

## LINKING HEALTH AND EDUCATION

Commentary on "Childhood Infections and Subsequent School Achievement Among 598,553 Danish Children"

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The study by Köhler-Forsberg et al<sup>1</sup> is an interesting and valuable contribution to the literature exploring the interplay between health and education. Using a registry-based dataset comprising almost 600,000 individuals, the authors analyze the association between childhood infections and educational attainment. Their exposure indicators include hospitalizations for infections and redeemed prescriptions for anti-infective agents. Their outcome indicators include rates of 9th-grade completion and 9th-grade test scores among completers.

The study's strengths include its large sample and its rich indicators of health, education and a host of social and economic variables. These attributes of the dataset allow the authors to control for numerous potential confounders, from birthweight to parents' educational attainment to mental health diagnoses to whether a child was the first born in his or her family. Its longitudinal nature facilitates tracking the associations between infections early in life and subsequent outcomes.

Notwithstanding a few puzzling results—for example, prescriptions for anti-infective agents demonstrating a positive association with 9th-grade completion rates but a negative association with 9th-grade test scores—the findings point fairly uniformly toward childhood infections tending to impinge on educational outcomes. As hypothesized, greater numbers of hospitalizations and longer durations of stay tend to be linked to worse educational outcomes. The study reports precise estimates, although the magnitudes are rather modest in size. For example, each hospitalization is linked with test scores that are only about 2.8% of a standard deviation lower, while the corresponding figure for each redeemed prescription is only 0.4%. But results are robust in sensitivity analyses.<sup>1</sup>

Overall, the estimates are in line with a well-established literature pointing to the importance of health as a mediator for the accumulation of human capital via education. The notion of human capital is one of the best-established constructs in the field of economics. It refers to the skills and capacities embodied in people that have productive value. Adam Smith, the father of modern economics, wrote about this notion over 2 centuries ago in *The Wealth of Nations*. This line of inquiry has been carried forward through time and has been celebrated via multiple Nobel Prizes in Economic Sciences, including those awarded to Theodore Schultz in 1979 and to Gary Becker in 1992.

The earlier work on human capital focused on schooling and formal and informal training as its main generators. However, a seminal article by Mushkin<sup>2</sup> elevated the notion of health as another important aspect of human capital.

Bloom and Canning<sup>3</sup> note that perhaps the most obvious contribution of health to human capital involves good health directly improving workers'—and, by extension, entire

economies'—productivity. But the study by Köhler-Forsberg et al<sup>1</sup> shows that health bolsters the productivity and value of human capital that comes from elsewhere—specifically, from education. Bloom and Canning<sup>3</sup> note that, if one is healthy, one is less likely to miss days of school, will likely attain more total education and will gain more from each day spent in school. The incentive to invest in education also tends to be higher when mortality is lower (ie, when life expectancy is higher).<sup>3</sup> In this sense, health is a conduit to, in addition to a form of, human capital. The value that health has as human capital is therefore magnified through its value for education. This link is the main focus of the study by Köhler-Forsberg et al.<sup>1</sup>

One corollary of the finding that negative health shocks hinder human capital accumulation is the observation that preventing these negative shocks would naturally protect human capital. While this point applies broadly to any health-promoting or health-protecting intervention, vaccination represents one of the best case studies available.

Evidence suggests that vaccination can impact human capital through improving educational attainment and performance. As a representative example, a study in the Philippines finds that childhood vaccination tends to improve teenagers' cognitive ability as measured by test scores.<sup>4</sup> Translating the teenagers' higher test scores to eventual earnings suggests a rate of return to spending on vaccination of 21%.

As reported by the World Health Organization, Denmark's 2016 vaccine coverage rates exceed those of the European region as a whole for all reported vaccine doses except the second dose of a measles-containing vaccine [which, at a difference of 3 percentage points, is plausibly within a reasonable (but unreported) margin of error].<sup>5</sup> These high coverage rates are partially a result of Denmark's high income; indeed, its per capita gross domestic product is currently the 9th largest of any country, just ahead of Singapore and just behind the United States.<sup>6</sup> However, the results of this study, and of other studies as well, suggest that the health generated by high vaccination rates is not just a consequence—but also a cause—of high income.

Such high vaccination coverage has surely prevented great numbers of the infections that Köhler-Forsberg et al<sup>1</sup> link to educational attainment and test scores. Improved educational outcomes represent just one of the many kinds of benefits that vaccines provide. Bärnighausen et al<sup>7</sup> note that economists have traditionally captured only a few of these benefits. Building on these insights, we find that analyses typically capture only 2 benefits: healthcare cost savings and health gains.

However, vaccination leads to myriad other (broad) benefits. Table 1 lists and briefly describes some of them.

Although a full discussion of these benefit categories is beyond the scope of this commentary, the central point is that vaccines impart many more benefits than economists tend to capture.

The implications of this broader framework for economic analyses of vaccination are profound. To cite just 1 example, Bärnighausen et al (in a different article<sup>8</sup>) surveyed the literature on the value of *Haemophilus influenzae* type b (Hib) vaccination and found that it focuses almost exclusively on a few narrow benefits. They make rough adjustments to existing studies to account in part for benefits of Hib vaccine above and beyond avoided medical care costs. They also account for the fact that the Hib vaccine can be delivered in a pentavalent form with the diphtheria-tetanus-pertussis and hepatitis B vaccines, which significantly reduces costs related to vaccine transportation, storage, administration and waste disposal. Based on these calculations, they find that the vaccine's benefit-cost ratio changes from less than 1.0 to well above 1.0 for most existing studies.<sup>8</sup> In economic terms, this represents a decisive

**TABLE 1.** Narrow and Broad Benefits of Vaccination

Perspective	Benefit Category	Brief Description
Broad Narrow	Healthcare cost savings	Savings of medical expenditures
	Health gains	The intrinsic value of better health beyond its instrumental value for productivity and earnings
	Education gains	The value of improved school attendance, educational attainment and retention stemming from improved health. This is the category that the study by Köhler-Forsberg et al <sup>1</sup> most directly addresses
	Outcome-related productivity gains	The value of increased productivity (including both paid and unpaid work) that arises directly from improved health
	Care-related productivity gains	Productive time savings for patients and caretakers who are relieved of time spent on care and recovery
	Behavior-related output gains	The value of increased productivity that arises from economically beneficial behavior changes, such as lowered fertility rates or increased educational investment, stemming from improved child survival
	Community health externalities	The value of health benefits that accrue to anyone besides the vaccine recipient, including benefits from herd protection or a slowed pace at which antimicrobial resistance develops
	Community economic externalities	Benefits to macroeconomic performance and to social and political stability associated with improved child survival
	Prevention and amelioration of comorbidities	The health benefits that vaccine recipients enjoy when infectious diseases would have caused or exacerbated other health problems
	Reduction in nosocomial infections	The value of avoiding any nosocomial infections that the vaccinated individual would have contracted or spread had he or she or his or her friends or family members visited the hospital
	Risk reduction gains	The value of reduced uncertainty and associated anxiety to risk-averse individuals, along with the value to health systems of saving on emergency or outbreak preparedness when the risk of catastrophic health shocks is reduced
	Social preference fulfillment	The value society places on benefits accruing to certain social groups that vaccines disproportionately benefit, such as women, children or racial and ethnic minorities, and the value of improved social equality stemming from protecting these groups' health
	Outbreak control gains	Avoided costs that are associated with disease outbreaks, including the costs of quickly mobilizing human and health resources and educating the affected community.

The structure of this table follows the structure of Table 2 of ref. 7.

change from a recommendation against investing in the vaccine to a recommendation in favor.

One central obstacle to including broad vaccination benefits in economic analyses surrounds a lack of robust data that speak to the magnitude of such benefits. Indeed, Jit et al<sup>9</sup> note the “need to design the requisite methods and initiate the relevant studies as soon as possible given the increasing importance of broader economic indicators of vaccine impact in informing investment decisions about vaccines.”

The dearth of appropriate data makes studies like that by Köhler-Forsberg et al<sup>1</sup> especially valuable. Their study provides a basis on which to estimate the impact of averting infections on educational outcomes in Denmark. By coupling their results with estimates of the impact of those educational outcomes on productivity and earnings, one could estimate the full long-term cost of infections and the full benefits of vaccination and other interventions that prevent or treat those infections.

Many acknowledge the importance of both health and education to human well-being and progress. Indeed, the United Nations' Sustainable Development Goals include both good health (goal 3) and quality education (goal 4). These goals are not going to be achieved in silos, but rather in contexts that acknowledge and properly account for their interrelatedness. The study by Köhler-Forsberg et al<sup>1</sup> makes a nice addition to the evidence base in support of this notion.

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