Behavior change and reducing health disparities☆

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A R T I C L E   I N F O

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A B S T R A C T

The mission of the National Institutes of Health, “...is science in pursuit of fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce illness and disability”. A wide range of factors contribute to longer life and to less illness. Although estimates vary, most analyses suggest that only about 10% of the variation in health outcome is attributable to medical care. Further, medical care is most effective in addressing and preventing infectious disease and acute illnesses. Recent large randomized clinical trials often fail to demonstrate that medical care lengthens life expectancy. International comparisons suggest that life expectancy in the United States is increasing, but the rate of increase is falling behind that of other wealthy countries. Strategies for improving health outcomes include better dissemination and implementation of proven evidence-based interventions. Further, reduction of services that use resources but do not offer health benefits must be considered. The final section of this paper reviews evidence relevant to factors outside the health care system that may enhance life expectancy and reduce illness and the disability. The relationship between educational attainment and life expectancy is used as a case example. The potential of behavioral and social interventions for increasing life expectancy may be orders of magnitude greater than traditional medical interventions. However, considerably more research is necessary in order to provide persuasive evidence for the benefits of these programs.

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The mission statement for the National Institutes of Health is, “Science in pursuit of fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce illness and disability”. The mission statement has two clauses. The first refers to the basic science mission of developing fundamental knowledge. It explicitly includes the study of the behavior of living systems. The second clause is the applied aspect of the mission. It requires the use of knowledge to make life longer and to improve life quality. This commentary focuses on the latter component of the mission. Behavioral and social sciences play a crucial role in understanding variation in life expectancy and in contributing to the science of improving health-related quality of life (Kaplan, 2000, 2002; Kaplan and Coons, 1952; Kaplan et al., 1976, 2011).

I come to this task as an investigator interested in outcomes research. Outcomes researchers have a different perspective than other biomedical investigators. We look at outcomes with reference to only two central measures: length of life, and quality of life (Kaplan, 2000, 2002). The central argument is that the goal of medicine and public health is to lengthening human life and/or improve quality of life during the years that people survive. As simple as this perspective seems, it often leads to different conclusions in comparison to the traditional biomedical model. The outcomes perspective argues that physiological measures are only important if they relate to life duration or life quality. Blood pressure, for example, is a meaningful biological measure because it is highly predictive of early death or disability associated with myocardial infarction or stroke. Other measures less clearly relate to the twin objectives of improved life quality or lengthened life expectancy. Catecholamine variations in response to acute stress, for example, are less clearly related to the objectives that outcomes researchers focus on.

Another different perspective arising from outcomes research is the focus on all cause mortality as opposed to disease specific mortality (Kaplan, 1990). A variety of large clinical trials in medicine have demonstrated reductions in one cause of death but compensatory increases in other causes of death (Kaplan, 1994). Trials on screening mammography, for example, frequently show that breast cancer screening leads to a reduction in breast cancer mortality. Yet the same trials often fail to show that breast cancer screening increases life expectancy (Gotzsche and Jorgensen, 2013; Navarro and Kaplan, 1996). Although breast cancer deaths might be reduced, other causes of death are increased during the study period (Kaplan and Porzsol, 2008). Another example of this problem is illustrated by the Physicians Health Trial. In this study, approximately 22,000 physicians were randomly assigned to take 325 mg of aspirin every other day or to a placebo. When the data were first analyzed significantly fewer physicians in the aspirin condition had died of myocardial infarction. However, considering all

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causes of cardiovascular death, the number of physicians who had died was exactly the same in the aspirin and placebo groups (see Fig. 1). All of these deaths were within the study period and all were considered premature deaths. Aspirin changed what was recorded on the death certificate, but did not extend the life expectancy (Kaplan, 1989). Considering the specific cause of death (MI) would lead to the conclusion that aspirin was highly effective. From the outcomes perspective, aspirin had no effect. From patient’s perspective, we would argue that people and families are most concerned about the person's vital status and less concerned about a specific cause of death.

**US life expectancy in international perspective**

International studies of life expectancy have gained particular attention in the last few years. These studies tend to show that the life expectancy advantage experienced by American citizens has been on the decline. One study from the National Research Council considered current life expectancy for 50-year-old women between the years 1955 and 2010 (Crimmins et al., 2011). Current life expectancy is the number of years of life on average remaining once a milestone age has been reached. So, current life expectancy for 50-year-old women is the median number of years of life remaining following the 50th birthday. In 1955 Americans were about 12th in the world on this indicator. By 2006, they had slipped to about the 26th position, just below Korea and Malta. In a life expectancy comparison of 10 wealthy countries, American women were 3rd out of 10 in 1955, but they slipped to 9th out 10 in 2006. Among the many countries with more rapid increases in life expectancy were Japan, France, and Spain, Japan, for example, was considerably below the United States in 1955 and now is many years ahead.

In response to these findings, the NIH Office of Behavioral and Social Sciences Research (OBSSR), along with the National Institute on Aging sponsored another study that compared life expectancy in the United States against 17 peer countries (Woolf and Laudan, 2013). These comparison countries were primarily in Western Europe, but also included Australia, Japan, and Canada. The results of the comparison are quite disturbing. Among the 17 countries, the United States had the second highest mortality rate from noncommunicable diseases. Mortality from communicable diseases was fourth from the bottom for the United States. The United States had the third highest AIDS rates, exceeded only by Brazil and South Africa, and the AIDS incidence in the United States was 122 per million which is about nine times the average of countries in the Organization or Economic Cooperation and Development (OECD).

We have known for some time that US life expectancy at birth is not keeping pace with other developed countries. Although our life expectancies are increasing, the rate of increase is much slower than it has been in other economic competitors. This trend has been developing over the course of several decades. Perhaps the most surprising finding in the study concerned years of life lost prior to age 50. The committee considered international differences in the probability of celebrating a 50th birthday. On this indicator, the United States was last among the 17 comparison countries for both men and women. United States losses in life expectancy prior to age 50 are about double the rate observed in Sweden. Perhaps most disturbing is that this problem profoundly affects women. Fig. 2 shows the trend in years of life lost in 21 high income countries between the years 1980 and 2006. For men, the US started at the low end of the distribution and worked its way to the bottom. For women, the US started near the bottom and now has gone off the scale in relation to the comparison countries.

**What about advances in medical care?**

It is often argued that the United States has the very best medical care in the world. So, we would expect advances in medical therapies to address many of our health care problems. The difficulty is that recent clinical trials often do not support the level of benefit that the public expects from medical therapies. In fact, most recent large randomized clinical trials have failed to show the expected benefit of medical and surgical therapies (Gordon et al., 2013). One example is the ACCORD trial of aggressive therapy for the treatment of non-insulin-dependent diabetes mellitus (Action to Control Cardiovascular Risk in Diabetes Study et al., 2008). Patients were randomly assigned to standard therapy or to an intensive therapy. The intensive therapy significantly changed biological outcomes in the expected direction. Specifically, those assigned to intensive therapy had significantly lower levels of glycosylated hemoglobin. From a traditional perspective the treatment achieved its goal. However, long-term follow-up considered total mortality and deaths from cardiovascular disease. Considering all cause mortality, those assigned to intensive therapy had a higher probability of death in comparison to the standard therapy condition.

The ACCORD trial is just one of many randomized clinical trials with similar results. Trials considering intensive therapy for anemia suggest that agents that increase red blood cells do their job and bring hemoglobin counts toward normal. Yet patients in these conditions have a higher probability of renal failure requiring dialysis and other adverse outcomes (Druke et al., 2006). Large studies on hormone replacement therapy usually show that estrogen levels are raised toward normal premenopausal levels. Yet the consequences for patients, from an outcomes research perspective, are usually poorer rather than better (Chlebowski et al., 2003).

Another example is provided by the Prostate Cancer Prevention Trial (PCPT) (Thompson et al., 2013). In this long-term study, 18,882 men with prostate cancer were randomly assigned to the drug Finasteride or to a placebo. All of the men were followed prospectively for at least 15 years using the National Death Index. Initially it appeared that the drug had worked successfully. Just over 10% of the men who took Finasteride showed evidence of prostate cancer in comparison to nearly 15% in the placebo group. However, the number of deaths in the two groups was virtually identical: 78.0% versus 78.2%. The drug reduced the number of men with clinical prostate cancer but the purpose for taking the drug had worked successfully. Just over 10% of the men who took Finasteride showed evidence of prostate cancer in comparison to nearly 15% in the placebo group. However, the number of deaths in the two groups was virtually identical: 78.0% versus 78.2%. The drug reduced the number of men with clinical prostate cancer but the purpose for taking the drug in the first place was to reduce deaths. The analysis suggested that there was little progress toward that ultimate goal. Further, those men who took the active drug had significantly higher rates of complicating side effects.

A final example considers treatment for coronary heart disease. The causes of heart disease are well understood. There is an initial injury to the endothelial wall of the coronary artery. Plaque builds up and narrows the artery and this results in restricted blood flow. Often, a fibrous cap on the lesion ruptures and a blood clot forms, totally occluding the flow of blood to the heart muscle. One solution for this problem is to perform angioplasty by placing a stent in the narrowed artery. The stent holds the artery open so that nourishing blood flow can continue.

![Fig. 1. Total Mortality in the Aspirin Component of the Physician’s Health Study. Overall the number of physicians who died was identical in the Aspirin and the Placebo conditions (adapted from Kaplan, NEJM 1989).](http://dx.doi.org/10.1016/j.jypmed.2014.04.014)
It seems obvious that this procedure should reduce deaths associated with myocardial infarctions. Yet systematic studies do not always support this hypothesis. One of the most important studies was the Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluation (COURAGE) trial (Boden et al., 2009). In this evaluation, 2,287 patients who had objective evidence of narrowing of their coronary arteries were randomly assigned to undergo either angioplasty using a stent or to optimal medical therapy. The patients were followed for an average of 4.6 years and the primary outcome was death from any cause or a nonfatal myocardial infarction. Over the course of follow-up, 19% of the patients in the stent group died or had a nonfatal heart attack. In comparison, 18.5% of the patients in the medical therapy group died or had a nonfatal myocardial infarction. The difference between the groups was nowhere near statistical significance.

In summary, randomized clinical trials in medicine often produce unexpected results. In fact, the number of recent null or negative clinical trials significantly exceeds the number of trials supporting the use of the proposed intervention. Certainly, we need to continually evaluate promising new therapies. However, we also need to devote more attention to nontraditional determinants of health outcome. In the next section, some of these determinants will be reviewed.

**Dissemination and implementation research**

Behavioral and social interventions can be important factors in achieving better dissemination and implementation of therapies that may benefit populations. Perhaps this is best illustrated through studies on prevention of heart disease and stroke. More than 50 years ago, the results of the Framingham heart study were first reported (Kannel et al., 1961). The initial paper suggested that the major risk factors for heart attacks included tobacco smoking, high blood pressure, high serum cholesterol, and diabetes. We have made very good progress in the reduction of deaths from heart disease since the publication of the Framingham study. Much of this is attributed to reduced tobacco use. Although there has also been progress in controlling blood pressure and cholesterol, we still have a long way to go. For example, according to the National Health and Nutrition Examination Survey (NHANES), only about 80% of people who have high blood pressure are aware of this problem. Among these, only about 70% receive treatment, and among those treated, only about half have their blood pressure adequately controlled. If we multiply those aware, times those treated, times those controlled (0.8 x 0.7 x 0.5 = 0.28) it appears that only about 28% of the population with high blood pressure are being adequately treated.

Several analyses suggest that relatively simple interventions might have a profound effect on outcomes. One analysis by Woolf and Johnson argued that simple behavioral reminders can significantly improve patient and physician compliance to guidelines. The return on investment from the simple interventions is often impressive. For example, in the Woolf and Johnson analysis, the return on investment for the behavioral interventions was about seven times higher than the return for investing in the development of more potent cholesterol-lowering drugs (Woolf and Johnson, 2005). We certainly are in favor of continuing the search for better medications and surgeries. However, this evidence suggests that we also need to continue the quest for better behavioral and social interventions that might enhance health and reduce the expensive medical care.

**Determinants of outcome outside of the health care system**

Finally, extending life and improving the quality of life may require greater attention to factors outside of the health care system. As noted earlier, health services researchers have raised questions about the relationship between US health care expenditures and the return on these investments in terms of lives saved. Fig. 3 uses OECD data to graph total health care expenditures for various countries (x-axis) against life expectancy (y-axis). The United States is an extreme outlier in terms of expenditures. We spend more than 17% of our gross domestic product on health care, while most of our economic competitors spend about 10%. If the US reduced its expenditures to the level of most European countries, we would save over $1 trillion per year—or about the same level as the US total debt held by the People's Republic of China. However, despite dramatically outspending any other country, life expectancy in the United States is considerably below that in other developed countries.

A variety of different analyses estimate the proportion of health outcome attributable to factors within the health care system as opposed to factors outside of health care. Schroeder suggested that medical care accounts for about 10% of the variation in health outcome (Schroeder, 2007). Behavioral and social factors, according to this analysis, account for about 55%. Although the exact number varies, most analyses suggest that behavioral and social factors account for at least half of the variation in health outcomes. One interesting example is provided by the Marmot report from the United Kingdom. An expert panel reviewed a variety of factors associated with life expectancy. Fig. 4 shows the relationship between neighborhood income deprivation and life expectancy (light green) and disability free life expectancy (darker green). As the figure suggests, there is a systematic relationship with those from most...
deprived neighborhoods having the shortest life expectancies (Marmot et al., 2010). A growing body of evidence reinforces the observation that social factors have a profound impact on life expectancy. For example, the Los Angeles County Public Health Department reports on life expectancy by gender and racial/ethnic background. The difference in life expectancy between Asian women with an average life expectancy of nearly 89 years versus African-American men with a life expectancy of about 70 years is a full 19 years! There have been significant improvements in the life expectancy of black males in recent years, but on average, white women still live about 9 years longer than black men (Hoyert and J, 2012). We do not fully understand the mechanisms underlying these enormous health disparities. However, we do recognize that the effects are profound.

Education as a case example

Health disparities are well documented. However, is there anything we can do about to address them? One example of a potential leverage point is education. A rapidly accumulating body of evidence suggests strong relationships between education and life expectancy.

The association between educational attainment and life expectancy is apparent for both sexes and for a variety of ethnic groups (Montez et al., 2012). In all groups, having less than a high school degree is associated with the shortest life expectancy and the relationship is a step function all the way through college graduation and beyond (Montez et al., 2011). Among white males, for example, the difference in life expectancy between those with less than a high school education and those with a college degree is about 12 years (Olshansky et al., 2012). In addition to life expectancy, those with less education report strong differences in health-related disability in comparison to those with more education (Zajacova et al., 2012).

Demographic studies show that educational attainment is changing. In 1990 about 78% of the population had a high school degree. By 2008 this percent dropped to just over 73%. At the other end of the spectrum, educational disparities have increased over the course of time (Snyder and Dilow, 2012). The number of people with little education and those who are well educated varies by race and ethnicity. For both men and women, Hispanic persons are less likely to a high school education while white respondents are most likely to have a college degree. African-Americans fall between Hispanic and white respondents (Olshansky et al., 2012).

Several studies have shown that the systematic graded relationship between educational attainment and life expectancy remains linear through the highest levels of education attainment. Rogers et al. (2010), for example, show that the benefit of education in terms of hazard of death remains constant for levels of education beyond college.
graduation. Those with master’s degrees live longer than those with bachelor’s degrees, and those with doctoral degrees live even longer than those with master’s degrees (Montez et al., 2009; Rogers et al., 2010).

Sorting out the influences of multiple variables upon life expectancy is challenging. Kaplan, Howard, and colleagues (in press) replicated the systematic relationship between educational attainment and life expectancy using evidence from a database of about 33,000 black and white adults (see Fig. 5). Although adjustment for income attenuated the relationship, the linear graded function remained intact. Adding demographic variables attenuated the relationship further, but it did not eliminate it. Next, they added medical risk factors to model, but controlling for these factors did make the relationship between education and life expectancy go away. Finally, they added behavior factors to model. The complete model including demographic, income, risk factor, and behavioral variables still demonstrated a systematic relationship between educational attainment and life expectancy ($p < .0001$).

What accounts for the relationship?

The mechanism relating education to life expectancy is not well understood. Cutler et al. (2010) suggest that health habits may play an important role. For example, the probability of being a current smoker systematically declines for individuals with more than a high school education (data from www.cdc.gov/tobacco). In fact, for each additional year of education there is a further decline in the probability of smoking. Similar relationships have been observed for other factors such as vigorous activity, being overweight, and the number of days a person consumed five or more drinks in the past year. Other investigators suggest that cumulative stress may result in biological processes, such as shortening telomere length. The length of telomeres on chromosomes declines with age and may be an indicator of remaining life expectancy. Some evidence suggests that there is a systematic relationship between educational attainment and the length of telomeres (Adler et al., 2013).

How large is the benefit?

The potential effect of educational attainment on life expectancy is quite strong. We spend a lot of time in medicine debating the advantage of certain medical interventions. For example, the number of quality adjusted life years gained by performing Pap smears every year as compared to every third year is quite modest—only about a day. The advantage of yearly mammography screening versus not screening is only about one month of life expectancy (Gotzsche and Jorgensen, 2013). The difference in life expectancy between those with elevated LDL cholesterol versus normal cholesterol is about six months (Clarke et al., 2009). In contrast, the difference in life expectancy between those with less than a high school education and those with an advanced degree is 10 to 12 years (Montez and Hayward, 2014). If we were to completely eliminate homicide, it would reduce deaths in the United States by about 12,000 per year. Completely eliminating death from automobile crashes would reduce deaths by about 30,000 per year. Eliminating diabetes would reduce the number of deaths by about 80,000. However, if the life expectancies of those with less than a high school education were brought up to those with more than a high school education it would reduce deaths by an estimated 240,000 deaths per year (Galea et al., 2011).

Does education cause changes in life expectancy?

We do not know whether the relationship between educational attainment and life expectancy is causal. A variety of different analyses have attempted to address this question. Some of them looked at natural experiments. For example, Clark and Roayer (Clark and Roayer, 2013) took advantage of natural experiments in the United Kingdom. In 1947, England increased the legal age for being able to drop out of school from 14 to 15 years. For the birth cohort born in 1933, approximately half dropped out of school as soon as the law allowed them to. In 1972 (1958 birth cohort) there was another change, bumping the threshold for being able to drop out of school from 15 to 16. These legal changes resulted in significant increases in educational attainment. It was expected that there would be a regression discontinuity showing greater increases in life expectancy when these individuals became older adults. However, the expected increases in life expectancy were not observed. The findings led some economists to conclude that the relationship between education and life expectancy is not causal. On the other hand, it is not clear that terminating education at age 15 versus 14 is really the appropriate strength of intervention to evaluate this hypothesis.

In summary, the goal of extending life and improving life quality may be well served by a better understanding of the social determinants of health. Although some social determinants may be difficult to change, others could potentially be modified. Enhancing health outcomes through enhanced educational attainment is an attractive alternative, although we still need better evidence that interventions to improve educational attainment will cause increased life expectancy.

Conclusions

International studies suggest that the rate of increase in life expectancy for Americans is falling behind other rich countries. Despite remarkable improvements in medical and surgical therapies, we must also confront limitations of medical science. Most estimates suggest that medical care accounts for only a small portion of the variation in life expectancy. Behavioral and social factors are likely to play a substantial role in determining how long we live.

We are only at the early stages of understanding the relationship between social factors and life expectancy. New research is beginning to illuminate the role of education, social circumstance, and health habits on life expectancy. However, research in this area is only in its earliest phases. New research on social determinants of health is likely to face skepticism because the application of traditional methods including RCTs is very difficult. We need creative new methodologies and more research that will help us better understand health determinants and the interventions that may help extend life and improve quality of life.

Conflict of interest statement

This paper was published when the author was an employee of the National Institutes of Health. The opinions expressed herein and the interpretation and reporting of these data are the responsibility of the author and in no way should be seen as an official recommendation, interpretation, or policy of the National Institutes of Health or the US Government.
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