The mission of the nation’s biomedical research enterprise is to generate new knowledge and apply it to improve the health and well-being of the population in this country and around the world. The primary responsibility for the support of the research and training programs necessary to achieve this important mission has been assigned to the National Institutes of Health (NIH), with its mission-specific institutes and centers. During my tenure of 14 years as Director of the National Institute of Environmental Health Sciences (NIEHS), I had the opportunity to participate in several health research priority-setting activities, and to give a lot of thought as to how the U.S. federal government sets its health research priorities and how we evaluate our scientific investments. The primary responsibility of an institute director is to make certain that the institute is addressing the most urgent and opportunistic health problems consistent with the mission of his or her institute. In my experience, this requires diligence in terms of outreach to the public and the institute’s stakeholders, and the capability to listen. The institute’s stakeholders include the scientific community, industry leaders, scientific societies, public interest groups, policymakers and the lay public. Priority setting and evaluation of the institute’s performance also requires good information about how investments have performed over the years in terms of the generation of new knowledge and technologies, impact on public policy and the economy, and improvement in human health and quality of life for all Americans and citizens of the world.

Given this important mission and the deplorable state of health care in the U.S., it may be time to ask some hard questions about the health research priorities.

For example, are the nation’s health research priorities consistent with the social, economic and health needs of the American people? Are our health research priorities contributing to health disparities and accelerating...
The American people should have a voice in deciding what the trade-offs ought to be because of the value-driven nature of the priority-setting process.

Because of broad concerns about the priority-setting process in health research, a Congressional Appropriations Committee of the U.S. House of Representatives asked the Institute of Medicine (IOM) of the National Academy of Sciences (NAS) to examine how the NIH makes decisions about allocation of its resources. This request grew out of concerns that allocation of funds was not consistent with the distribution of disease burden and costs to the population. Furthermore, disease-specific interest groups had expressed their frustration to Congress about lack of access to the leadership of the NIH and input into the priority-setting process. In response to the Congressional Committee’s request, the IOM issued a report in 1998 entitled *Scientific Opportunities and Public Needs, Improving Priority Setting and Public Input at the NIH* (Institute of Medicine 1998). The IOM committee concluded that the “NIH system for setting priorities has generally served the nation well.” However, the Committee did recommend the expansion of public participation in the NIH priority-setting process by creating a Council of Public Representatives (COPR), and by adapting best practices (e.g., Town Meetings by the NIEHS and the National Institute of Mental Health) of various institutes.

The nation’s health research priority setting should be goal-oriented and guided by analysis of how our previous and current investments are performing in terms of the overall objective of the enterprise. That is, have our investments reduced the burden of disease and improved quality of life? To answer this question, we need good information. However, as of 2004, only four institutes (NCI [National Cancer Institute], NICHD [National Institute of Child Heath & Human Development], NIA [National Institute on Aging] and NIEHS) had a Portfolio Analysis Branch that had been developed many years earlier, capable of retrieving bibliometric data to track the publications and assess the potential public health impact of their grantees. Three institutes (NIEHS, NICHD and NIA) collaborated to develop the portfolio analysis database to improve the priority-setting process. The system developed by these three institutes is now being used across the NIH (personal.
There needs to be a high-level systematic process for identifying and coordinating federally funded scientific research to make certain that resource allocation is directed to areas where it can do the most good. This is needed because the nation’s research and development (R&D) investments are distributed across many different agencies and under the jurisdiction of several Congressional Committees. The research missions of many of the agencies are often overlapping and interrelated. A 1989 NAS report (National Research Council 1989) concluded that agencies generally do a good job in deciding which investments are needed to support their missions. However, new interdisciplinary programs have difficulty in reaching critical mass of effort if they do not clearly fit within established agency missions. The report recommended that Congress should consider funding priorities before budgets are disaggregated by agency or program by allocation to subcommittees.

The Science Mobilization Act of 1943, shaped by Vannevar Bush, Director of the President’s Office of Scientific Research and Development, and Senator Harley Kilgore of West Virginia, created the first National Science Coordinating Agency. The agency was administered with the assistance of both scientists and non-scientists. The thinking at the time was that control by non-scientists would ensure effective representation of the public interest and keep the effort directed toward relevant ends (Smith 1990).

The proposed high-level commission could address issues of balance in our investment portfolio and the percent of the gross domestic product (GDP) that we should be investing in science. Scientific opportunity is indeed an “endless frontier.” Even before doubling of the NIH budget was completed in 2007, there were already calls for more resources—a new round of doubling. The Commission could be composed of distinguished Americans like Jimmy Carter, George H.W. Bush, Colin Powell and Derek Bok. Scientists could provide expert testimony, as the input of experts is important, but they would no longer dominate the decision-making process.

There needs to be a high-level systematic process for identifying and coordinating federally funded scientific research to make certain that resource allocation is directed to areas where it can do the most good.

Priorities has generally served the nation well.” If we are doing such a good job in establishing our health research investment priorities, how do we explain the obvious disconnect between the overall health of the American people and our investments in research and training? According to the World Health Report, a World Health Organization survey of 191 countries, the U.S. ranked poorly in terms of health indicators such as infant mortality rate (32nd), life expectancy at birth (24th) and overall performance of the health system (37th) (World Health Organization 2006). A more recent study of multinational data reported that from 2002–2003, the U.S. ranked 17th out of 19 countries with respect to mortality amendable to appropriate and timely health care (Nolte & McKee 2008). Yet, U.S. health-care expenditures, which are inclusive of research and training, exceed those of any other nation. The U.S. is spending approximately $6,700...
annually for every American; this amounts to $1.98 trillion or approximately 16% of the annual GDP (U.S. Department of Health & Human Services 2007). The U.S. is a leader in high-tech medicine, but trails other nations in most indicators of population health (Etheridge 2007). In fact, Cuba and the Czech Republic are among the 41 countries that have a lower infant mortality rate than the U.S. (Kristof 2005). So, something is dreadfully wrong since our nation’s investment, training and leadership in scientific research are not being translated into improved health for millions of Americans. In fact, it is troubling that the gap between research investments and practice is growing (Glasgow and Emmons 2007). This is consistent with the fact that the U.S. Department of Health and Human Services achieved only 21% of its Healthy People 2000 objectives, with an additional 15% of the objectives declining even though medical knowledge was readily available (Centers for Disease Control & Prevention 2001). The major contributor to not achieving the targeted objectives was our failure to reduce certain health problems in urban areas (e.g., HIV infection, asthma, violence, substance abuse, cancer, heart attacks and stroke, and preterm delivery) (American College of Physicians 2000). In large part, this was due to our failure to apply existing knowledge with sufficient intensity, duration and comprehensiveness (Freudenberg 2000). In the follow-up to Healthy People 2000, only 14% of the Healthy People 2010 objectives have yet to be met, and even more troubling is that thus far 22% of the objectives have worsened (U.S. Department of Health & Human Services 2006). Our prediction is that we will be no more successful in achieving our Healthy People 2010 objectives as we have not reformed our health research priority-setting process, nor the social, economic and health-care delivery systems required for the efficient translation of knowledge into prevention and curative treatment strategies.

**WHAT ARE THE DRIVERS OF RESEARCH PRIORITY SETTING?**

Obviously, the poor quality of and limited access to health care, and the gap between knowledge and practice are having a more significant impact on the overall health outcome of the American people than biology and genetics. So, is the nation’s health research priority-setting process “working well” as concluded in the 1998 IOM report? Well, it depends on who

---

**Autism Research:**

**Funding, Priorities and Results**

**BY MARK A. CORRALES, M.P.P.**

**Research Results**

Autism research has started to provide some benefits to patients:

- **Diagnosis:** Research has enabled better screening and earlier diagnosis of autism—Age at diagnosis has been 3 to 6 years of age, but is now possible at 14 months in some cases (Landa 2008).
- **Therapy:** Behavioral therapy has been enhanced through research.

More substantial health benefits, however, remain to be seen:

- **Medication:** The only medication approved for autism, Risperdal, does not address the core symptoms or etiology.
- **Prevention and treatment:** Although some autism cases may be preventable or treatable, research has not produced any significant interventions.

**Funding for Autism**

- Autism research funding from NIH has grown from $100 million in FY 2004 to $127 million in FY 2007 (NIH 2008).
- NIH funding per DALY (disease adjusted life year) has been just $150 for mental health, compared to $1,100 for cancer and $2,800 for infectious diseases in the U.S.¹
- Autism funding is also constrained by the NIH budget for biomedical research, which is less than $30 billion per year.² U.S. investment in health research & development (R&D) is $116 billion/year, a small figure compared to health expenditures of $2 trillion (Research!America 2006).

**Priorities in Autism Research**

- Federal grants awarded for autism research have emphasized behaviors (almost 40% of grants) and

---

**CONTINUED ON PAGE 21**
Millions of Americans would likely argue that our health research priorities are driven more by scientific opportunities and the intellectual interests or curiosity of scientists than by the public health needs of the nation, and that health research has become a highly technical endeavor with diminishing relevance to the problems of society (Dresser 1999).

Therefore, the nation is making important public health investment decisions without considering the overall ramifications on the health and economic well-being of the American people. These decisions are made without adequate input of the lay public, without adequate coordination with other government programs that impact human health, and without adequate information about how our investments are performing in the real world.

The fact that our funding decisions are made by assigning the highest priority to investigator-initiated, basic research has led to the perception that the “NIH cares more about curiosity than cure, more about fundamental science than application” (Institute of Medicine 1998). One could argue that we are supporting the science and technology development projects that are of interest to scientists, rather than research needed to improve human health. The policy of emphasizing investigator-initiated, basic research in our funding decisions was articulated in 1945 in a report to President Truman entitled The Endless Frontier, authored by Vannevar Bush (Bush 1945). The most important principle expressed in the report was that basic research should be the centerpiece of our national science policy, so that America would never again have to rely on imported knowledge. However, the Bush policy was articulated with World Wars I and II as the backdrop. So, is this policy still sound more than 60 years later? The rationale for assigning highest priority to basic research was that scientists working in the various fields would have better ideas than the public and policymakers about opportunities for making progress. While the basic premise is correct, there are numerous examples where research opportunities were delayed for years while scientists identified them as important and opportune areas of investigation. Typically, scientists tend to continue to promote the area of science that they are engaged in, even if opportunities to impact public health are significantly reduced. Because of this tendency, research topics become institutionalized with a large scientific following and the generation of many publications. The authors of these publications continue to emphasize the need for further studies. A cynical view of this practice is that scientists are fearful of advocating for new areas of science because their favorite funding stream might dry up or be reduced. Given this background, it is an interesting finding that most of the papers published by scientists are rarely, if ever, cited by their peers, and most of the scholarly work appears in 10% of the journals (Smith 1990).

PUBLIC INPUT
To date, we have not done a good job of involving non-scientists in health research priority setting. The process has largely been driven by scientists and others (e.g., the leadership of the pharmaceutical industry) who stand to benefit directly from such investments. But, since these decisions affect the public’s health and use the public’s money, citizens should have a say in how investment priorities are determined. Furthermore, health research priorities often require the infusion of new resources and trade-offs with respect to other federally funded programs. Examples of programs initiated with the infusion of substantial resources include the “war on cancer,” the human genome project, minority health and HIV/AIDS research.

To some extent, public input has been institutionalized at the NIH through institute advisory councils, which include members of the public. Also, the Congressional appropriation process includes public hearings, and both the Executive and Legislative branches of government provide opportunity for public interest groups to be heard on issues of importance to them. But, this does not go far enough. Government agencies responsible for health research and training should be proactive in involving the public as
full partners in priority-setting exercises. The public should be made to feel valued, respected and included. Public interest groups should not have to jockey for position, hoping to have the rare opportunity to express their views on the direction that research should take.

Such involvement of nonscientists would serve to reduce the tension between science and society, as the public would gain a better understanding of scientific challenges and scientists might acquire a greater appreciation of society’s sense of urgency. Citizen participation would expand the discussion to include society’s values and social norms. For example, affordability, equity and access to medical knowledge and technologies would be a consideration in using public money. Also, by involving citizens, we can find the common ground between what is good for science and technology and what is in the best interest of the public. The involvement of individuals from different communities and perspectives would enhance the likelihood that the research agenda would have sufficient breadth to benefit the largest number of Americans.

Consumer and community participation has been the standard operating procedure for obtaining public input for some federally funded programs for many years (Conway, Uh, & Harrington 1997). For example, the federal government formed community boards to ensure public input in the program development of the Tennessee Valley Authority in the 1930s. Clearly, the intent of the federal government is for citizens to be involved in the development and management of publicly funded programs. Our leaders understand that strong community relationships are required for translation of policy into practice.

One of the best models for promoting public engagement is through community-based participatory research (CBPR) (Israel, Schulz, Parker, & Becker 1998) (O’Fallon, Wolfe, Brown, Dearry, & Olden 2003). CBPR is a collaborative approach to research that involves community members, organizational representatives and researchers as equal participants in all phases of the research process. CBPR has been endorsed as a valuable research approach in the U.S. by the NIH, the Centers for Disease Control and the IOM (Institute of Medicine 1999). Since the early 1990s, CBPR has been a large part of the translational research program of the NIEHS, developed to address the immediate environmental genetics (30–40% of grants). Some recent grants have funded treatment trials or epidemiological studies to investigate preventable risk factors.

• Published autism research literature per year has grown dramatically to over 1,000 new articles in 2007 (as indexed in PubMed).

• About 20% of the autism literature during 1985–2007 focused on diagnosis, while just 10% has addressed therapy, and only 1% has focused on prevention. Research at the molecular level has been dominated by genetics and a handful of other risk factors. Many chemicals, processes, cell types, circuits, brain regions and systems have not been adequately explored.

• Of the 63 autism-related active intervention trials on clinicaltrials.gov in early 2008, almost 75% (47) focused on medications, 14% (9) on behavioral therapy and 10% (6 trials) on dietary therapy or supplements.

Toward Process Improvements

• The autism research strategy should explicitly consider which research programs appear likely to lead to successful interventions in the foreseeable future.

• Funding and research prioritization processes require substantive partnerships with the public and patients who fund and are the customers of NIH research programs. The Interagency Autism Coordinating Committee (IACC) is one forum for public input.


2 This is less than half as much as the pharmaceutical, biotech and medical technology industries spend on R&D. Most federal R&D spending is not related to health.

3 Analysis of CRISP database as of June 2007.

4 Analysis of PubMed bibliographic database of the National Library of Medicine at NIH, using qualifier MeSH terms.
health concerns of socioeconomically disadvantaged communities throughout the U.S. By involving the community, the lessons learned can be effectively translated into successful public health prevention measures without the long delays characteristic of traditional investigation-driven research. Also, community-based approaches offer a mechanism to enhance the relevance and effectiveness of research products. One of the major barriers to translation of health research knowledge and technologies is failure to consider the community perspective.

**TRANSLATION**

As noted earlier, the gap between research and practice is large and growing. The health research priority-setting process needs to remedy this problem, as this is a major reason for the tension between science and society. In fact, a Rand Corporation study concluded that, on average, only about 50% of evidence-based health-care knowledge is translated into practice. Therefore, we need research to identify the barriers to effective translation.

Whereas opportunities to improve human health through institutional policies still exist ... behavioral change at the level of the population will be crucial for future progress.

One potential barrier may be the issue of context. A great deal of health information is context specific. Contextual knowledge is absolutely critical for its translation into health outcomes in the various sectors of society. Contextual research has the potential to provide important insight into how culture, gender, race, socioeconomic status and community influence risk. To strengthen the fight against tuberculosis and other infectious diseases, community-based treatment programs were implemented in the resource-poor regions of Haiti and Brazil by training community residents to administer drugs and monitor for toxicity and drug resistance (World Health Organization 2000). Intervention and clinical trials need to be conducted under conditions that reflect the complexity, diversity and co-morbid conditions and context of the real world. In the past, prevention of morbidity and death was largely achieved through institutional change (e.g., environmental and occupational health safety standards, sanitation and food safety practices, and immunization). Whereas opportunities to improve human health through institutional policies still exist (e.g., adoption of national health insurance), behavioral change at the level of the population will be crucial for future progress. Modifying individual behavior through clinical practice will not lead to significant nor lasting improvement in health.

**EQUITY**

Special attention needs to be given to inequalities in health as part of the process to redress social injustice. Inequalities in health status can be overlooked in a disease burden approach to priority setting. For example, the overall disease burden in the population at large of a disease may not reach the threshold needed to be assigned a high priority in research funding decisions, yet the rates may be much higher among the ranks of the poor, recent immigrants, and racial and ethnic minority groups. Ethics used in the design and conduct of human health research should be extended and strengthened in the area of application. Knowledge and technologies derived from public funds should be available to all. Health resources should be allocated to develop prevention and treatment strategies that provide the highest possible overall level of population health (Makundi, Kapriri, & Norheim 2007). Fairness requires that health benefits should be distributed according to some notion of equity and that the public perceives this distribution as fair. Research to develop gene therapy, stem cell and organ replacement therapy, and nanomedicine will likely exacerbate health disparities when translated into health-care practice. Those who are most vulnerable and needy—the poor, the elderly, racial and ethnic minorities, and rural Americans—will reap little benefit. Furthermore, these technologies will accelerate the nation’s health-care crisis as they drive up cost. For example, the technology to identify the BRCA1 breast cancer susceptibility gene, developed based on the discovery of a research team led by Roger Weissman and Andy Futrell at the NIEHS, is not available to most women because of the cost of the test (approximately $2,000).
This is not an attack on basic science. Our point is that knowledge acquisition and application should be more closely linked, especially at the level of policymakers who are responsible for our nation’s strategic investments. Our plea is not that our nation should invest less in basic research and clinical medicine, nor that basic researchers should take on the responsibility of translation—a task for which we are poorly prepared—but that we should invest more in public health. Our health research priorities should include the much-needed expertise and contributions of our public health colleagues. Translation should not be an afterthought, and it should not be left to the whims and curiosity of researchers. It is too important to the success of the biomedical research enterprise and to the health and well-being of the American people.

In fact, translation requires original and creative research to generate new knowledge and tools. Admittedly, we too often fail to translate our discoveries into practice because of lack of planning and commitment. The planning, priority setting and commitment called for here is a government-wide activity that requires coordination before resources are allocated to mission-specific agencies. Somewhere within the U.S. government, there should be a “master plan,” with someone responsible for the success of the plan. This will require deliberate allocation of resources, coordination among agencies and development of a tracking system to monitor progress.

How we set health R&D priorities and link these activities to national policies has become increasingly important over the past 25 years as the biomedical research enterprise has grown in complexity. The biomedical research enterprise must broaden its horizon beyond basic research and drug development to target behavior or entire communities to change unhealthy lifestyles. Appeals for public support of science are framed in terms of practical benefits, yet our enthusiasm and commitment to translate the discoveries into practice does not match our enthusiasm for discovery. The link between research and translation must be strengthened; otherwise, science will lose public support. Interestingly, the reported decline in NIH’s “favorability rating” may be related to this issue (American Association for the Advancement of Science 2008).

The authors take the position that the best priorities are made with input from multiple sources, including the lay public. Furthermore, many areas of investigation critical for improving human health are not assigned a high priority. We believe that the appointment of the high-level commission to advise the Executive and Legislative branches on R&D investments will bring needed balance to reduce the widening gap between scientific investments and discovery and health outcomes. Science should be a commodity that benefits all Americans, not just scientists and others in the health care industry.

The health care delivery system is flawed, but so is the health research priority-setting process. The delivery system can only distribute the products provided by the health research enterprise. Let’s make sure that we are delivering products that provide the most benefit for the most people.

References
Institute of Medicine, Committee on Environmental Justice. (1999). Towards environmental justice: Research, education,

Institute of Medicine, National Academy of Sciences. (1998). Scientific opportunities and public needs: Improving priority setting and public input at NIH. Washington, DC.


About the Authors

KENNETH OLDEN, PH.D., SC.D., L.H.D., is Chief of the Metastasis Section, Laboratory of Molecular Carcinogenesis, and former director at the National Institute of Environmental Health Sciences.

ROSEMARIE RAMOS, PH.D., M.P.H., has been an NIEHS Health Disparities Fellow since 2005. Her research interests include the diminishing health care delivery infrastructure in the U.S., addressing the public health workforce shortage and the fetal origin of environmentally related disease.

MARK CORRALES, M.P.P., is a Senior Analyst at the U.S. Environmental Protection Agency, Office of Policy, Economics, and Innovation/Office of the Administrator.