understanding of Education and Health/Mortality in the United States **Robert Hummer, PhD, The University of Texas-Austin**

Theoretical Background

In the contemporary United States, researchers often conceptualize educational attainment as a fundamental cause of health, disease, and longevity by providing access to flexible resources and affecting multiple health and behavioral outcomes.¹⁹ The mechanisms by which educational attainment impacts health are varied and probably shift over time.

Educational attainment appears to work across the life course to influence health, disease, and mortality in the United States although not in the same way for all cohorts or for people in every geographic location or population subgroup.²⁰ As a result, very long term and contextualized scientific and policy lenses are necessary to best understand the relationships between education, health, and mortality. Indeed, it may take several or even many decades for the full impact of cohort-specific educational investments to be realized.

Educational attainment in the U.S. context has been shown to be not only a flexible individual resource, but also a family/household, intergenerational, peer, and community resource. These spillover effects may be additive or even multiplicative; however, there are few research and policy discussions about these spillover effects.

It is important to consider the effect of confounders. Educational attainment is not randomly distributed in the U.S. population and other factors may influence individual educational attainment and health, including birth cohort, gender, race, genetics, childhood health, and parental SES. Moderators have been shown to influence how much education is translated into a health benefit. Educational attainment has been more important for health and mortality in more recent cohorts and has exhibited weaker associations with health and mortality among racial minority groups.²¹ Also, men seem to accrue greater mortality benefits from higher education than women, although the mechanisms of this difference are not clear.

Analytically, this theoretical background strongly suggests that researchers place great emphasis on accurately describing the context-specific educational attainment and health/mortality relationships; examine temporal changes and geographic variations in educational attainment and health/mortality relationships; explore the extent to which educational attainment is an inter-individual resource as well as intra-individual resource for health/mortality; thoroughly address confounders; and constantly consider moderators of educational attainment and health/mortality associations.

Five lessons learned

Dr. Hummer listed five lessons learned from a recent social demographic examination of educational attainment and adult mortality in the United States:

¹⁹ B G Link and J Phelan, "Social Conditions as Fundamental Causes of Disease," *Journal of Health and Social Behavior* Spec No (1995): 80–94.

²⁰ Catherine E Ross and John Mirowsky, "The Interaction of Personal and Parental Education on Health," *Social Science & Medicine* (1982) 72, no. 4 (February 2011): 591–99, doi:10.1016/j.socscimed.2010.11.028.

²¹ Anna Zajacova and Robert A Hummer, "Gender Differences in Education Effects on All-cause Mortality for White and Black Adults in the United States," *Social Science & Medicine* (1982) 69, no. 4 (August 2009): 529–37, doi:10.1016/j.socscimed.2009.06.028.

1. **The contemporary functional form of the association between educational attainment and U.S. adult all-cause mortality for both women and men includes a mix of both linear and step changes.**²²

This functional form has clear relevance for broad social and health policies. There are some race differences in the functional form; step changes are more pronounced and linear changes are less pronounced for African-Americans. Future research includes accurate descriptions of the relationship between educational attainment and context-specific health outcomes.

2. **The association between educational attainment and U.S. adult mortality has clearly become stronger in recent decades.**²³

Widening gaps in mortality by educational attainment seem to be unfolding on a cohort basis rather than on a period basis; this result is consistent with the observation that people are educated within birth cohorts, not time periods. This birth cohort effect has implications for thinking about long-term, life-course based scientific and policy issues. The widening gaps in cohort health outcomes are concentrated in preventable causes of death. Future research in this area includes examination of temporal changes and geographic variations in education and health.

3. **Educational attainment seems to be more than an intra-individual resource.**

Spousal educational attainment exhibits strong associations with individual self-rated health and mortality. There are similar benefits for married men and women with high educational attainment. Future research includes exploration of the extent to which educational attainment is an inter-individual resource.

4. **Confounders are present and must be accounted for.**

Accurately describing the relationship between health and education depends on the ability to tease out confounders. Dr. Jason Boardman and his colleagues have conducted some important and innovative work on genetic confounders. Recent work from Dr. Hummer and colleagues addressed the role of childhood SES and adversity; even accounting for these confounders, educational attainment is still strongly associated with active life expectancy.²⁴ Future research in this area should focus on addressing confounders of the education and health/mortality relationships in even more thorough ways.

5. **Moderators such as subgroups and geographic contexts affect the relationship between education and health.**

Education and mortality associations differ in major ways across international contexts (e.g. this association is modest in Costa Rica but strong in the United States). The education and mortality gradient in the United States has changed over time; it used to be modest for men in 1960 and wider for women but now is very wide for men and has

²² Montez, Hummer, and Hayward, "Educational Attainment and Adult Mortality in the United States."

²³ Jennifer Karas Montez et al., "Trends in the Educational Gradient of U.S. Adult Mortality from 1986 to 2006 by Race, Gender, and Age Group," *Research on Aging* 33, no. 2 (March 2011): 145–71, doi:10.1177/0164027510392388.

²⁴ Jennifer Karas Montez and Mark D Hayward, "Cumulative Childhood Adversity, Educational Attainment, and Active Life Expectancy Among U.S. Adults," *Demography* 51, no. 2 (April 2014): 413–35, doi:10.1007/s13524-013-0261-x.

become wider for women as well.²⁵ Future research in this area includes further consideration of the moderators of the associations between education and health.

Pressing social and demographic questions in education and health

Dr. Hummer concluded that the field has made substantial progress; however, there is much still to learn, especially given our highly complex, rapidly changing, diverse, and stratified society. Several social and demographic questions remain, including:

- How healthy are the newest cohorts of the most highly ever educated Americans and how long are they living? How do these cohorts compare with populations in other countries?
- How is the relationship between educational attainment and health unfolding for post-Civil Rights Era African-Americans, Hispanics, and other minorities? Are the most highly educated minorities experiencing similar health and mortality outcomes as non-Hispanic whites? And are highly educated women experiencing similar health outcomes to highly educated men?
- In which U.S. states and regions or other countries do we find significantly wider or narrower educational gradients in health and mortality?
- How does educational content and quality moderate the associations between educational attainment and health?
- To what extent do confounders account for the education and health associations?
- What are the contexts in which educational attainment acts as an inter-individual resource?

Social and demographic research on education and health has yielded valuable information over the last 50 years and a big picture approach significantly contributes to scientific and policy debates.

Discussion

Adam Gamoran, PhD, The William T. Grant Foundation

Dr. Gamoran agreed with researchers that have thus far been cautious in claiming the causal effects of education on health outcomes. He outlined three possible reasons for what appears to be a causal relationship of education on health:

1. **Education increases resources.**
Individuals with higher education have more money, access to better health care, higher SES, and better access to healthy food.
2. **Education increases access to and use of information.**
Individuals with higher education have higher health and financial literacy and make better use of information on biology and health.
3. **Education changes preferences, norms, and behaviors.**
Certain behaviors are less normative in populations with higher education levels (e.g., smoking and drug use).

²⁵ Zajacova and Hummer, "Gender Differences in Education Effects on All-cause Mortality for White and Black Adults in the United States."

Health and education have a dynamic relationship: poor education can affect health and poor health can affect education. For example, children who are sick and miss school have been shown to be less successful academically compared to healthy children. The causality between education and health is difficult to sort out, yet it is an important consideration in developing effective social policies. It is not clear if policymakers should focus more on policies to reduce disparities in health or in education. Confounders would tend to temper the outcomes of health and education policies and should be considered wherever possible.

Dr. Gamoran agreed with Dr. Hummer on the most pressing areas of research, including: developing better measures of health outcomes, improving study designs, identifying mechanisms underlying the relationship between education and health, and considering contextual issues. However, he argued that it is not necessary to wait for more results to begin policy implementation. Education and health interventions have the potential to improve the overall health of the nation.

Natural Experimental Studies of Education on Health **Mitchell Wong, MD, PhD, The University of California-Los Angeles**

Preschool programs and parent-child educational interventions have been shown to improve educational and health outcomes.^{26 27 28} The Perry Preschool Project, the Carolina Abecedarian Project, and the Child-Parent Center Education Program have demonstrated a link between education and improved health and behavioral outcomes, including decreased teen pregnancies, fewer arrests, lowered cardiovascular risk, and less drug use. However, there is a lack of evidence for interventions targeting the education of high-school age students and the effects on health outcomes in this population.

Reducing Inequities through Social and Educational Change (RISE) study

Dr. Wong and his colleagues leveraged a natural experiment of charter school lotteries that allow children from low SES neighborhoods to attend a well-functioning high school. The aim of the study was to examine the impact of exposure to a high-performing public charter school on educational and behavioral outcomes.

The study population included 931 students randomly sampled from applicant pools to three high-performing Los Angeles public charter high schools. The intervention assignment was the offer of admission from the lottery (i.e., an intention-to-treat analysis). Dr. Wong's group sent out an initial letter with an opt-out option and obtained parental and student consent. The study design included 60-90 minute face-to-face interviews and audio recordings of answers to questions regarding risky behaviors. This technique was intended to reduce the fear of a child speaking to an adult about sensitive issues such as alcohol, substance use, and sex.

The population cohort was 85 percent Latino, 91 percent of parents were employed full-time, and 40 percent of families owned a home. Baseline test scores in 8th grade demonstrated no differences between the control and experimental groups. However, results from the most

²⁶ L J Schweinhart, "Evaluation of Early Childhood Programs," *Child and Adolescent Psychiatric Clinics of North America* 8, no. 2 (April 1999): 395–407, viii–ix.

²⁷ Frances Campbell et al., "Early Childhood Investments Substantially Boost Adult Health," *Science (New York, N.Y.)* 343, no. 6178 (March 28, 2014): 1478–85, doi:10.1126/science.1248429.

²⁸ Arthur J Reynolds et al., "School-based Early Childhood Education and Age-28 Well-being: Effects by Timing, Dosage, and Subgroups," *Science (New York, N.Y.)* 333, no. 6040 (July 15, 2011): 360–64, doi:10.1126/science.1203618.

recent standardized tests demonstrated that the experimental group had significantly higher scores in math and English than the control group.

Surprisingly, the use of alcohol and drugs and number of sexual encounters was not significantly different between the intervention and control group; the rates of these behaviors are similar to state and national rates.

Dr. Wong and colleagues also examined the effect of improved education on very risky behaviors: binge drinking, alcohol use at school, hard drug use, membership in a gang, multiple sexual partners, and sex without condoms or contraception. In this case, individuals from the intervention group had a significantly lower odds ratio for engaging in these very risky behaviors. These effects were larger if the individual came from a lower-performing middle school as compared to a high-performing middle school.

There are several possible mediators of the effect of education on less engagement of very risky behaviors. Only two behaviors—school retention and academic achievement—explained the relationship between education and risk behaviors. Peer behaviors and depression were not shown to be mediators of this relationship.

Dr. Wong and colleagues were surprised not to see more substantial differences in adolescent health behaviors. It may be that the impact of improved education on health might occur later in life during adulthood through better job opportunities, higher income, better health insurance and other resources.

Conclusions

Exposure to a successful school environment resulted in slightly lower rates of very risky behaviors and no change in casual substance use or in sexual encounters. The small intervention effect on lowering very risky behaviors primarily occurred through better school retention (explained 58 percent of the effect) and improved academic success (explained 16 percent of the effect). The interventions had no effect on levels of depression, hopelessness, or self-efficacy.

Dr. Wong reported that exposure to better education did not have as large an effect on adolescent health behaviors in his study as he would have expected. Issues such as poverty, parents and family, neighborhood and peers may have confounded the strong associations found in previous observational studies. Predictors of risky behaviors in the RISE study were school performance, social network, hopelessness, self-efficacy, and school engagement. The use of drugs and alcohol by an individual's peer group (20 individuals) was highly predictive of an individual's own drug and alcohol use. Attendance at a high-performing school does not change the child's after-school environment or the child's group of peers. Dr. Wong asserted that it should be possible to flip the vicious cycle of academic failure and risky behaviors into a virtuous cycle of academic success and health behaviors.

Future research efforts include a prospective study funded by the National Institute on Drug Abuse (NIDA) of low-income students in high-performing schools and a parent education intervention giving parents real-time feedback on their children's progress in school.

Discussion

Thomas Brock, PhD, The Institute of Education Sciences

Dr. Brock noted that Dr. Wong's research illuminates the synergies between health and education and commended him for taking advantage of a natural experiment with the school lottery system. He cautioned, however, that the study had significant issues with participant follow-up, including a high number of refusals to participate in the follow-up survey and a high number of crossovers between the intervention and control groups. Dr. Brock also questioned the researchers' decision to drop some students from the intent-to-treat analysis. For these reasons, Dr. Brock suggested that the study may best be viewed as exploratory. Dr. Brock made three suggestions for future research that seeks to understand the relationship between health and education:

1. **Replicate studies to verify results.**
 - Lotteries are increasingly common and present fruitful opportunities for research.
 - There may be good opportunities to pursue questions on the effects of school context on students' health attitudes and behaviors within postsecondary education systems. For example, some public universities receive many more qualified applicants than they can enroll, and either defer admission or advise students to attend less selective institutions (such as community colleges) before enrolling in the university.
 - When future studies of this type are conducted, it will be important to have agreements in place to maintain the separation between the intervention and control arms.
 - Participation rates in follow-up surveys may be improved when participants are told about the study before the lottery is conducted and provide written consent to participate.
2. **Use national longitudinal studies to explore the relationship between education and health.**
 - Several nationally representative cohort studies include questions regarding education and health behaviors.
 - These studies may provide an opportunity to link survey and school records data.
 - Nationally representative studies tend to be consistently funded and have higher response rates, multiple waves, and multiple data points for participants over longer periods of time.
3. **Continue research into the mechanisms behind the relationship between education and health.**
 - Dr. Brock commended Dr. Wong's research for examining the variables that may explain the relationship between education and health.
 - There is a need for intense qualitative research to shed light on the processes underlying the link between education and health.

Dr. Brock noted the importance of Dr. Wong's research and commented that his research makes a compelling argument for collaborative health and education research.

New Data Opportunities/Next Generation of Data

Neal Halfon, MD, MPH, University of California, Los Angeles School of Medicine

Dr. Halfon contended that health and educational attainment are fundamental developmental capacities that are intimately and interdependently entwined. Dynamic life course health development and historical transformation models help researchers understand this complex interdependence. The drivers of health and educational optimization are virtually the same and developmental mismatches are the cause of poor health outcomes. Life-long optimization of health and educational outcomes must begin in early life to result in less chronic disease and greater social prosperity.

The National Research Council (NRC) and Institute of Medicine (IOM) revised the definition of children’s health in 2004 to reflect the dynamic nature of children’s developmental capacity:

“Children’s health is the extent to which individual children or groups of children are able or enabled to (a) develop and realize their potential, (b) satisfy their needs, and (c) develop the capacities that allow them to interact successfully with their biological, physical, and social environments.”²⁹

This perspective defines health by not just the absence of disease but also the presence of health potential and health reserves. Current biomedical models focus on individual health conditions, an approach that is not a good model for population health. Dr. Halfon’s vision of population health includes the health potential of individuals and populations and the determinants of health over the lifetime.

The big changes and big challenges in health and education

According to Dr. Halfon, the United States is in the midst of a third Industrial Era, which in contrast to the components of the second Industrial Era, is characterized by increased globalization, dissolution of the nuclear family, and an interest in human developmental capacities (See Table 1).

Components of the 2nd Industrial Era	Components of the 3rd Industrial Era
Mass production, education, and culture	Network production, interconnected world
Tools to make and transport products	Tools to make and transport knowledge
Manufacturing drives wealth	Knowledge production drives wealth
Pursuit of material self interests	Pursuit of non-material shared interests
Emphasis on the nuclear family	Dissolution of the nuclear family
Focus on public education	Focus on early childhood development
Focus on human development	Focus on human developmental capacities

Table 1: Comparison of the components of the second and third industrial eras in the United States

Dr. Halfon argued that these shifts in products, pursuits, and values result in different requirements for human health development. Demographic changes challenge societies to identify ways to raise healthy children in an aging society where the flow of capital and health investments is directed to older populations. There is currently no national vision for a health and human capital development system and no integrated policy roadmap to optimize health.

²⁹ *Children’s Health, the Nation’s Wealth: Assessing and Improving Child Health*, accessed June 13, 2014, http://www.nap.edu/catalog.php?record_id=10886.

These deficiencies are potentially responsible for the fact that the United States routinely rates last in health outcomes among developed nations.^{30 31}

The conceptual model: Life course health development

Biomedical models that drive current health care systems do not account for the complex relationships between education and health. A transition to a biopsychosocial model of life course health development is needed to understand the complex and dynamic relationship between education and health.

It is important to address the factors shaping health development trajectories over the lifespan. To improve a child’s health trajectory, it is necessary to both increase protective factors and decrease risk factors. Multiple levels of interventions (i.e., children, families, and neighborhoods) must all work together at developmentally sensitive periods to change the trajectory of a child’s health. A lack of investment in child health in the first decade can lead to a downward spiral including school failure, depression, obesity, diabetes, and premature aging.

The new framework for health system transformation: Health System 3.0

Dr. Halfon presented his work on the development of a new framework for health system transformation that focuses on optimizing health and well-being throughout the life course. Health care can be described in terms of three historical eras: the first era (in the past) focused on acute, emergency, and rescue care and the second era (today) is focused on prolonging life and decreasing levels of disability through chronic disease management and secondary prevention. The third era (future) would focus on optimizing health and well-being by primary prevention and health promotion through community-integrated delivery systems. The third era—Health System 3.0—would be able to significantly cut costs by intervening earlier before sickness and disability occur.

The U.S. healthcare system is still stuck somewhere between the first and second eras and transitioning to Health System 3.0 requires attitudinal and behavioral shifts in all levels of healthcare (See Table 2).

Outcome	Old Operating Logic (2.0)	New Operating Logic (3.0)
Definition of health	Absence of disease	Development of health capacities
Goal of the health system	Maintain health, prolong life	Optimize population health
Client model	Individual	Individual, population, and community
Health production model	Biomedical	LCHD
Intervention Approach	Diagnosis, treatment, and rehabilitation	Prevention, health promotion, and optimization
Time frame	Short or episodic	Life-long and continuous

Table 2: A comparison of the old and new operating logics in health frameworks 2.0 and 3.0

Transitioning to Health System 3.0 also requires new measures of children’s health and education. The Early Development Inventory (EDI) is a composite measure of school readiness that incorporates social competency, physical well-being, language and cognitive skills, emotional maturity, and communication skills. Dr. Halfon’s research focuses on mapping EDI measures onto population data at the community level to identify areas requiring more

³⁰ *U.S. Health in International Perspective.*

³¹ “Report Card 11: Child Well-being in Rich Countries,” accessed June 13, 2014, <http://www.unicef.org.uk/Latest/Publications/Report-Card-11-Child-well-being-in-rich-countries/>.

investments in health and education. His research has demonstrated that the EDI is predictive of grade 3 and grade 4 reading scores and health inequalities. Data linking individual EDI scores to grade 4 standardized tests in Canada show that decreased vulnerability in children is associated with increased growth. Dr. Halfon estimated that the vulnerability of U.S. children must be reduced from 29 to 10 percent in order to increase high school graduation rates from 42 to 56 percent.

Conclusions

Educational outcomes are population health outcomes in the life course health development model and health and educational optimization are co-dependent on the same upstream developmental factors. The Health System 3.0 transformation framework will synergize the optimization of both outcomes. Future research should focus on interventions that target upstream social and developmental drivers of population health. Engaging the health system in early education could promote a virtuous social learning system needed by our current complex society.

Discussion

John Haaga, PhD, National Institute on Aging, NIH

Dr. Haaga recommended that datasets evaluating education and health add measures of personality to account for the relationship between these two factors. A study by Friedman *et al.* on the Terman cohort demonstrated that high conscientiousness is associated with lower mortality.^{32 33} Conscientiousness is stable but not immutable and is a powerful factor on educational attainment. A 2011 study by Moffitt *et al.* provides further evidence for personality factors on health and educational attainment; specifically, childhood self-control predicts later health and wealth and partially explains educational and health outcomes.³⁴

There are several data sources available for analyses of the mechanisms underlying the relationship between education and health and the study of health trajectories:

- **[The Health and Retirement Study \(HRS\)](#)**
 - Premier source of data on health, retirement, pensions, and social security.
 - Sub-studies include in-home cognitive assessments.
 - Includes national genome-wide association study (GWAS) data for approximately 20,000 participants.
 - Allows for international comparisons.
 - Funded by the National Institute on Aging (NIA).
- **[Midlife in the United States \(MIDUS II\)](#)**
 - Follows individuals from early adulthood into midlife and old age.
 - Includes measures of behavioral, social, psychological, physiological, and neurological factors.
 - Funded by the NIA.

³² H S Friedman et al., "Childhood Conscientiousness and Longevity: Health Behaviors and Cause of Death," *Journal of Personality and Social Psychology* 68, no. 4 (April 1995): 696–703.

³³ H S Friedman et al., "Does Childhood Personality Predict Longevity?," *Journal of Personality and Social Psychology* 65, no. 1 (July 1993): 176–85.

³⁴ Terrie E Moffitt et al., "A Gradient of Childhood Self-control Predicts Health, Wealth, and Public Safety," *Proceedings of the National Academy of Sciences of the United States of America* 108, no. 7 (February 15, 2011): 2693–98, doi:10.1073/pnas.1010076108.

- **Panel Study of Income Dynamics (PSID)**
 - Evaluates economic behavior and includes information on demographic, sociological, and psychological measures.
 - Funded by the National Science Foundation (NSF).
- **Project Talent**
 - A national longitudinal study of more than 440,000 high school students in 1960 funded by the U.S. Office of Education (now the U.S. Department of Education).
 - A follow-up study of a random sample of the original participants is currently under development.
 - The follow-up study could be a potentially important data source for the study of the effects of education on health over the life-course.

Dr. Haaga further observed that the epidemiologic transition is changing the burden of illness worldwide. Infectious diseases affecting children most severely are less prevalent now and the burden from chronic conditions is growing, even in poor countries; therefore, increased research is needed to understand how education affects both the incidence and the management of chronic conditions.

Breakout Sessions

Four breakout sessions addressed additional topics such as where along the age spectrum investments should be targeted, global perspectives, the availability and strengths of IES data, and interventions. A summary of each breakout follows, and more detailed write-ups are included as appendices 4 through 7.

Before the First 1,000 Days: Where on the Age Spectrum Do You Invest?

Participants discussed real-world limitations on shared data in the health and education arenas along with ideas on how to achieve data integration on a national level. Federal policies already limit the ability of researchers to connect educational outcomes data with health-related outcomes data. Data measurements of health and education statistics have traditionally been siloed. Proposed changes to the protection of human subjects stipulations and for the removal of geographic data identifiers would both further restrict and devalue available meaningful data. Participants suggested that NIH should coordinate data collection and harmonization in a proposed collaboration between the U.S. Departments of Education and Health and Human Services. NIH staff at the breakout agreed and offered perspectives on the separation of education and health research agencies and funding.

The overall breakout session theme regarding the first 1,000 days of an at-risk child's life was explored in terms of health and education disparities, access to families, and the most effective components of intervention approaches. Early placement in an enriched education-based environment along with parenting sessions focused on infant/toddler health and well-being are most effective in terms of motor development. If interventions occur after 24 months, they are not as successful as they could have been earlier on when differences in language abilities become apparent.

Support of individuals, communities, cities, and counties for enhanced child wellness and early education needs to be complemented by better training for parents, doctors, and teachers to implement sustainable improvements in children from disadvantaged backgrounds. Early interventions may be more expensive to implement but they improve social interactions, promote learning, and focus on both emotional and cognitive development.

Global Perspectives

In this breakout session, participants considered the effect of education on the spread of disease and delivery of financial resources, as well as universal truths and discrete differences in health policies and practices. While not all NIH-sanctioned policies and best practices are used everywhere in the world, it would be advantageous to learn much more from global population studies in terms of science and policy. Participants described relationships between education, populations, and disease, and one participant maintained that the wealthy frequently first experience diseases that later diffuse to the general population. It may well be that an educated population lives longer but also has more chronic disease.

Brain development, brain health, and educational attainment are interrelated at many levels. Education and physical activity promote brain health and inactivity or neglect lead to language or cognitive deficits. When properly implemented, an infusion of financial resources positively impacts children's health and development and spurs educational achievement in numerous ways. This phenomenon occurs universally and American researchers should examine global models of health care money delivery for application in the United States. Targeted investments in education can result in reductions in health disparities among minorities and between the sexes.

A compounding factor is that differing cultural norms affect the conduct of research into health and education. Non-U.S. cultures may regard health decisions as a community determination rather than an individual right. Consultation with researchers studying belief systems, as well as the integration of health and education, could be useful for studying individual disease cycles. Health outcomes are dependent on both belief systems and the systems of care. In the United States, implementation of new health or education policies is often slowed by the involvement of a multi-branch form of government. In addition, the concept of global perspectives may not always include the United States and assumed constants about human well-being may not be universally accepted.

Finally, there are numerous constraints on the ability of investigators to both access and share data. NIH has two competing data issues: individuals' clinical data must be protected at all costs, but there is also increasing pressure for researchers to share data. There are disparate international governmental guidelines about open data; in the United States, funding can be dependent on data-sharing arrangements, yet privacy issues frequently preclude open access to new or archived research.

Institute of Education Sciences Data

The Department of Education Institute of Education Sciences concentrates on four areas, reflected by the names of its four centers: the National Center for Education Research, the National Center for Education Statistics (NCES), the National Center for Education Evaluation and Regional Assistance, and the National Center for Special Education Research.

Certain school-based NCES studies have also included the collection of health data. The Early Childhood Longitudinal Study-Birth Cohort (ECLS-B; birth through kindergarten) covered the domains of diet, physical development, weight, and general health, and collected data on children's cognitive, physical, and social and emotional development in the home, childcare, and school settings. The same ECLS-B domains were covered in the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 study (kindergarten through 8th grade), which also measured fine and motor gross skills. The Early Childhood Longitudinal Study, Kindergarten Class of 2010-11 (kindergarten through 5th grade) had the same domains but focused on executive function instead of motor skills. An upcoming cohort is the Middle Grades Longitudinal

Study of 2016–17 (6th grade), which plans to cover similar domains and will include associations between contextual factors and student outcomes. The High School and Beyond set of NCES studies included the National Longitudinal Study of the High School Class of 1972 (high school seniors through 1986), which collected data on general health (self-rated), access to health care, and health insurance status.

NCES also fields cross-sectional studies that allow for correlational analyses and static international comparisons and some include health data. The Program for the International Assessment of Adult Competencies, which has four domains covering literacy, numeracy, problem solving in technology-rich environments, and reading components, collects data on self-assessment of general health, access to health care, and use of basic medical treatment in the past 12 months. The National Assessment of Educational Progress (NAEP) contains information about disabilities and assessment scores that may also be relevant for health-related issues.

Other topics were discussed, including data access and use, the impact of electronic records, and opportunities for interagency coordination. The idea of collaborations with the National Academy of Sciences (NAS) and NIH was raised. Some NIH Institutes and Centers are listed as collaborators and sponsoring agencies for certain of the ECLS studies and there is potential for the IES to fund an expanded health module in a future NCES longitudinal study.

Interventions

Extensive investments have been made toward improving the quality of early childhood education and ensuring needed support for children. In education/health blend areas, there is a lot more systematic emphasis on healthy foods and on physical activity, but there is also enhanced awareness of the need for protective mechanisms. There has been a very exclusive focus on early childhood; however, many challenges happen to the same children as they age through the school years but these are not as readily monitored or measured.

Participants maintained that a single-generation approach is inadequate. Some of the resiliency principles that are applied to communities around preparedness and reactions to natural disasters are how teachers and interventionists actually work with children to adopt their social and emotional learning and reinforce that resiliency throughout life. Home visits help modify the circle of parents in a given community by modeling how to take care of their children or how to react in a crisis. But the data systems used are not sensitive enough to determine which approaches work best and the data do not “talk” to each other because health and education data are segregated. Multi-generational considerations need to come into play along with selecting the right metrics.

Collaborative interventions might use education as a tool to help with health disparities, or conversely, identifying health interventions that could be used as a tool to reduce education disparities. Self-affirmation writing exercises to de-internalize stereotypes reduced disparities by 20 percent among Asian, white, black, and Hispanic 6th graders and showed lasting effects in terms of educational achievement two years later. Thus, limited interventions can have powerful effects. A gambling intervention aimed at reinforcing a person’s strengths, so that when someone fails at something they can then contrast a weakness with their strong areas and build on a baseline of resilience. It was suggested that anticipatory guidance should become part of pediatric training and help educate clinicians who need to understand the blended issue of education and medicine. As for education affecting health, there was discussion on intervention approaches that would emphasize critical thinking over non-cognitive skills, such as resiliency, patience, grit, and self-control. For communities that do not have the infrastructure or the social

networks necessary to make for a successful intervention, it is critical to assess beforehand which programs do work and why and how to replicate what works.

The business sector is becoming more engaged because early childhood through middle school youth are being viewed as their future work force. An example given described the partnership between the Chamber of Commerce in Spokane, WA, and the area education system as well as the health care and medical university systems. Part of this effort comprises measures around health outcomes and part has to do with educational achievement, including high school truancy monitoring and attaining a secondary degree. The business sector's investment reasoning is driven by the economic viability of the community, the ability to retain locals who would return after higher education, and as a vehicle to attract industry and secure jobs. Another example involved the fact that the Target store chain already donates 5 percent of its profits to education, but it was suggested that they could be approached by offering evidence-based guidance on how to better direct their education investments using best-practice intervention standards.

Education and health care intervention collaborations should ideally not be done with just one age group—there needs to be the ability to keep reinforcing a positive influence, but there is very little literature available on anything other than early childhood programs. The real challenge is how to best study and evaluate older children and youth, because critical incidents that matter most often happen later in life rather than in early childhood. The breakout concluded with a discussion on federal public expenditures. The consensus was that there are not enough dollars in public health to do prevention, there is not a lot of money in education but there is money to support the infrastructure for daily education, not all policy changes have to cost money, and more up-front investment is needed for health care.

Potential Mechanisms: Three Hypotheses

Born to Fail, Nurtured to Thrive? Biological Plasticity, Education, and Healthy Development

Gabriella Conti, PhD, University College, London

Dr. Conti's research seeks to understand the origins of educational disparities in health and health behaviors.³⁵ She is interested in the role of biology in child development and in designing interventions to promote health. To achieve this goal, it is necessary to understand how early environments and biological differences in susceptibility shape healthy development. Understanding how adversity damages development can lead to knowing whether, when, and how these damages can be remediated.

Prior research efforts have demonstrated that interventions must nurture human development at the time when nature is most amenable to change. Evidence has accumulated that early interventions result in signal transduction cascades that influence the epigenetic regulation of gene transcription; this signaling cascade ultimately results in the expression of different phenotypes. Much work is still needed to bridge biology and intervention science in order to:

- Identify the children in need of intervention.

³⁵ Gabriella Conti and James J Heckman, "Understanding the Early Origins of the Education-Health Gradient: A Framework That Can Also Be Applied to Analyze Gene-Environment Interactions," *Perspectives on Psychological Science: a Journal of the Association for Psychological Science* 5, no. 5 (2010): 585–605, doi:10.1177/1745691610383502.

- Identify the pathways disrupted by developmental risks.
- Identify the age periods in which such interventions can have stronger and long-lasting effects.
- Elucidate the mechanisms of change in effective interventions.
- Provide insight into the differential responses of children to effective interventions.
- Improve measurements (e.g., neural-based measures of cognition and attention).

There are several gaps in the current literature, including a lack of understanding of the interactions between different biological systems and the links between biological and behavioral phenotypic changes. Dr. Conti described a research roadmap that first identifies the known and unknowns linking biology to child development. The second part of the research roadmap examines whether the pathways disrupted by adversity can be restored by enrichment interventions, and if so, when, how, and at what cost. Interventions that reorganize relevant biological systems might mitigate or even reverse the consequences of adversity. Early experiences can alter children's neurobiology in multiple ways that affect their ability to succeed, emotional competence, and health; children are 'biologically designed' to incorporate early experiences. For example, maternal smoking has been shown to affect fetal development during pregnancy.

The six components of biological plasticity

Dr. Conti contended that early experiences affect the biological basis of the traits affecting education, health behaviors, and health. She described six evidence-based components of biological plasticity and the known and unknown factors in each:

1. Genetic components contribute to biological plasticity.

- **Known**
 - Although twin and adoption studies have demonstrated a role for genetics in health and education, recent studies have challenged these findings.
 - Genome-wide Association Studies (GWAS) have met with some success (e.g., the role of the fat-mass and obesity associated (*FTO*) gene in educational outcomes).³⁶
 - Gene-environment interaction (GxE) studies have demonstrated that children have a genetic susceptibility to both positive and negative environments.³⁷
- **Unknown**
 - The role of GWAS studies in the future is unclear, given that these studies often detect only rare variants that are not amenable to broad interventions.
 - There is an increasing scientific debate on the validity of GxE findings; very few GxE studies use randomized controlled designs.^{38 39} Also, several

³⁶ Cornelius A Rietveld et al., "GWAS of 126,559 Individuals Identifies Genetic Variants Associated with Educational Attainment," *Science (New York, N.Y.)* 340, no. 6139 (June 21, 2013): 1467–71, doi:10.1126/science.1235488.

³⁷ Conti and Heckman, "Understanding the Early Origins of the Education-Health Gradient."

³⁸ Marian J Bakermans-Kranenburg et al., "Effects of an Attachment-based Intervention on Daily Cortisol Moderated by Dopamine Receptor D4: a Randomized Control Trial on 1- to 3-year-olds Screened for Externalizing Behavior," *Development and Psychopathology* 20, no. 3 (2008): 805–20, doi:10.1017/S0954579408000382.

³⁹ Dante Cicchetti, Fred A Rogosch, and Sheree L Toth, "The Effects of Child Maltreatment and Polymorphisms of the Serotonin Transporter and Dopamine D4 Receptor Genes on Infant Attachment and Intervention Efficacy," *Development and Psychopathology* 23, no. 2 (May 2011): 357–72, doi:10.1017/S0954579411000113.

interactions have been demonstrated to be statistically valid but biologically implausible.

2. Epigenetic regulation contributes to biological plasticity.

• Known

- The extracellular environment has been shown to ‘get under the skin,’ resulting in epigenetically regulated differences in gene expression.⁴⁰
- The effects of maternal care in epigenetic responses to stress have been examined in rats.⁴¹
- The evidence in humans for the role of epigenetics in biological plasticity is mostly correlational, with some quasi- and experimental evidence emerging on fetal programming.⁴²

• Unknown

- It is unclear under which circumstances animal findings are transferable to humans.
- There is a lack of consistency and replicability across studies.
- Observational study results need to be validated with randomized controlled trials.
- It is unclear if epigenetic effects are persistent or reversible (in humans).
- Epigenetic studies have technical issues, including inappropriate power calculations and questions of tissue specificity.
- It is unclear how genetic polymorphisms and epigenetic regulation interact to result in phenotypic heterogeneity.⁴³

3. Gene expression levels contribute to biological plasticity.

• Known

- Differences in epigenetic regulation have been shown to result in differences in gene expression in rats and monkeys.^{44 45 46} Dr. Conti commented on recent work with Dr. Stephen Suomi and others on how differential rearing in rhesus monkeys affects gene expression levels in genes related to inflammation and immunity.⁴⁷

⁴⁰ Michael J Meaney, “Epigenetics and the Biological Definition of Gene x Environment Interactions,” *Child Development* 81, no. 1 (February 2010): 41–79, doi:10.1111/j.1467-8624.2009.01381.x.

⁴¹ Ian C G Weaver et al., “Epigenetic Programming by Maternal Behavior,” *Nature Neuroscience* 7, no. 8 (August 2004): 847–54, doi:10.1038/nn1276.

⁴² Marilyn J Essex et al., “Epigenetic Vestiges of Early Developmental Adversity: Childhood Stress Exposure and DNA Methylation in Adolescence,” *Child Development* 84, no. 1 (February 2013): 58–75, doi:10.1111/j.1467-8624.2011.01641.x.

⁴³ Torsten Klengel et al., “Allele-specific FKBP5 DNA Demethylation Mediates Gene-childhood Trauma Interactions,” *Nature Neuroscience* 16, no. 1 (January 2013): 33–41, doi:10.1038/nn.3275.

⁴⁴ Meaney, “Epigenetics and the Biological Definition of Gene x Environment Interactions.”

⁴⁵ Steven W Cole et al., “Transcriptional Modulation of the Developing Immune System by Early Life Social Adversity,” *Proceedings of the National Academy of Sciences of the United States of America* 109, no. 50 (December 11, 2012): 20578–83, doi:10.1073/pnas.1218253109.

⁴⁶ Jenny Tung et al., “Social Environment Is Associated with Gene Regulatory Variation in the Rhesus Macaque Immune System,” *Proceedings of the National Academy of Sciences of the United States of America* 109, no. 17 (April 24, 2012): 6490–95, doi:10.1073/pnas.1202734109.

⁴⁷ Steven W Cole et al., “Transcriptional Modulation of the Developing Immune System by Early Life Social Adversity,” *Proceedings of the National Academy of Sciences of the United States of America* 109, no. 50 (December 11, 2012): 20578–83, doi:10.1073/pnas.1218253109.

- Evidence for gene expression and biological plasticity in humans is scant and related mostly to early adversity and obesity.^{48 49}
 - **Unknown**
 - The unknowns for gene expression relationships with biological plasticity are the same as those of epigenetics.
4. **The brain contributes to biological plasticity.**
- **Known**
 - Early experiences have been shown to result in both structural and functional variations in brain development.^{50 51}
 - These structural and functional variations include those in cortical processes, limbic structures, and the hippocampus.^{52 53}
 - There is evidence for the role of nutrition in brain development.⁵⁴
 - The brain has multiple developmentally sensitive periods, especially adolescence.⁵⁵
 - **Unknown**
 - It is unknown if the brain is causally related to biological plasticity.
 - The extent of late-life reversibility of negative brain development is unclear.
 - The role of epigenetic regulation in brain development is unclear.
5. **Telomeres and telomerase levels affect biological plasticity.**
- **Known**
 - Shortened telomeres, reduced telomerase production, or both have been linked to stress, several diseases, and mortality.⁵⁶
 - Telomere biology is a possible mechanism connecting fetal programming to health outcomes.⁵⁷

⁴⁸ Gregory E Miller et al., "Low Early-life Social Class Leaves a Biological Residue Manifested by Decreased Glucocorticoid and Increased Proinflammatory Signaling," *Proceedings of the National Academy of Sciences of the United States of America* 106, no. 34 (August 25, 2009): 14716–21, doi:10.1073/pnas.0902971106.

⁴⁹ Andrea G Edlow et al., "Maternal Obesity Affects Fetal Neurodevelopmental and Metabolic Gene Expression: a Pilot Study," *PLoS One* 9, no. 2 (2014): e88661, doi:10.1371/journal.pone.0088661.

⁵⁰ Sonia J Lupien et al., "Effects of Stress Throughout the Lifespan on the Brain, Behaviour and Cognition," *Nature Reviews. Neuroscience* 10, no. 6 (June 2009): 434–45, doi:10.1038/nrn2639.

⁵¹ Yvonne M Ulrich-Lai and James P Herman, "Neural Regulation of Endocrine and Autonomic Stress Responses," *Nature Reviews. Neuroscience* 10, no. 6 (June 2009): 397–409, doi:10.1038/nrn2647.

⁵² Courtney Stevens, Brittni Lauinger, and Helen Neville, "Differences in the Neural Mechanisms of Selective Attention in Children from Different Socioeconomic Backgrounds: An Event-related Brain Potential Study," *Developmental Science* 12, no. 4 (July 2009): 634–46, doi:10.1111/j.1467-7687.2009.00807.x.

⁵³ Joan L Luby et al., "Maternal Support in Early Childhood Predicts Larger Hippocampal Volumes at School Age," *Proceedings of the National Academy of Sciences of the United States of America* 109, no. 8 (February 21, 2012): 2854–59, doi:10.1073/pnas.1118003109.

⁵⁴ Michael K Georgieff, "Nutrition and the Developing Brain: Nutrient Priorities and Measurement," *The American Journal of Clinical Nutrition* 85, no. 2 (February 2007): 614S–620S.

⁵⁵ Mark H Johnson, "Sensitive Periods in Functional Brain Development: Problems and Prospects," *Developmental Psychobiology* 46, no. 3 (April 2005): 287–92, doi:10.1002/dev.20057.

⁵⁶ Elissa S Epel et al., "Accelerated Telomere Shortening in Response to Life Stress," *Proceedings of the National Academy of Sciences of the United States of America* 101, no. 49 (December 7, 2004): 17312–15, doi:10.1073/pnas.0407162101.

- Some experimental animal studies have been shown to provide a causal link between telomeres and biological plasticity.
 - **Unknown**
 - The human evidence for the role of telomeres is limited and mostly correlational.
 - The direction of causality between telomeres and plasticity is unknown.
 - The determinants of newborn telomere length are poorly understood.
 - The role of epigenetic regulation in telomere function is unknown.
6. **Metabolomics offers insights into biological plasticity.**
- **Known**
 - The analysis of metabolites in body fluids has been shown to provide information on the metabolic phenotype.⁵⁸
 - Metabolic phenotypes have been shown to be affected by both genetic and environmental factors.⁵⁹
 - The field of metabolomics has yielded promising applications in neonatology, metabolic diseases, and perinatal programming.⁶⁰
 - **Unknown**
 - The relationship between early-life nutritional status and later disease risk is unclear.
 - The role of genetic and epigenetic regulation on metabolism is unclear.

When and how can we intervene?

Dr. Conti identified six components that affect the biological pathways of education and health behaviors.⁶¹ Both early- and late-in-life education may provide the power to prevent, remediate, or reverse negative education and health outcomes. High-quality, early-life interventions have been shown to have long-term effects by enriching the environment of children born in adversity by providing information to parents, protecting biological pathways from the damage, and preventing damage before it occurs or becomes embedded. There are multiple enrichment components in high-quality early life interventions, yet the mechanisms of each, and their interactions are unknown. It is also unclear how high-quality interventions could be scaled to the larger population.

There are several examples of successful early life interventions in education and health. The United Kingdom has founded The Foundation Years program to provide information on education and health policies and interventions. There are several intervention examples in the areas of attachment, access to information, cognitive and behavioral stimulation, and nutrition and health care. Interventions that enhance parental sensitivity have been shown to enhance a

⁵⁷ Sonja Entringer, Claudia Buss, and Pathik D Wadhwa, "Prenatal Stress, Telomere Biology, and Fetal Programming of Health and Disease Risk," *Science Signaling* 5, no. 248 (2012): pt12, doi:10.1126/scisignal.2003580.

⁵⁸ J K Nicholson, J C Lindon, and E Holmes, "'Metabonomics': Understanding the Metabolic Responses of Living Systems to Pathophysiological Stimuli via Multivariate Statistical Analysis of Biological NMR Spectroscopic Data," *Xenobiotica; the Fate of Foreign Compounds in Biological Systems* 29, no. 11 (November 1999): 1181–89, doi:10.1080/004982599238047.

⁵⁹ Elaine Holmes et al., "Human Metabolic Phenotype Diversity and Its Association with Diet and Blood Pressure," *Nature* 453, no. 7193 (May 15, 2008): 396–400, doi:10.1038/nature06882.

⁶⁰ V Fanos et al., "Metabolomics in Neonatology and Pediatrics," *Clinical Biochemistry* 44, no. 7 (May 2011): 452–54, doi:10.1016/j.clinbiochem.2011.03.006.

⁶¹ Conti and Heckman, "Understanding the Early Origins of the Education-Health Gradient."

child's attachment and sense of security.⁶² Interventions that improve access to information include the Olds' Nurse-Family Partnership and Dr. Cunha's recent work. The cognitive and behavioral simulation intervention of the Perry Preschool Project demonstrated long-term effects on healthy behaviors and the Carolina Abecedarian Project has shown a benefit of nutrition and health care on health outcomes.⁶³ These studies have moved the field forward, but also raise questions for future research, including:

- Are there sensitive periods for interventions?
- How long do the effects of interventions last?
- Do the benefits of an intervention translate to other behaviors?
- Can interventions be replicated on a larger scale?
- Is providing information adequate or do individuals require the capacity to act on it as well?
- What is the best way of providing information and by whom?

Late-in-life education interventions may hold the key to the remediation of negative education and health outcomes. Dr. Conti hypothesized that later-in-life interventions may have comparable long-term effects by exploiting the persistent malleability of biological systems. Interventions could include providing enrichment (e.g., mentorship), targeting the pathways already damaged, developing alternative pathways to compensate for existing damage, and providing information to promote behavioral change. For example, Dr. James Heckman has demonstrated that education may have causative effects on personality in adolescents. Late-in-life interventions may even reverse damage after it has occurred.

Future research directions

Future research needs to address understanding the mechanisms of change between early and late education and developing interventions that target malleable systems in both parents and children.⁶⁴ Dr. Conti recommended that interventions nurture human development at a time when nature is most amenable to change. Researchers usually include only study-specific measures, which limit the generalizability or comparability of research results and the broader effects of interventions are unknown. Moving forward, Dr. Conti noted the importance of designing biologically-based interventions and evaluating their effectiveness by collecting and analyzing a vast array of biological markers.⁶⁵

Discussion

Jason Fletcher, PhD, University of Wisconsin-Madison

Dr. Fletcher agreed with Dr. Conti on the importance of nurturing human development at the time when nature is most amenable to change. Future research should set high standards for evidence, including the understanding of biological pathways, the use of human subjects, and

⁶² Marian J Bakermans-Kranenburg, Marinus H van IJzendoorn, and Femmie Juffer, "Less Is More: Meta-analyses of Sensitivity and Attachment Interventions in Early Childhood," *Psychological Bulletin* 129, no. 2 (March 2003): 195–215.

⁶³ Campbell et al., "Early Childhood Investments Substantially Boost Adult Health."

⁶⁴ Helen J Neville et al., "Family-based Training Program Improves Brain Function, Cognition, and Behavior in Lower Socioeconomic Status Preschoolers," *Proceedings of the National Academy of Sciences of the United States of America* 110, no. 29 (July 16, 2013): 12138–43, doi:10.1073/pnas.1304437110.

⁶⁵ Rui Chen et al., "Personal Omics Profiling Reveals Dynamic Molecular and Medical Phenotypes," *Cell* 148, no. 6 (March 16, 2012): 1293–1307, doi:10.1016/j.cell.2012.02.009.

the determination of causal effects. Dr. Conti presented evidence supporting the idea of sensitive periods of development, the concept of differential susceptibility, and the role of biological components such as genetics, epigenetics, gene expression, brain development, telomeres, and metabolomics.

Current research gaps include the nature of the causal relationship between education and health and that the standards of evidence differ by discipline. The transferability of animal models to humans is unclear, particularly for education outcomes. Small sample sizes are also problematic for most research, except GWAS studies. There are still significant strides to be made in the fundamental understanding of genetics, epigenetics, telomeres, and neuroscience, although some large GxE studies have resulted in an increase in biological understanding and a determination of causal inference in education and health.

The field of education and health is moving forward in several areas. Association studies are hypothesis-generating exercises that build the evidence base and candidate gene studies are exploring the genetic heterogeneity in education and health interventions. GxE interaction studies can leverage the stability of genetics, the variation of genetics within families, and the variation in environments with experimental designs to untangle the relationship between education and health.

Dr. Fletcher's own work on effects of birth weight on adult cognition and wages identified individuals who are sensitive to the environment (likened to orchids) and individuals who are robust with regards to the environment (likened to dandelions). 'Dandelions' are versatile individuals who thrive regardless of the environment. Dr. Fletcher is using multiple approaches to identify individuals who are 'orchids' for early interventions.

Education and Behavioral Health: A Mechanistic Hypothesis

Sandro Galea, MD, MPH, DrPH, Columbia University

Dr. Galea has studied the interrelationships between SES and education and how they influence the production of population health over the life course. Previous research has identified a number of factors that influence an individual's contribution to population health, including physiological pathways, genetic and individual risk factors, social relationships, living conditions, neighborhoods, and social policies.⁶⁶ Dr. Galea emphasized that SES is tightly linked to education across generations and individuals who are born poor are less likely to have high educational attainment.⁶⁷ Persons with low SES are also more likely to engage in health risk behaviors; previous studies have demonstrated a consistent relationship between low educational attainment and more smoking, less exercising, and obesity.⁶⁸ However, the differences in health risk behaviors do not adequately explain SES-based health inequalities. Lantz (1998) demonstrated that the addition of health risk behaviors dampens the effects of education but not the effects of income. These results have significant implications for health and education policy in improving the health of disadvantaged populations:

⁶⁶ George A Kaplan, "What's Wrong with Social Epidemiology, and How Can We Make It Better?" *Epidemiologic Reviews* 26 (2004): 124–35, doi:10.1093/epirev/mxh010.

⁶⁷ J W Lynch, G A Kaplan, and J T Salonen, "Why Do Poor People Behave Poorly? Variation in Adult Health Behaviours and Psychosocial Characteristics by Stages of the Socioeconomic Lifecourse," *Social Science & Medicine* (1982) 44, no. 6 (March 1997): 809–19.

⁶⁸ P M Lantz et al., "Socioeconomic Factors, Health Behaviors, and Mortality: Results from a Nationally Representative Prospective Study of US Adults," *JAMA: The Journal of the American Medical Association* 279, no. 21 (June 3, 1998): 1703–8.

*“Although reducing the prevalence of health risk behaviors in low-income populations is an important health goal, socioeconomic differences in mortality are due to a wider array of factors and, therefore, would persist even with improved health behaviors among the disadvantaged.”*⁶⁹

Several researchers have attempted to account for the additional factors involved with SES-based differences in mortality. One study examined risk behaviors over time to account for changes in patterns of health behaviors, which demonstrated a substantial dampening of the role of SES once time variant health behaviors were accounted for.⁷⁰ This work confirmed the importance of social inequalities in unhealthy behaviors and suggested that efforts to mitigate these effects would be to focus on eliminating negative health behaviors.

However, this relationship does not consistently hold true on a larger scale. Previous research has demonstrated very few associations between changes in macro-economic factors and population health risk behaviors.⁷¹ The authors concluded:

“Our results do not support the hypothesis that health behaviors mediate the effects of local-area economic conditions on mortality.”

A mechanistic hypothesis for the relationship between education and behavioral health

Considering the distribution of educational attainment may provide clues for mechanisms behind SES-based health disparities. Several studies demonstrated that more variability in educational distribution was associated with less health risk behaviors, such as drinking alcohol.^{72 73} Further research confirmed that increased variability in education is associated with a broad range of better, and potentially behaviorally-mediated, health indicators. Research has demonstrated that more educational variability is associated with more variability in social norms and is driven by differences in norms between populations with low and high levels of education.⁷⁴

Lack of education has also been shown to confer population vulnerability to other stressors. For example, in high poverty areas, there is more variability in homicide rates compared to low poverty areas.⁷⁵ This variability is usually obscured by the field’s overall focus on the linear relationship between SES and health. Research has shown that the variability in health indicators was particularly present with potentially behaviorally-mediated health indicators but

⁶⁹ Ibid.

⁷⁰ Arijit Nandi, M Maria Glymour, and S V Subramanian, “Association Among Socioeconomic Status, Health Behaviors, and All-cause Mortality in the United States,” *Epidemiology (Cambridge, Mass.)* 25, no. 2 (March 2014): 170–77, doi:10.1097/EDE.0000000000000038.

⁷¹ Arijit Nandi et al., “Economic Conditions and Health Behaviours During the ‘Great Recession’,” *Journal of Epidemiology and Community Health* 67, no. 12 (December 1, 2013): 1038–46, doi:10.1136/jech-2012-202260.

⁷² Félice Lê, Jennifer Ahern, and Sandro Galea, “Neighborhood Education Inequality and Drinking Behavior,” *Drug and Alcohol Dependence* 112, no. 1–2 (November 1, 2010): 18–26, doi:10.1016/j.drugalcdep.2010.05.005.

⁷³ Sandro Galea et al., “Education Inequality and Use of Cigarettes, Alcohol, and Marijuana,” *Drug and Alcohol Dependence* 90 Suppl 1 (September 2007): S4–15, doi:10.1016/j.drugalcdep.2006.11.008.

⁷⁴ Lê, Ahern, and Galea, “Neighborhood Education Inequality and Drinking Behavior.”

⁷⁵ Adam Karpati et al., “Variability and Vulnerability at the Ecological Level: Implications for Understanding the Social Determinants of Health,” *American Journal of Public Health* 92, no. 11 (November 2002): 1768–72.

less so with others.⁷⁶ Furthermore, the variability in health indicators linked to low SES was dampened once other stressors were accounted for, including the quality of local schools, unemployment, and low education.⁷⁷

Dr. Galea hypothesized that lack of education sets the stage for vulnerability in populations; however, a host of other individual, social, and societal factors affect the final health behaviors.⁷⁸ This model takes the field away from the linear associations between education and health and explains the contradictory evidence of SES-based effects on health.

Conclusions

Dr. Galea estimated the effect of foundational SES differences on population mortality. He suggested that there is evidence that as many individuals have died from low education as from heart attacks.⁷⁹ These results have significant implications as the obesity epidemic focus is on stopping risk behaviors. However, these research results suggest that broader educational and social policies might have a greater impact. More research is needed to confirm the mechanisms underlying the relationship between education and health to make the most effective public health decisions.

Discussion

Wilson Compton, MD, MPE, National Institute on Drug Abuse, NIH

Dr. Compton focused his remarks on drug abuse/addiction and education, including providing insights from prevention. He identified two reasons to consider drug abuse/addiction prevention when examining educational outcomes: drugs can impair academic achievement and the very same targets that are useful for drug abuse prevention are useful for improving academic functioning.

He thanked Dr. Galea for his discussion on the complex literature on SES and education. Primary discussion points from Dr. Galea's talk included the idea of educational variability and the importance of broader social determinants in public health policy.

Dr. Compton focused his response on behavioral issues in marijuana use. There are shifting social and legal policies regarding marijuana use in the United States that make it important to consider the educational and health consequences of drug abuse. Drug abuse and educational outcomes should be considered because drugs can impair academic achievement and the same behavioral mechanisms that decrease drug abuse also improve education.

Previous research has shown that marijuana use is associated with a number of brain changes and decreases in educational outcomes. Marijuana use and later-life outcomes, such as

⁷⁶ Sandro Galea, Jennifer Ahern, and Adam Karpati, "A Model of Underlying Socioeconomic Vulnerability in Human Populations: Evidence from Variability in Population Health and Implications for Public Health," *Social Science & Medicine* (1982) 60, no. 11 (June 2005): 2417–30, doi:10.1016/j.socscimed.2004.11.028.

⁷⁷ Jennifer Ahern et al., "Population Vulnerabilities and Capacities Related to Health: a Test of a Model," *Social Science & Medicine* (1982) 66, no. 3 (February 2008): 691–703, doi:10.1016/j.socscimed.2007.10.011.

⁷⁸ Sasha Rudenstine and Sandro Galea, *The Causes and Behavioral Consequences of Disasters: Models Informed by the Global Experience 1950-2005*, 2012 edition (Springer, 2011).

⁷⁹ Sandro Galea et al., "Estimated Deaths Attributable to Social Factors in the United States," *American Journal of Public Health* 101, no. 8 (August 2011): 1456–65, doi:10.2105/AJPH.2010.300086.

educational attainment and income, are also dose-dependent.⁸⁰ Persistent marijuana users showed a significant intelligence quotient (IQ) drop between ages 13 and 38.⁸¹ Heavy marijuana use has been associated with major changes in the morphology and function of the hippocampus, resulting in decreased memory performance; in addition, long-term marijuana use has been shown to decrease axonal fiber connectivity.^{82 83}

Research has demonstrated that the prevalence of marijuana use increases significantly with the number of risk factors in a six-state survey of 6th to 12th graders in public schools. Marijuana use was associated with the same risk and protective factors that influence academic success, including self-control and self-regulation. In fact, childhood self-control predicts a number of adult outcomes, including health, wealth, and public safety.⁸⁴

Early childhood interventions that enhance aspects of self-regulation are likely to bring a greater return on investment for multiple behaviors than harm reduction programs targeting adolescents alone. Examples of potentially beneficial interventions to reduce drug use and improve educational outcomes include parent skill training, social skills training, training to increase self-regulation and impulse control, academic tutoring, and improving health literacy. These interventions target modifiable risk and protective factors, such as early aggression, social skills deficits, academic problems, media glamorization, and association with deviant peers. Interventions must take into account moderators of the health and education relationships, including age, gender, race, poverty, and genotype.

There are several examples of successful drug prevention interventions that resulted in positive health and educational outcomes. The Nurse Family Partnership has been shown to reduce substance use in adolescence. Early grade school interventions like the Good Behavior Game and Seattle Social Development Program have been shown to lead to long-term positive academic outcomes and lower negative health outcomes. Elementary to middle school interventions such as the Family Check-Up, Strengthening Families Program 10-14, and Positive Action Intervention have all been shown to be effective drug abuse prevention mechanisms.

Dr. Compton emphasized the utility of interventions that both improve academic functioning and decrease substance abuse. Policymakers do not need to wait for a full understanding of the mechanisms behind such interventions for policymakers to begin implementation of these programs.

⁸⁰ David M Fergusson and Joseph M Boden, "Cannabis Use and Later Life Outcomes," *Addiction (Abingdon, England)* 103, no. 6 (June 2008): 969–976; discussion 977–978, doi:10.1111/j.1360-0443.2008.02221.x.

⁸¹ Madeline H Meier et al., "Persistent Cannabis Users Show Neuropsychological Decline from Childhood to Midlife," *Proceedings of the National Academy of Sciences of the United States of America* 109, no. 40 (October 2, 2012): E2657–2664, doi:10.1073/pnas.1206820109.

⁸² Murat Yücel et al., "Regional Brain Abnormalities Associated with Long-term Heavy Cannabis Use," *Archives of General Psychiatry* 65, no. 6 (June 2008): 694–701, doi:10.1001/archpsyc.65.6.694.

⁸³ Andrew Zalesky et al., "Effect of Long-term Cannabis Use on Axonal Fibre Connectivity," *Brain: a Journal of Neurology* 135, no. Pt 7 (July 2012): 2245–55, doi:10.1093/brain/aws136.

⁸⁴ Moffitt et al., "A Gradient of Childhood Self-control Predicts Health, Wealth, and Public Safety."

Mitigating the Health Consequences of Childhood Disadvantage through Educational Attainment

Jennifer Karas Montez, PhD, Case Western Reserve University

Educational attainment should be framed in the context of the entire lifespan. Chronic or acute early childhood circumstances can either have a direct link to adult health, or these early events can put an individual on a certain education trajectory, thus indirectly affecting adult health. Previous research has tended to aggregate adverse childhood circumstances or events together without considering the commonality of such events, or which ones contributed most to adult health outcomes. Dr. Montez hypothesized that the commonality and significance of early childhood adverse events could predict adult health outcomes.

MIDUS, a nationally representative longitudinal study, includes rich data on the number and types of adverse childhood events in the cohort population. The main types of adverse childhood events in this population were grouped together as follows:

1. Interpersonal (e.g., parental divorce, sent away from home)
2. Financial (e.g., parents unemployed, ever on welfare)
3. Death or illness of a loved one
4. Legal (e.g., prison)
5. Parental substance abuse
6. Physical or sexual abuse
7. Academic (e.g., ever expelled, flunked out, or dropped out of school)

Almost 50 percent of participants experienced at least one of these events and almost 25 percent experienced two or more events. The most common type of adverse childhood event was academic: 20 percent of all childhood events were related to suspension, expulsion, or dropping out of school. Furthermore, an analysis of which events impacted health outcomes most revealed that academic events significantly increased the odds ratio for diabetes, heart disease, and obesity. Even after an adjustment for educational achievement, there was still evidence for both a direct and indirect link between early academic adversity and negative adult health outcomes.

Can education mitigate childhood disadvantage?

Montez (2013) examined the extent to which educational attainment can compensate for adverse circumstances in early life. Data from the HRS, another nationally representative longitudinal study, demonstrated that each additional year of education had similar benefits for men's health (health was measured by functional limitations) regardless of whether men had low- or high-education parents. However, for any given level of a man's education, men with low-education parents had worse health than men with high-education parents.⁸⁵ In other words, although educational attainment was highly beneficial for men's health, it did not compensate for early-life disadvantages. The data suggested that education might not be as advantageous for women from families with low education mothers as it was for women from families with highly educated mothers. The mechanisms for this gender difference in health outcomes are not clear, although some evidence points to obesity. Dr. Montez mentioned that a growing number of studies have concluded that early-life circumstances are more consequential for women's than men's risk of obesity, regardless of adult circumstances.

⁸⁵ Jennifer Karas Montez, "The Socioeconomic Origins of Physical Functioning Among Older U.S. Adults," *Advances in Life Course Research* 18, no. 4 (December 2013): 244–56, doi:10.1016/j.alcr.2013.08.001.

The active life expectancy for white men at age 50 from the HRS study who experienced favorable childhood health was also examined.⁸⁶ Results demonstrated that more education increases good health beyond the age of 50. This increase in good health is tempered by the presence of SES adversities in a linear fashion (i.e., the more SES adversities, the fewer years of benefit from the same level of educational attainment).

Conclusions

Dr. Montez's results indicated that education cannot compensate for early adversity; individuals appear to carry the health consequences of early adversity with them throughout their adult life course. However, education appears to "level or better the playing field" among individuals raised in disparate childhood environments. For example, her recent work indicates that individuals who were raised in unfavorable childhood environments but then achieved high levels of education had better physical functioning and longer life expectancy than individuals who were raised in favorable childhood environments but then achieved low levels of education. Education is a powerful lever for improving public health among the disadvantaged. These findings support the view that "education policy is health policy."

Discussion

Eric Grodsky, PhD, University of Wisconsin-Madison

Dr. Grodsky thanked Dr. Montez for presenting a model of the benefits of educational attainment in overcoming adverse childhood circumstances. There are a number of possible confounders to consider when evaluating the results of Dr. Montez's research. For example, the age boundaries for childhood academic events are unclear. The academic events considered in her work include disparate experiences across a range of ages, including repeating a grade, suspension, expulsion, and dropping out. It is also unclear where the 'dropout process' begins.

The MIDUS cohort experienced a number of different adverse childhood events, with differing impacts across health outcomes. Dr. Montez's research demonstrated that academic events were strongly associated with health outcomes but did not identify a mechanism for this process. The association between academic events and health outcomes may be due to educational attainment; however, the measurement of educational attainment was too crude to differentiate between individuals with education levels that do not exactly match high school, college, or graduate school graduation.

Data from the National Longitudinal Survey of Youth 1997 (NLSY97) study includes more gradations of education in the 'more than high school graduation' category, including 'some college,' 'two-year degree,' 'four-year degree,' and 'some graduate school.' It is possible that the distribution of educational attainment above high school is related to childhood adversity.

Consideration of day-to-day disparities is important when evaluating the relationship between education and health. Previous work has demonstrated that disparities in achievement in 8th grade are similar to those found in kindergarten. Dr. Grodsky proposed childhood circumstances at work in this phenomenon in addition to those mentioned by Dr. Montez, including:

- **Maternal health:** Prenatal care, exposure to toxins, and maternal health behaviors, such as smoking, drinking, and nutrition, can influence educational and health outcomes.

⁸⁶ Montez and Hayward, "Cumulative Childhood Adversity, Educational Attainment, and Active Life Expectancy Among U.S. Adults." *Demography* 2014 51(2):413-435.

- **Sleep:** Sleep problems can exacerbate anxiety, depression, and externalizing behaviors in children. There are SES and race differences in the quality of sleep among children. The link between sleep and IQ is unclear; however, sleep does influence skill formation.
- **Nutrition:** Food insecurity and poverty can decrease both education and health outcomes.
- **Stress:** Maternal stress affects birth weight and can inhibit the maturation of neurons.

The hypothesis that *maternal* health policy is education policy is entirely consistent with Dr. Montez's assertion that education policy is health policy. The field does not require the strongest levels of evidence for the mechanisms underlying the relationship between health and education to move forward on policy decisions that can improve public health.

Outcomes

What Are the Educational Outcomes? What Are the Health Outcomes?

Mark Hayward, PhD, University of Texas-Austin

Dr. Hayward presented his perspectives on the historical relationship between education and health, how these relationships have changed from the past, and how the United States can improve them in the future, and introduced a conceptual framework for understanding the dynamic association between education and adult health. There is empirical evidence to support the dynamic nature of the association between education and adult health and there are implications of this evidence for measuring education and health in the future.

There are several critical issues to keep in mind when evaluating education and health in a historical context. Education and health associations are endogenous to larger societal changes in technology, the political economy, and changing national demographics. These associations have changed in fundamentally important ways in recent decades, but not equally, and not for everyone. The mechanisms underlying the relationship between education and health will very likely shift over time.

Technological and physiological improvements over the past 300 years have resulted in unprecedented control over the environment and an increased capacity for improved population health. Dr. Hayward examined who is most likely to take advantage of the growth in the social capacity for population health. Highly educated individuals are usually the first to learn new technologies, should be the best able to act on this new information, and are the most likely to have socioeconomic resources to take advantage of potentially expensive innovations. In an era of fast-paced technological change, health should be especially good among persons with more education. In this model, significant differences across population subgroups occurs because of the stratification of resources along racial and ethnic lines.

Historical changes to the functional form of associations between educational attainment and adult mortality

Dr. Hayward hypothesized that technological, social, and economic changes have resulted in changes to the functional form of the association between educational attainment and adult mortality. Changes in the functional form reflect the types of mechanisms behind education and health, whether the associations are more or less causal over time, and what types of macro societal changes contribute to these changes. Limitations of previous research include an assumption of the linear relationship between education and health and basing education categorically on events (e.g., high school graduation).

Three factors may theoretically influence the functional form. All three of these factors may be operating simultaneously to define the functional form and may vary over time and across social groups.

1. **Selection:** The education-mortality association is influenced by the characteristics of individuals with different levels of education.
2. **Exposure:** The continuous exposure to education lowers mortality risk by increasing cognitive function, access to information, social ties, and problem-solving skills.
3. **Credentialism:** Educational degrees may open up opportunities in the labor market that lead to more income and other societal rewards.

The 1973 study by Kitagawa and Hauser analyzed sex- and age-specific mortality ratios for white men and women by educational attainment in 1960. This data demonstrated a shallow gradient in the relationship between education and mortality; however, after 16 years of education, there was a significant drop in mortality. Women with a college degree or more demonstrated a large benefit in mortality; these women were a select group at this time point in history. Analysis of education and mortality in African Americans showed no benefit of education on mortality. It is possible that the social and economic position of African Americans in the 1960s lessened their ability to benefit from educational attainment.

The best model of the functional form in more recent history (1985) demonstrated that a three category measure (<12, 12-15, 16+ years of education) best predicted adult mortality. These results suggested that attainment of high school and graduate degrees (credentialist pattern) was the critical education factor associated with increased health benefits. More recent work by Dr. Montez from analysis of the National Longitudinal Mortality Study (1990 cohort) demonstrated a linear relationship between education up until graduation and a reduction in mortality, with a modest slope.⁸⁷ Attaining a high school degree was associated with a step reduction in mortality, followed by a steeper dose-response relationship between further post high school education and lower mortality.

Dr. Hayward presented his work on the functional form of the education and health relationship from the National Health Interview Survey-Linked Mortality Files (NHIS-LMF) cohort over two time periods (1986-1999 and 2000-2006). This data included information on 7.4 million person-years and 109,000 deaths and focused on the ages of 45-84. The results were separated by race (white and African American) and gender. Data from white males and females in both time periods demonstrated a similar functional form to that reported by Dr. Montez; there was still a step reduction after high school graduation, demonstrating strong credentialing effects. Data from African American men from 2000-2006 suggested the emergence of a new functional form with a linear, single-slope relationship between mortality and the number of years of education.

⁸⁷ Montez, Hummer, and Hayward, "Educational Attainment and Adult Mortality in the United States."

Data from African American women from both time periods followed a credentialing model almost exclusively, where degree attainment was the educational factor likely responsible for reduced mortality.

Conclusions

Dr. Hayward summarized his work by noting that shallow declines in mortality risk with less than 12 years of education were steeper post-2000. There were clear credentialing effects at 12 years of education for all groups, implying that high school degrees matter in an important way. Each additional year of education after high school was associated with reduced adult mortality risk for all groups excepting African American women. Finally, mortality among the most highly educated was low and is becoming even lower.

Changes in the functional form over time reflect changes in the larger social environment that may have brought new mechanisms into play operating at different parts of the educational distribution. Data from the 1960s demonstrated a modest educational gradient in mortality but only for white men and women. In the 1980s, data revealed the emergence of the credentialist model and the 1990s-2000s demonstrated the emergence of a combined credentialist-exposure functional form.

Dr. Hayward hypothesized that there is no inherent causal association between education and health but rather that specific historical and social contexts make it possible for educational attainment to have a causal effect on mortality. Evidence for current causal relationships between education and health are likely to be highly dependent on exogenous conditions that allow education to garner resources and deploy them.

Priorities for future research in this field include adding detailed questions to surveys regarding the influence of advanced education on health outcomes. The demographics of educational attainment may be changing as the prevalence of General Educational Development (GED) credentials increases and adults seek advanced education later in life. Approaches to consider in future population surveys include adding a set of measures to collect more information on the educational experience (time, place, educational content) and taking advantage of administrative data to collect corroborating information on the educational experience. It is important to place the significance of education for population health in a larger context, as these educational experiences have implications for labor market attainment, quality of social relationships, and health risk behaviors.

Closing Discussion

Meeting participants generally agreed that intervention development and implementation is a complementary line of research that can exist concurrently with research attempting to better understand the mechanisms behind the relationship between education and health. Participants encouraged collaboration between education and health researchers to capitalize on existing evidence to design and implement effective and efficacious interventions.

Several participants noted that education and schooling occupy a large number of hours and years in a young adult's life. It is important to consider the nature of the educational system and how it shapes our children's values, norms, behaviors, and health.

The need for better data

Meeting participants agreed that more and better data are necessary to continue unpacking the complex relationship between education and health. Investments in childhood data will allow researchers to conduct high-quality analyses and better inform policy. Education and health data collection is an opportunity for local, state, and national agencies to work together and break down barriers in these traditionally siloed fields.

Participants also noted the importance of real-time data in designing a forward-thinking, responsive health and education system. The increase in electronic health record use and new health technologies should pave the way for more and better data for education and health research.

Closing Remarks

Robert M. Hauser, PhD, Division of Behavioral and Social Sciences and Education, National Research Council

Dr. Hauser encouraged more research on the effects of a variety of psychosocial characteristics on educational and health outcomes, including IQ, health literacy, and conscientiousness. He proposed that concepts such as achievement and IQ be considered cognitive variables critical to understanding the link between education and health. He expressed his interest in conscientiousness and noted that high school grades are a good measure of organization and conscientiousness. Data from the Wisconsin cohort demonstrate that high school grades correlate with mortality for individuals 18 to 70 years old. Conscientious children know how to consistently do the right thing, at the right time, and in the right way. These skills are critical to prepare children for challenges later in life.

Dr. Hauser remarked on other opportunities and challenges in the fields of education and health research. He noted the functional form that describes the relationship between education and health and recommended analyzing other relationships that might exhibit a similar functional form. The fascinating relationship between an individual's health and spouse's educational level is an excellent opportunity to unpack the underlying educational effects on health. Measurement error should also be considered in academic reports; the results of some studies have been so unexpected that the only reasonable explanation is that older individuals tend to lie about the level of their educational attainment. Lastly, the Affordable Care Act is an opportunity to analyze how increased access to health care affects morbidity and mortality.

While the relationship between educational attainment and health is robust, Dr. Hauser indicated that precisely how educational experiences affect individuals is endlessly variable. This variability is expressed within individuals, but also, and equally importantly, in the ways that environments interact with individuals (and groups) with variable educational experiences. The challenges and solutions for the future include developing frameworks that allow researchers to address existing gaps in a heterogeneous set of variables that includes educational attainment, health, morbidity, and mortality. He added that there are wide variations in health among the healthy, multiple sources of health and disease, both distal and proximate, and multiple causes of death. There are many disaggregated characteristics of education, health, and biology that deserve to be separated and analyzed. Analysis of these characteristics over the entire life course is necessary to move the education and health field forward.

Cora Marrett, PhD, National Science Foundation

Dr. Marrett thanked the social and behavioral science community for supporting this meeting on the relationship between education and health. Conveying the importance of behavioral and social research to better understand the relationship between educational attainment and beneficial health outcomes to the appropriate funding agencies is critical. Health and education should be matters of national interest and are necessary to retain our country's competitiveness in a global market.

The greatest challenges moving forward are to overcome the boundaries of Federal agencies, encourage collaborative research efforts, and engage in intervention development and implementation. Dr. Marrett encouraged meeting participants to think of possible intersections in current research and assist in obtaining the necessary resources to conduct this important work.

William Riley, PhD, Office of Behavioral and Social Sciences Research, NIH

Dr. Riley concluded the meeting by echoing Dr. Hauser and Dr. Marrett's call to harmonize the fields of education and health. He suggested researching other large epidemiological studies where the mechanisms of association are not clear and encouraged meeting participants to focus on clearly defining constructs to better understand the relationship between education and health.

Appendix 1: Meeting Agenda

Wednesday, June 4, 2014

- 8:45 a.m. Welcoming Remarks**
Robert Kaplan
- 9:00 a.m. Keynote Address**
“Education, Information, and Health”
Flávio Cunha
- 9:30 a.m. Plenary Presentations**
- 9:30 a.m. “Epidemiology of Education and Health”**
James House – presenter
David Kindig – discussant
- 10:05 a.m. “What Demographic Data and the Big-Picture Examination of Patterns and Trends Adds to Our Understanding of Education and Health/Mortality in the United States”**
Robert Hummer – presenter
Adam Gamoran – discussant
- 10:40 a.m. Break**
- 10:50 a.m. “Natural experimental studies of education on health”**
Mitchell Wong – presenter
Thomas Brock – discussant
- 11:25 a.m. “New data opportunities/next generation of data”**
Neal Halfon – presenter
John Haaga – discussant
- 12:00 p.m. Lunch**
- 1:00 p.m. Breakout Sessions**
- “Before first 1,000 days: Where on the age spectrum do you invest?”**
Jim Griffin – moderator
- “Global perspectives”**
Sharon Ramey and David Baker – moderators
- “IES data: availability and strengths of education data”**
Jeff Owings and David Baker – moderators
- “Interventions”**
Mitch Wong – moderator

- 2:00 p.m. Break**
- 2:15 p.m. Presentations on Potential mechanisms: Three Hypotheses**
- 2:15 p.m. “Neuroplasticity, Personality, and Habits”**
Gabiella Conti – presenter
Jason Fletcher – discussant
- 2:45 p.m. “Drug and alcohol use”**
Sandro Galea – presenter
Wilson Compton – discussant
- 3:15 p.m. “Mitigating the Health Consequences of Childhood Disadvantage through Educational Attainment”**
Jennifer Montez – presenter
Eric Grodsky – discussant
- 3:45 p.m. Break**
- 4:00 p.m. Presentations on Outcomes**
- 4:00 p.m. “What are the educational outcomes? What are the health outcomes?”**
Mark Hayward – presenter
Robert Kaplan – discussant
- 4:30 p.m. Discussion**
Robert Kaplan
- 5:00 p.m. Closing Remarks**
Robert Hauser, Cora Marrett, and Bill Riley
- 5:30 p.m. Adjourn**

Appendix 2: List of Invited Participants

David P. Baker, PhD, Pennsylvania State University
Thomas Brock, PhD, Institute of Education Sciences
Wilson M. Compton, MD, MPE, National Institute on Drug Abuse, NIH
Flávio Cunha, PhD, Rice University
Gabriella Conti, PhD, University College, London
Jason Fletcher, PhD, University of Wisconsin-Madison
Sandro Galea, MD, MPH, DrPH, Columbia University
Adam Gamoran, PhD, William T. Grant Foundation
James Griffin, PhD, *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, NIH
Eric Grodsky, PhD, University of Wisconsin-Madison
John Haaga, PhD, National Institute on Aging, NIH
Neal Halfon, MD, MPH, UCLA Schools of Medicine
Mark Hayward, PhD, University of Texas-Austin
James House, PhD, University of Michigan
Robert M. Hauser, PhD, University of Wisconsin-Madison
Robert A. Hummer, PhD, University of Texas-Austin
Robert Kaplan, PhD, Agency for Healthcare Research & Quality
David Kindig, MD, MPH, University of Wisconsin-Madison
Felice J. Levine, Executive Director AERA
Cora Marrett, PhD, National Science Foundation
Jennifer Montez, PhD, Case Western Reserve University
Jeff Owings, PhD, National Center for Education Statistics
G. Stephane Philogene, PhD, Office of Behavioral and Social Sciences Research, NIH
Sharon Ramey, PhD, Virginia Tech Carilion Research Institute
William Riley, PhD, Office of Behavioral and Social Sciences Research, NIH
Michael L. Spittel, PhD, Office of Behavioral and Social Sciences Research, NIH
Mitchell Wong, MD, PhD, University of California-Los Angeles
Tia Zeno, PhD, MPH, Office of Behavioral and Social Sciences Research, NIH

Appendix 3: Summary of Breakout 1

Where on the Age Spectrum Do You Invest?

Moderator:

Jim Griffin, NICHD

Participants:

Brett Miller, NICHD
Janet Currie, Princeton University
Martha Zaslow, SRCDC
Rose Marie Martinez, IOM
Steve Woolf, Virginia Commonwealth University
Bob Hummer, University of Texas-Austin
Derek Chapman, Virginia Commonwealth University
Jennifer Montez, Case Western Reserve University
Mark Hayward, University of Texas-Austin
Jonathan Scaccia, OASH/HHS
Gabiella Conti, University College, London
Dave Kindig, University of Wisconsin-Madison
Jason Fletcher, University of Wisconsin-Madison
Rosalind King, NICHD

Measures of health and education were historically collected as part of separate research efforts; in fact, these research silos have existed for more than 50 years. Impediments in large, population representative databases prevent the collection of health information from educational studies or education data from health-related research.

Several policies, including the Health Insurance Portability and Accountability Act of 1996 (HIPAA), limit the ability of researchers to connect educational outcomes data with health-related outcomes data from such databases as the Centers for Medicare & Medicaid Services (CMS). Several proposed changes to NIH Federal Policy for the Protection of Human Subjects (a.k.a. the Common Rule) would further hinder efforts to collect health and education data. Removal of geographical level data is a way to de-identify data; however, removal of this information reduces the richness of the dataset and limits the breadth and depth of research.

Several participants recommended the systematic collection of data through a collaborative effort between the U.S. Department of Education and the U.S. Department of Health and Human Services. These two large agencies are working on a population level to improve the well-being of American citizens. NIH should facilitate collaborations that improve data collection and harmonization across the fields of education and health.

NIH staff agreed with these recommendations and offered their perspectives on the separation of education and health research agencies and funding. Traditional silos in education include pre-school (ages 3-5) and elementary school (ages 5-11). Similar silos are evident in health research; almost every NIH Institute is named after a disease. Collaboration is a worthwhile goal; however, researchers should be mindful of the realities of working within long-standing government bureaucracies.

Some states and private organizations are spearheading efforts to track children across their educational lifespan (including pre-school; elementary, middle, and high school; college; and graduate school) and integrate this information with other health-related data. However, there is no national plan for the integration of health and education data and states are developing systems and policies without federal guidance. States that are paving the way for integration of health and education data can provide insights into the best mechanisms to achieve data integration on a national level.

Components of the Most Effective Health and Education Interventions in the First 1,000 Days

Educational and health disparities in children are evident by 24 months of age and are associated with SES, race, and ethnicity. Prior to 24 months of age, these disparities appear as differences in motor development; however, after 24 months, researchers can detect sizable differences in language skills. Interventions to improve the health and education of infants and toddlers must take place at the right time and place and with the right components.

It was found that earlier intervention programs involving home visitations were no longer feasible when both parents returned to work. In addition, undocumented immigrants were afraid to let educators and nurses into the home for fear of deportation.

Interventions that are intense and take place early in development are more successful; however, they are also more expensive. Examples of successful early interventions include intensive education centers that place a child in an enriched environment for the majority of the day. This childcare is accompanied by parenting sessions for mothers and/or fathers on their child's health and well-being. Interventions centered on child wellness exams are another possible mechanism to couple child health and parental education, although these exams may not occur frequently enough to change parent and child behaviors.

It is necessary to change the attitudes of parents, doctors, and teachers on the best ways to nurture a young child. Children from disadvantaged backgrounds are just as capable as children from advantaged backgrounds; however, disadvantaged children are not learning as efficiently. Interventions that improve social interactions also promote learning; these interventions include interactive reading and talking and removing distractions such as cellphones and television whenever possible.

Interventions should focus on the emotional as well as the cognitive development of the child. Some parents require education on the importance of attachment to their child and how their relationship will change over time. The initial purpose of pediatric care was for acute care and immunizations; however, developmental and behavioral problems need to be assessed as well. Some participants noted that to truly impact infants and toddlers, adult education is necessary before couples begin having children. The college setting provides a captive audience for messages regarding the importance of child health and education.

Interventions should also be practical; many evidence-based interventions have failed when implemented in the field. Deploying interventions on a larger scale requires the support of individuals, communities, cities, and counties to ensure that information and funds can sustain the intervention. Ultimately, the best interventions are sustainable, practical, and have beneficial effects that trickle down into subsequent generations.

Appendix 4: Summary of Breakout 2

Global Perspectives

Moderators:

Sharon Ramey, Virginia Polytechnic Institute and State University
David Baker, Pennsylvania State University

Participants:

Cora Marrett, National Science Foundation
Jane Costello, Duke University
Stephane Philogene, Office of Behavioral and Social Sciences Research, National Institutes of Health
Mike Spittel, Office of Behavioral and Social Sciences Research, National Institutes of Health
John Haaga, National Institute on Aging, National Institutes of Health
Wilson Compton, National Institute on Drug Abuse, National Institutes of Health

Relationships Between Education, Populations, and Disease

Causality and commonality theories regarding education, populations, and disease were discussed. A participant, doing research outside the United States and using demographic health survey data, discussed the education status of a population and the kinds of diseases that are related to education status. NIH research tends to focus on American populations, but in terms of science and policy, it would be advantageous to learn much more from global population studies.

While many researchers may concentrate on the relationship between disease and populations who are undereducated, his research has examined the relationship between well-educated populations and disease transition. As a population goes through a nutritional or epidemiological transition from infectious to chronic disease, the education health gradient first happens and then the traditional disease gradient will occur. Educated people will end up with the disease first, and then the disease will spread to other members of the population. However, educated people will then contribute to finding a cure and/or prevention strategies for the disease. Examples of this include the spread of HIV in sub-Saharan Africa and the spread of smoking in the United States. Educated males with more status and money first acquired the virus and spread it to females within various levels of African society. In the United States, educated people smoked first before members of the general population took up the habit. This construct argues for public health programs being targeted towards educated people as well as poorer members of the population.

It was postulated that education is driving populations toward chronic disease as a higher cause of mortality. Thus, education is a paradox—an educated population lives longer but has more chronic disease.

Educational disparities in society can become intensive. If there is a complex health care system and a lot of chronic disease, a lack of high school education often correlates to a lack of cognitive emotional development.

The Influence of Education and Delivery of Financial Resources on Children's Health and Development

The participants discussed the relationships between brain development, brain health, and education. Education could directly promote brain health. Physical activity promotes prefrontal cortex reasoning and many children who are not engaged in active education early in life are restricted, sometimes due to neglect. Investigations have been conducted on the 1990s Romanian orphans, who were confined to cribs and could not move about. Research has been done in the United States with children being neglected, such as not being physically active as well as not getting language or cognitive input.

The influence of enhanced financial resources on child development has been investigated in families with children on the Cherokee Indian Reservation in North Carolina. This population has its own health care and educational systems. The new financial resources came from the operation of casinos on the reservation. Children were studied from the pre- and post-casino development timeframe and children in Appalachian North Carolina were used as comparison populations. Families who had children in the family for 4 to 6 years while they received the new money experienced health and social benefits for those children. Behavioral problems and substance abuse rates went down among these children. Participants noted that studies over a long period of time where money was delivered directly to families had more beneficial impacts on the children than simply obtaining financial resources to build a new clinic and that these effects carried over into adulthood.

The participants also discussed the influence of enhanced financial resources on families in other countries. Older members of families with new pensions from the post-apartheid South African government enjoyed a windfall from the new resources, which also positively affected family members of all ages, including children. A similar trend was noted with former East Germans who started receiving pensions from the reunified German government, where both grandchildren's education costs and overall health well-being were positively impacted.

It was suggested that researchers could examine global models of health care money delivery for application in the United States. The countries of Finland, Denmark, and Norway were mentioned as examples. There are no children in residential care for mental health problems in Norway by law, as a home-based care approach is used instead. For mental health outcomes, Norway had only a third of the DSM-IV ("Diagnostic and Statistical Manual of Mental Disorders," fourth ed.) category mental illnesses as comparable children in the United States. This kind of research could examine natural variations in health and education levels in U.S. states and across other countries. Cohort longitudinal analyses could be performed within countries and U.S. states that might generate reforms in education or health policy, or both. This could represent a way to assess which diseases are sensitive to education levels and health, including genetics and physical environment.

A participant discussed her research on preconception research, which involved community, neighborhood, and psycho-social factors that affect a mother's readiness in terms of supporting healthy embryonic and fetal development. This research showed that such factors as stress could alter a mother's physiology prior to the time of conception, which could affect fetal development, and animal cocaine models have shown evidence for this. Animals have to be bred for six generations to characterize such an illness-deficit model. Many people have been marginalized through inadequate health and education supports for at least six to eight generations and these populations may need longer interventions in order to be helped. Short-term high school interventions may not help children within these populations. Whole-life

improvements in marginalized populations may not be helped as much by short-term investments. As shown by expenditures made by the state of Massachusetts, targeted investments in education can result in reductions in health disparities among minorities and between the genders.

The old “industrial model” of education does not work anymore. Education has shifted to a cognitively intense model. More evidence is needed to examine the larger effects of cognitively intense education. The cognitive load is higher and there are now greater expectations of children. Globally, the spread of mass schooling first initiated a demographic transition, which contributed to both lowered child mortality and fertility and led to longer lives. A second transition has resulted in lowered fertility below population replacement in some countries of the northern hemisphere. Without factoring in immigration patterns, developments in education have outweighed advances in industry in terms of lowered fertility and longer life expectancy rates. This situation has not been studied enough and needs more attention from demographers.

Differing Cultural Norms Affect the Conduct of Research into Health and Education

It is important that scientists examine locations that are doing better than expected and to assess the roles of health and education. In the United States, we look at health at the individual level and assume that individuals are in charge. Other cultures may regard health decisions as a community determination.

For example, it is a community-based decision as to when females should get pregnant in certain Alaska Native populations. The decision to educate the individual or the community on health-based topics depends on the cultural norms of the population in question.

Interventions through HIV education and early education are examples of implementation science. When a particular intervention creates the best of plasticity across the life force, how can countries adopt that approach quickly and with high fidelity? If the intervention is adopted poorly, it could be disruptive to society. Scientists need to study which approaches work best and why. If researchers segregate themselves too much by their study of an individual disease, their research might not be effectively conducted in an international setting with different belief systems. Consultation with researchers studying belief systems, as well as the integration of health and education, could be useful for studying individual disease cycles. A global perspective requires knowing systems in different countries and studying how science fits in. Health outcomes are dependent on both belief systems and the systems of care and not segregating the two.

Policy and Practice of Science

Overall population health could be enhanced through policy changes, science advances, or new treatment of illness approaches. In the United States, policy changes can occur slowly. European countries are often able to make policy-based decisions faster than the United States because of our three branches of government.

An example is the use of beta-blockers. These medications had good clinical trial results in the early 1980s. In other countries, heart attack patients received beta-blockers upon discharge from hospitals, but this only became common practice in the United States 20 years later after

individual doctors began prescribing beta-blockers. This is an example of clinical fragmentation that occurs in the American health system.

Global Versus Universal Perspectives

The participants had a variety of interpretations about the meaning of the word “global;” for instance, global perspectives may not include the United States and assumed constants about human well-being may not be universally accepted. Others said “global” includes the United States, which has 51 separate state health care systems that might be considered part of a “global” perspective.

It was suggested that there is a difference between global and international issues. Global issues do not have national boundaries (e.g., climate change) while national boundaries impact issues within nation states. NIH funds international studies that result in data that would not be available from U.S.-only studies.

Researchers and Sharing of Data

The participants expressed concern about data not being readily available to share. Research data is diffusely spread throughout the U.S. government, but at least six federal agencies have data-sharing arrangements. In addition, there are governmental guidelines about open data and publications. NIH has two competing data issues: individuals’ clinical data must be protected at all costs, but there is also increasing pressure for researchers to share data.

The issue of access to principal investigator’s (PI) data is complicated. Different levels of access exist regarding the sharing of PI data; many PIs will share data if funding is dependent on data-sharing arrangements. PIs should devise plans for data sharing that safeguard privacy, but financial implementation of such plans also needs to be established. Public access to datasets that were meant to remain private can also be problematic.

Datasets from one study involving 25 countries were discussed. Data are shared as long as there is an agreement in advance regarding openness and payment is forthcoming if data are not closed.

Appendix 5: Summary of Breakout 3

Institute of Education Sciences Data

Moderator:

Chris Chapman, National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education

Participants:

Thomas Brock, National Center for Education Research, Institute of Education Sciences, U.S. Department of Education

Eric Grodsky, Department of Sociology, University of Wisconsin-Madison

Robert Hauser, Division of Behavioral and Social Sciences and Education, National Research Council, National Academy of Sciences

Veronica Irvin, Office of Behavioral and Social Sciences Research, Office of the Director, National Institutes of Health

Robert Kaplan, Office of the Director, Agency for Healthcare Research and Quality

Institute of Education Sciences

The IES in the U.S. Department of Education was established under the Education Sciences Reform Act of 2002 to consolidate the department's education research efforts into one entity.⁸⁸ The IES consists of four centers: the National Center for Education Research (NCER), the National Center for Education Statistics (NCES), the National Center for Education Evaluation and Regional Assistance (NCEE), and the National Center for Special Education Research (NCSER).

The mission of the IES is to provide rigorous and relevant evidence to inform education practice and policy and share this information broadly to ultimately improve educational outcomes for all students, and particularly for those at risk of failure. The IES operates with the counsel and oversight of the National Board for Education Sciences.

The four centers housed in the IES communicate and collaborate and staff members are working on improving the existing integration of efforts. For example, the NCES regularly interacts with NCSER to ensure that NCES-developed surveys incorporate the latest research findings on disabilities and special education and to inform the special education research field about available data products.

IES Studies

The NCES collects and maintains a wealth of education data that is publicly available to researchers.⁸⁹ Almost all NCES data contain information on disability status based on the

⁸⁸ More information about the IES is available at <http://ies.ed.gov>.

⁸⁹ Information about the NCES, including access to datasets, instruments, and training products for researchers, is available at <http://nces.ed.gov>.

categories defined in the Individuals with Disabilities Education Act (IDEA):⁹⁰ autism, deaf-blindness, deafness, developmental delay, emotional disturbance, hearing impairment, intellectual disability, multiple disabilities, orthopedic impairment, other health impairment, specific learning disability, speech or language impairment, traumatic brain injury, and visual impairment, including blindness. However, in many datasets, the sample sizes for low-incidence disabilities are too small to enable analyses of subgroups.

Early Childhood Longitudinal Studies

Given the close relationship between physical health and cognitive development, the NCES has included the collection of health data in its longitudinal studies of early childhood. For example, the Early Childhood Longitudinal Study-Birth Cohort (ECLS-B)⁹¹ began collecting data on a nationally representative sample of 14,000 children born in 2001 and followed them through kindergarten. The ECLS-B included measures of children's cognitive, physical, and social and emotional development in the home, childcare, and school settings at four time points (9 months, 2 years, 4 years, and once enrolled in kindergarten). Data collection methods included direct assessments, observation, and parent/caregiver interviews or questionnaires.⁹²

Health data were collected in four domains in the ECLS-B: diet, physical activity, weight, and general health. Examples of information collected in each domain include:

- *Diet*: breast or formula fed, skipped meals, household food sufficiency, and access to food;
- *Physical activity*: how often engaged in physical play, organized physical activities, and recess time in and/or time in physical education class in non-parental care settings;
- *Weight*: direct measures of height, weight, and upper arm circumference, calculated body-mass index (BMI), mother's weight before, during, and after pregnancy; and
- *General health*: parent assessment of overall health relative to other children of the same age, access to health care, vaccinations, health insurance, frequency of physician and dentist visits, and sleep habits.

Most NCES studies of individual young children also collect household information about access to the Supplemental Nutrition Assistance Program (SNAP), the Children's Health Insurance Program (CHIP), and State Children's Health Insurance Programs (S-CHIP).

Long-term follow up of this cohort would be difficult but not impossible. The sample was determined using birth certificate information from state vital statistics records and required clearance from each state-level Institutional Review Board, which provided an extensive sampling frame but posed logistical hurdles. For future birth cohort studies, the NCES is considering starting with hospital records to avoid the limitations of using state vital statistics. ECLS-B data products are considered to be restricted because of the use of vital statistics.

NCES also has two early childhood longitudinal kindergarten cohort studies with nationally representative samples of children attending public and private schools. The Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K) followed these kindergarteners through 8th grade. The Early Childhood Longitudinal Study, Kindergarten Class of 2010-11

⁹⁰ The most recent reauthorization of IDEA was in 2004. The original law upon which IDEA is based is the Education for All Handicapped Children Act of 1975 (PL94-142). Information about IDEA 2004 is available at <http://idea.ed.gov>.

⁹¹ Information about the ECLS-B is available at <http://nces.ed.gov/ecls/birth.asp>.

⁹² Instruments used in the ECLS-B are available online at <http://nces.ed.gov/ecls/birthinstruments.asp>.

(ECLS-K:2011) will follow these kindergarteners through 5th grade (2015-16 school year).⁹³ These studies have many of the same design elements as ECLS-B, although some of the health measures are less detailed. Data collection for these cohorts includes basic information on the same four domains of diet, physical activity, weight, and general health. These data are available for public use because the sample was not drawn from state vital statistics.

As noted, ECLS-K:2011 was recently initiated and is ongoing. One major change between the first and second kindergarten cohorts is that the first cohort included direct measures of fine and motor gross skills, but in the second cohort, the NCES decided to include a measure of executive function instead. The NCES is ending the second kindergarten cohort in 5th grade, rather than 8th, because attrition rates are high as children move to middle schools. There are many challenges associated with following children as they progress through different schools. Initial study cooperation is gained from the elementary schools; however, by middle school, the same sample is spread among multiple schools, most of which did not originally agree to participate in the study. This and the natural transiency of students lead to significant attrition. The NCES is now planning to set up synthetic cohorts to address these issues. The Middle Grades Longitudinal Study of 2016–17 (MGLS:2017) is being designed for a 6th grade cohort starting in 2016-17, where the ECLS-K:2011 cohort leaves off, and is expected to cover associations between contextual factors and student outcomes.⁹⁴ The NCES intends for researchers to link these data across the synthetic cohort models.

High School and Beyond

The ECLS cohort studies contain the richest health information of all of the NCES studies. However, there are some health data included in a set of NCES longitudinal studies of older students and young adults, starting with the National Longitudinal Study of the High School Class of 1972 (NLS-72), which covered these high school seniors through 1986.⁹⁵ Data were collected on general health (self-rated), access to health care, and health insurance status. In addition, the NCES recently started including functional definitions of disabilities in its longitudinal studies of older children and young adults (i.e., problems dressing, bathing, or walking) rather than only including IDEA-defined disability categories. Functional disability data are hugely important for calculating disability-adjusted survival rates, which could make this data valuable to health researchers.

Dr. Grodsky is helping to design and field a follow up to the High School and Beyond (HS&B) study, a panel study of a nationally representative sample of adults who were first surveyed as high school sophomores in 1980 in an original cohort sample of 14,825. The follow up will include measures of health limitations for work and school, a global subjective health assessment, blood pressure, and other health-related items. Sample consent and data collection efforts are ongoing.

Cross-Sectional Studies

The NCES also fields cross-sectional studies that allow for correlational analyses and static international comparisons. One study that includes health data is the Program for the International Assessment of Adult Competencies (PIAAC). The PIAAC comprises a nationally representative sample of adults to examine the basic competencies needed to function in a

⁹³ Information on the ECLS-K study is available at <http://nces.ed.gov/ecls/kindergarten.asp> and about the ECLS-K:2011 study at <http://nces.ed.gov/ecls/kindergarten2011.asp>.

⁹⁴ Information about the forthcoming middle school study is available at <http://nces.ed.gov/surveys/mgls/>.

⁹⁵ Information about NCES high school and beyond studies is available at <http://nces.ed.gov/surveys/hsb/>.

modern society. Measures in four domains are included in the U.S. administration—literacy, numeracy, problem solving in technology-rich environments, and reading components. The PIAAC interview contains some questions specific to health, such as a self-assessment of general health, access to health care, and use of basic medical treatment in the past 12 months.

The National Assessment of Educational Progress (NAEP), also administered by the NCES, contains information about disabilities and assessment scores that also may be relevant for health-related issues.

Discussion

Data Access and Use

Information on NCES data usage was not readily available during the breakout session. Most data are available to the public freely, although some data products, such as the ECLS-B, are available on a restricted-use basis. Researchers may access restricted-use data for free once a data-use agreement (DUA) with the IES is established. DUAs are issued fairly quickly; most are processed within a week or two.

Impact of Electronic Records

Dr. Kaplan observed that there have been many recent improvements in the availability and use of electronic health records for research and quality improvement. He learned from the recent Health Datapalooza⁹⁶ meeting that many restrictions on data for public use have been relaxed in the last few years, resulting in remarkable changes in health care. It is unclear if the same revolution of data availability and access is happening in the field of education research. States maintain a wealth of education data and some do have sophisticated electronic systems for doing so; however, each state sets its own data-sharing rules, which vary and can change over time.

Opportunities for Interagency Coordination

Dr. Hauser noted that a NAS panel on the Design of the National Children's Study and Implications for the Generalizability of Results chaired by Greg J. Duncan (University of California-Irvine) plans to issue a report on June 16, 2014.⁹⁷ The NCES has advised the National Children's Study on early cognitive assessments.

Drs. Kaplan and Grodsky raised the possibility of great potential for NIH to communicate, coordinate, and even possibly co-sponsor studies and data collection efforts. For example, NIH might be interested in funding an expanded health module in a planned NCES longitudinal study. Several NIH institutes and centers are listed as collaborators and sponsoring agencies for the ECLS-B and ECLS-K:2011 studies on the NCES website. For example, NIH contributed significantly to the health content of the ECLS-B study and the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD) supported oversampling of subgroup populations and a self-administered questionnaire for fathers. Chapman indicated that the IES is always open to such discussions but noted that often in its longitudinal studies, time with respondents is limited; therefore, adding questions or assessments may not be feasible.

⁹⁶ Information about Health Datapalooza is available at <http://healthdatapalooza.org>.

⁹⁷ Information about the NAS Panel is available at http://sites.nationalacademies.org/dbasse/cnstat/currentprojects/dbasse_084432.

Alternatives to School-Based Samples

Given the challenges of using school-based samples (e.g., transiency and lack of incentive for schools to which students have transitioned to provide access and participate), Dr. Grodsky inquired about the feasibility of maintaining the panel without the schools. Chapman noted that in-person interviews and direct assessments were conducted in each child's home for the ECLS-B cohort and that strategy could be explored again. However, home visits would increase costs such that the sample size would likely need to be halved. The middle and high school follow up studies rely heavily on administrative records and minimize the need for in-person follow up, which, along with the synthetic cohort design strategy, is intended to reduce attrition.

Appendix 6: Summary of Breakout 4

Interventions

Moderator:

Mitchell Wong, University of California-Los Angeles

Participants:

Adam Gamoran, William T. Grant Foundation

George Isham, HealthPartners, Inc., & Institute of Medicine Roundtable on Health Literacy

William Riley, Office of Behavioral and Social Sciences Research, National Institutes of Health

Alina Bacin, Institute of Medicine, the National Academies

Pamela Russo, Robert Wood Johnson Foundation

Michelle Larkin, Robert Wood Johnson Foundation

Jose Montero, Division of Public Health Services, New Hampshire Department of Health and Human Services, & Association of State and Territorial Health Officials

Martha Gold, City College, New York

James House, University of Michigan

Mary Pittman, Public Health Institute

Participants covered the future agenda for education and health and discussed new ideas and opportunities for research as well as future directions. Discussion centered on four main themes related to age-appropriate enhancements to health and education outreach, successful interventions, business sector involvement, and the way forward for education and health care collaborations.

Age-Appropriate Enhancements to Health and Education Outreach

A presentation in the main meeting discussed how children's vocabulary skills depend on how much their mothers interact with them. It would be interesting to measure the interactions and levels of conversation between the parents of children in a pre-school or daycare setting and also to assess what the average child is exposed to in such a situation. Such evaluations would be relevant from a policy perspective and could have significant implications.

Parental involvement and other contextual influences that impact children matter to the Commission to Build a Healthier America (Robert Wood Johnson Foundation) and some of their recent recommendations include investing in the quality of early childhood education and making sure that children get the support they need, whether it's the enthusiastic educator, their parents, grandparents, or another caretaker. In terms of programmatic interventions, longer term studies on the right approaches are needed to really know what makes a difference.

In education/health blend areas, there is a lot more emphasis on healthy foods and on physical activity being more systematic, but there is also enhanced awareness of the need for protective mechanisms. More work is being done on toxic stress issues and the stability factor, and more exploration could be done on whether or not pre-school provides a sense of stability to children who may not have it in their home lives. Some of the resiliency principles that are applied to communities around preparedness and reactions to natural disasters are how teachers and interventionists actually work with children to adopt their social and emotional learning and

reinforce that resiliency throughout life. The practices that actually work need to be identified to discern “what makes the difference for the kids.”

The Health Resources and Services Administration (HRSA) has been advocating for home visits to target at-risk families and neighborhoods and parents in a one-to-one setting. That can be expensive but it works and shows success when these parents are given structure and shown how to take care of their children or how to react in a crisis. It works not just for that child, but for the next child, and starts to modify the circle of parents. There is not enough data to show how this is working at a state level yet, or to correct that data, and the systems that are used for data are not sensitive enough to determine which approaches work best. The data do not “talk” to each other—it’s health data here, education data there—but Head Start has a lot of data from studies that have assessed blended interventions and blended outcomes.

There seems to have been a very exclusive focus on early childhood, while over the last 30 years the nation’s financial situation has worsened, health costs have soared, and the overall population’s health has declined. It appears that a lot has happened “not just to little kids, but also the big kids, and it all makes a difference on whether or not kids make it through high school.” The collapse of financial supports was also cited; in 1965 or 1970, it was relatively rare to take out a personal loan to go to college. State universities used to educate students for \$125 a semester and now they charge \$22,000. The fixation on pre-school was questioned because of the range of ages for students who struggle their way through middle school, high school, college, or beyond.

Participants maintained that a single-generation approach is not sufficient; multi-generational considerations come into play along with selecting the right metrics. Certain upstream policy decisions might have made it more difficult and provide less support for people and some of these decisions might preclude people from being able to take advantage of financial supports. The federal drug policy and the exclusion due to a mistake made at a young age guarantee upstream policy challenges that disallow participation in an advanced education.

There is a skill set involved in being verbal and being successful. In a clinical doctor-patient setting, doctors could do better in giving health advice but they relate better to people who are more similar to themselves in terms of educational achievement. In the school setting, a verbal child would attract the attention of teachers, which leads to more interaction.

Sampling of Successful Interventions

Collaborative efforts to improve health outcomes through education and education outcomes through better health must involve a discussion of disparities. The agenda should be about suggesting the kinds of interventions that might use education as a tool to help with health disparities, or conversely, identifying health interventions that could be used as a tool to reduce education disparities.

An example was shared of a middle school intervention at a low-income school that had the students write a paragraph that was self-affirming and this had an impact on educational achievement that lasted 2 years. Psychological intervention has been replicated, as shown in an article by David Yeager and Gregory Walton, “Social-Psychological Interventions in Education: They’re Not Magic.” There are a set of limited interventions that have powerful effects. Self-affirmation exercises used to reduce the effects of stereotyped threat—where children see themselves as members of a social category and have internalized the stereotype that people in that category perform worse—are especially effective when there are high-stakes tasks to be

performed. Many large laboratory experiments have shown that if young people get to see themselves as multi-faceted individuals, then the stereotype does not have the power to disrupt their performance of the task. The writing exercise in the treatment group was to write about values (family, friends, or sports) and why they are important, so students see themselves as multi-faceted individuals. In the laboratory experiments that aimed to reduce disparities, the effects were not quite as powerful as in the field, but a one-hour writing exercise intervention did reduce disparities by 20 percent among Asian, white, black, and Hispanic students.

Through a gambling intervention restriction, treatment modalities provoked individuals to have a range of experiences. Individuals' strengths and weaknesses across many areas can be tested and self-knowledge of these ranges is beneficial. When someone fails at something, they can then contrast a weakness with his or her strong areas and build on a baseline of resilience.

One participant said it is a stretch from the topic of educational interventions to prove a health outcome, or for health interventions to prove an educational outcome, but others disagreed and said that schools are providing those experiences for children.

The first presentation of the day mentioned that the whole litany on associations is largely unknown to most health care professionals with 97 percent of the resources. The first intervention ought to be about awareness around that fact, and would involve boards of directors of community organizations and getting people to talking about associations. A second intervention would bring up the mechanisms and hypotheses about how these approaches work. The distillation of potential mechanisms as presented at the meeting seemed provocative in terms of what might be done in our health system and how resources might be allocated, but the potentials of the two-way relationship between health and education should be pursued. A third intervention might begin a conversation about the kind of structure needed in government (federal, state, and local) to begin to bring together the data and the conversations in a way that is more effective in terms of macro interventions.

Some states share their public health and education data and others have a total firewall. There are also different interpretations regarding the Family Educational Rights and Privacy Act (FERPA) and the flow of information versus not sharing information.

Families do not understand the importance of anticipatory guidance in terms of well-child care, and this technique might be added to pediatric clinical practices. Perhaps anticipatory guidance should become part of pediatric training and help educate clinicians who need to understand the blended issue of education and medicine. For example, pediatricians could model reading a book to a child and this might translate to the parents who tend to take a clinician's advice seriously. Such a pediatrician-driven approach might be synthesized into best practices.

One participant said there is a commercial vendor that makes developmental indicator charts and commented that there is no standardized guideline in the United States for pediatric development charts. Another participant countered that there is the Denver Developmental Test.

Discussions on the meeting's section on changing the models of care elicited numerous ideas and suggestions: ambition is the best tool, but the tools are so expensive; different connections and systems can be used, including health coaches; and different pilot approaches can be tried, like in Atlantic City with gambling. Innovative types of resources and educational approaches are being used to test one-to-one interactions with adults and children. On the public health side, there are attempts to moderate the outreach workers' approach and change their focus, including going to where the families are and also getting into the schools to target a systemic

intervention for both families and children. There is higher access to younger children than when they are older, even for vaccinations. What is needed is twofold: getting practitioners to a basic level of knowledge that encourages use of interventions and taking a systematic approach that would result in better access to youth at all ages. One participant met with the heads of Shasta County's Office of Education and Department of Public Health in California to gain better access to all ages but was told "that's not our priority" and that they do not have the resources.

As for education affecting health, there were questions about intervention approaches that would emphasize critical thinking over non-cognitive skills, such as resiliency, patience, grit, and self-control. For example, one approach might target literacy or the ability to do math problems that can positively impact a different health trajectory; another might focus on the educational environment of a school and how their approaches translate.

On health literacy, the parent-child interactions are critical. Smoking and health interventions have been a big success and part of that has involved public education. A participant said that smoking interventions were not done well at the clinical level; the focus was more on economic and normative factors as well as constraints on what people can do and cannot do. Comparative effectiveness needs to be assessed, from medical health trends of treatments to a broader range of treatments, and comparisons can be made across various approaches.

In Minneapolis-St. Paul, clinics overlap with numerous school districts. Discussion ensued on involving individual clinic staff with co-located schools and school districts while convincing the school districts to use research-based mechanisms and try incremental interventions. Again, the appropriate model is tobacco. In the 1990s, the Centers for Disease Control and Prevention (CDC) instructed the health care delivery system to "ask and advise" every patient encountered. In districts with overlapping municipalities where smoking legislation was being put forward, doctors were sent to city council meetings to testify on indoor smoking. This model suggests that a grand-scale strategy template could be tested by first trying a smaller scale intervention to get people engaged, then testing and funding it. The Robert Wood Johnson Foundation played a huge role in this area and it was a bottom-up strategy across the country from communities to the state levels. This campaign gave the chance for economics and policy people to evaluate the effects of different changes (such as a tax on cigarette sales across states) on communities and led to quasi-experimental evaluations of real policy interventions.

Education policy makers have been trying out all kinds of changes in terms of funding and charter schools and outcomes in any given state should be assessed. Michigan disinvested \$55 billion, taking it out of state and local funding for public services over the last two decades, and most of that was cut from education and roads. In the mode of fund cutting, comparisons of the approaches taken by Michigan and Minnesota could be evaluated. There are varying views on the top-down versus the bottom-up approaches. Available funds have to be used wisely, but both the top-down and bottom-up approaches are viable and adaptable to different funding realities.

Without knowing the mechanisms that should be targeted and identifying the most robust mechanisms, it may be premature to think about interventions. Yet small-scale interventions can be tried to test competing theories, just as companies use research and development to test things out. Head Start is contentious in terms of viability, but it is worth the effort to figure out which programs work and why, and how to replicate what works in communities that do not have the infrastructure or the social networks necessary to make for a successful intervention.

Business Sector Involvement

The business sector is becoming more engaged because early childhood through middle school youth are being viewed as their future work force, so there may be opportunities to do some evaluations of certain investment-driven interventions. In Spokane, WA, the Chamber of Commerce has partnered with the education system and its health care and medical university system. The chamber has committed to making sure that every Spokane-area child graduates from high school and gets a secondary degree. Part of this effort comprises measures around health outcomes and part has to do with educational achievement. There is a program in place for early intervention with the child that involves the family, teachers, social services, and health care services. The partnership includes the truancy board, which uses a data system to track absenteeism, and the sheriff's department is also involved where needed. Business joined with the education, health care, and public health systems to make a difference. The reasoning was driven by the economic viability of the community, the ability to retain locals who would return after higher education, and as a vehicle to attract industry and secure jobs. The government is not paying for this effort; some community colleges and charter schools give scholarship funds, but it is not funded by any one source. So some interesting evaluations can be made on the Spokane partnership.

Another participant brought up the example of the Target store chain, which donates 5 percent of its profits to education. The question of approaching Target from a guidance standpoint was raised. An evidence-based "grading" of Target's education investments could be offered against a standard of best practices. Such an approach would involve "grading them to guide them." Further ideas covered the best ways to broach the subject with Target or IBM.

Education and Health Care Collaborations—the Way Forward

A participant said that education and health care interventions should ideally not be done with just one age group—there needs to be the ability to keep reinforcing a positive influence. The dose effect needs more research; it is not static for all people and it has to be varied based on different factors, but there is very little literature available on anything other than early childhood programs. The real challenge is how to best study and evaluate things that happen so early in life when the things that matter most happen later in life?

One participant said there is so much money for health care but not prevention, "paying for the repair work but not the maintenance or prevention." However, another participant maintained that the largest federal public expenditures are for health care and insurance (the largest), then education, income support programs, and national defense. The consensus was that there are not enough dollars in public health to do prevention; there is not a lot of money in education, but there is money to support the infrastructure for daily education; not all policy changes have to cost money; and more up-front investment is needed for health care.

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