National Institutes of Health Funding for Behavioral Interventions to Prevent Chronic Diseases

Chris Calitz, MPP, Keshia M. Pollack, PhD, Chris Millard, MPP, Derek Yach, MBChB

Chronic non-communicable diseases (NCDs) cause the majority of premature deaths, disability, and healthcare expenditures in the U.S. Six largely modifiable risk behaviors and factors (tobacco use, poor nutrition, physical inactivity, alcohol abuse, drug abuse, and poor mental health) account for more than 50% of premature mortality and considerably more morbidity and disability. The IOM proposed that population burden of disease and preventability should be major determinants of the amount of research funding provided by the U.S. NIH. Data on NIH prevention funding between fiscal years 2010 and 2012 for human behavioral interventions that target the modifiable risk factors of NCDs were analyzed during 2013–2014. The NIH prevention portfolio comprises approximately 37% human behavioral studies and 63% basic biomedical, genetic, and animal studies. Approximately 65% of studies were secondary prevention versus 23% for primary prevention, and 71% of studies intervened at the individual and family levels. Diet and exercise were the most-studied risk factors (41%), and few studies conducted economic analyses (12%). NIH spends an estimated $2.2–$2.6 billion annually (7%–9% of the total of $30 billion) on human behavioral interventions to prevent NCDs. Although NIH prevention funding broadly aligns with the current burden of disease, overall funding remains low compared to funding for treatment, which suggests funding misalignment with the preventability of chronic diseases.

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Introduction

The burden of largely preventable non-communicable chronic diseases (NCDs) in the U.S. is responsible for a disproportionate share of mortality, morbidity, and healthcare costs. Annually, seven of ten deaths are due to NCDs, and treating people with chronic conditions currently accounts for approximately 84% of annual healthcare expenditures ($2.7 trillion in 2011, or 17.9% of U.S. gross domestic product).[1–7] Medical costs are driven by NCDs at all ages, yet 67% of healthcare dollars are spent on treating NCDs among working adults aged <65 years.[4] The U.S. Burden of Disease study[6] showed that adult men and women increased their life expectancy between 1990 and 2010; however, despite these gains there has been a faster increase in years lived with disability. Five modifiable risk behaviors—tobacco use, poor diet, physical inactivity, alcohol abuse, and drug abuse—are responsible for the majority of deaths and premature mortality in the U.S.[6–9] Increasing rates of mental health disorders are also contributing toward greater disability, for which there are few successful interventions.[10] These risk factors also contribute substantially to the observed disparities in life expectancy and mortality rates between population groups.[11–13] The U.S. has the largest per capita healthcare expenditures of all other industrialized nations, yet it consistently ranks near the bottom in preventable health outcomes compared with other high-income countries.[14] Furthermore, national healthcare costs are heavily skewed toward prescription drugs, medical devices, and clinical services, with public health and prevention activities accounting for only 3% of annual spending.[4]

The IOM proposed that population burden of disease and preventability should be major determinants of priorities for public health interventions and the amount of research funding provided by the NIH.[15,16] Four barriers related to health research and development result in significant missed opportunities to improve

From the American Heart Association (Calitz); Department of Health Policy and Management (Pollack), Bloomberg School of Public Health, Johns Hopkins University (Millard), Baltimore, Maryland; and the Vitality Institute (Yach), the Vitality Group LLC, New York, New York

Address correspondence to: Chris Calitz, MPP, c/o the American Heart Association, National Center, 7272 Greenville Avenue, Dallas TX 75231. E-mail: chris.calitz@heart.org.

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population health through disease prevention and health promotion: (1) persistent knowledge gaps about specific cost-effective prevention policies and programs; (2) the full potential of behavioral economics has not been realized; (3) lack of effective dissemination strategies for different population groups and implementation settings; and (4) where robust evidence exists, an absence of comprehensive dissemination.[17,18] Limited empirical data on these barriers fuel the protracted debate about whether prevention and preventive health services save money and represent good investments.[19–22] Until recently, the Congressional Budget Office (CBO) questioned the value of prevention, scoring it low in federal funding decisions.[23] However, the CBO has since supported some prevention strategies, such as a sharp increase in federal tobacco taxes,[24] and called for better evidence on how interventions targeting risk factors might reduce long-term cost increases.[25] Estimates suggest that approximately 50% of NCDs are preventable by modifying the major risk behaviors and an additional 20%–30% by addressing the social and environmental determinants of health.[6–9] Consequently, improving population health will require comprehensively implementing effective evidence-based programs and policies that target these determinants of health and can be sustained by public–private partnerships.[17,26,27]

The NIH is the world's largest funder of biomedical research and receives approximately 90% ($30 billion) of the $34 billion annual U.S. federal health research and development budget.[28,29] The scale, structure, and priorities of NIH funding have a significant impact on research universities with medical schools and the career development of research scientists. More than 80% of the NIH budget funds extramural grants, which support around 350,000 scientists at 2,500 universities across the U.S. and around the world.[29–31] The NIH estimates that it spent roughly $6 billion in fiscal year (FY) 2012—almost 20% of total annual expenditures—on prevention research, including infectious disease prevention.[32] Figure 1 summarizes data from Appendix Table 1 and shows the distribution of all grants coded as Prevention by the NIH between FY2010 and FY2012. Based on average award value, the National Institute of Allergy and Infectious Diseases is the largest funder of prevention research (24.6%) followed by the National Cancer Institute (18.9%); both of these Institutes spend more than $1 billion annually on prevention research (Appendix Table 1).

The purpose of this research was to characterize NIH prevention funding according to a variety of prevention attributes and assess whether the current portfolio is aligned with the U.S. burden of disease and the major

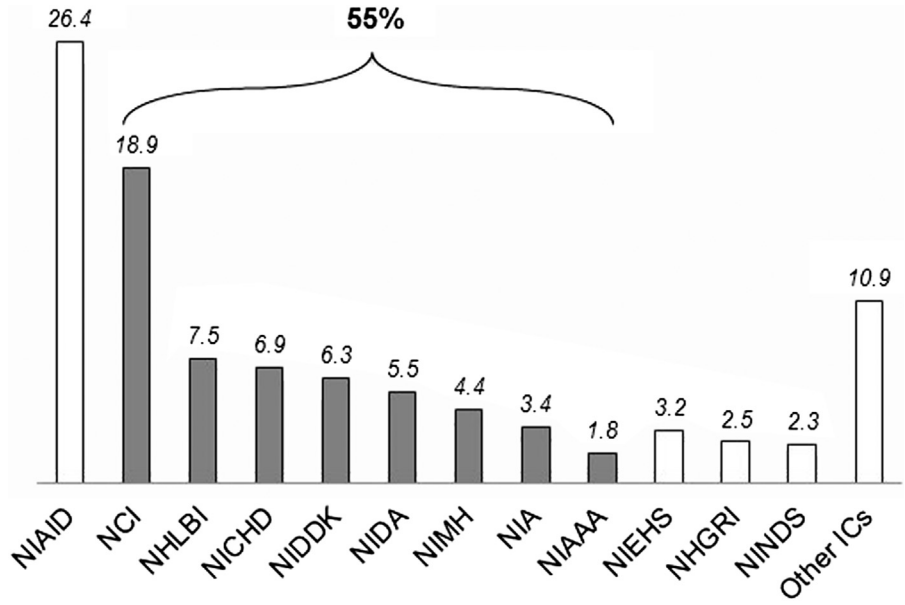

Figure 1. Average annual NIH funding for prevention (FY2010–FY2012).
Source: reportnih.gov/categorical_spending.aspx; authors' analysis.
Note: Percentages based on grants coded as Prevention by Research Condition and Disease Categorization (RCDC) algorithm. Mean proportion based on annual spending, not number of grants. Other ICs include the remaining 13 Institutes and Centers.
FY, financial year; IC, institutes and centers; NCI, National Cancer Institute; NHGRI, National Human Genome Research Institute; NHLBI, National Heart Lung and Blood Institute; NIA, National Institute on Aging; NIAAA, National Institute on Alcohol Abuse and Alcoholism; NIAID, National Institute of Allergy & Infectious Diseases; NICHD, National Institute of Child Health Development; NIDA, National Institute on Drug Abuse; NIDDK, National Institute of Diabetes and Digestive and Kidney Diseases; NIEHS, National Institute of Environmental Health Services; NIMH, National Institute of Mental Health; NINDS, National Institute of Neurological Disorders and Stroke.

modifiable behavioral risk factors attributed to six major and costly NCDs—cancer, coronary heart disease, hypertension, stroke, diabetes, and obesity. Consequently, data were analyzed from eight Institutes and Centers (ICs) that are significant funders of NCD prevention: the National Cancer Institute, National Heart Lung and Blood Institute, National Institute of Child Health Development, National Institute of Diabetes and Digestive and Kidney Diseases, National Institute of Mental Health, National Institute of Drug Abuse, and National Institute on Alcohol Abuse and Alcoholism. Together, these ICs comprise 55% of annual prevention research funded between FY2010 and FY2012 (Figure 1). Previous studies on NIH prevention funding have focused on single diseases, analyzed data from a small sample of ICs or short time frames, or compared overall NIH funding levels for specific disease conditions with the U.S. burden of disease.[27,33–35] This article extends these prior studies and presents the first comprehensive analysis of the NIH's prevention portfolio over 3 recent years for predominantly human behavioral interactions that aim to prevent six major, costly NCDs.

Statistical Methods

Design and Search Strategy

A cross-sectional study design was employed, and data from the NIH Research Portfolio Online Reporting tool (RePORTER) were collected for analysis. An epidemiologic approach to defining prevention and the stages of prevention was adopted.[36] Analysis focused on funding for predominantly human behavioral interventions to prevent NCDs ("Behavioral Studies") and therefore excluded basic biomedical, animal, and genetic studies without a human behavioral intervention component ("Non-Behavioral

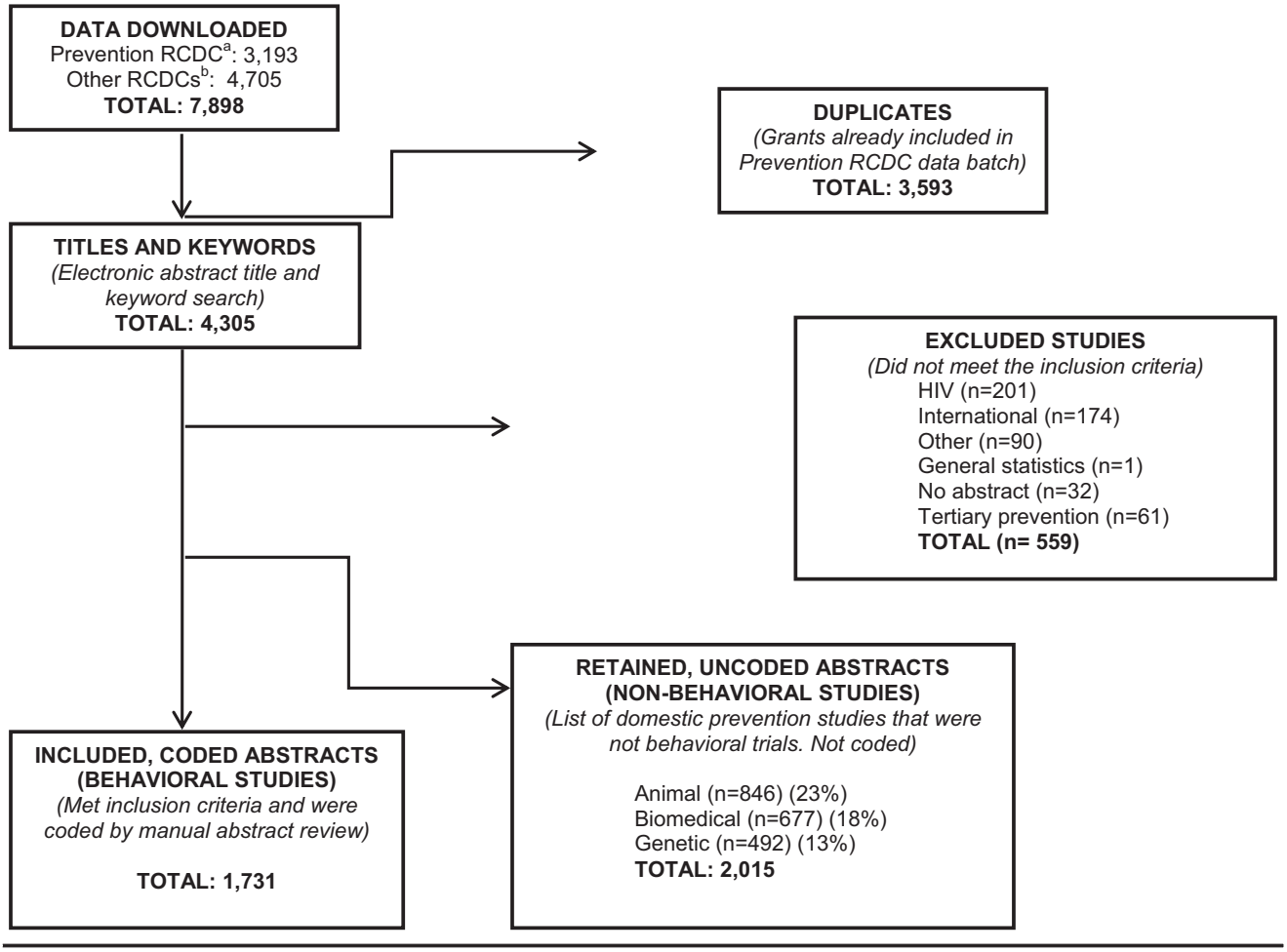

Figure 2. Data extraction.

[a]Grants extracted from Prevention Research Condition and Disease Categorization (RCDC).

[b]Grants extracted from the following RCDCs: Basic Behavioral Science & Research, Behavioral Science & Research, Depression, Mental Health, Mind and Body, Nutrition, Smoking and Health, Suicide Prevention, Tobacco, Underage Drinking, Violence Against Women, Youth Violence Prevention, Aging, Alcoholism, Cancer, Cardiovascular, Chronic Obstructive Pulmonary Disease, Diabetes, Heart Disease–Coronary Heart Disease, Hypertension, Lung Cancer, and Obesity.

Studies") (described further in the Data Selection section). Early drafts of this manuscript were shared with NIH representatives. The NIH developed the Research, Condition, and Disease Categorization (RCDC) process in 2006, which organizes research funding annually into 235 categories, including a category for Prevention. RCDC is a computer algorithm based on category boundaries that are validated by testing assigned projects against the experts' consensus of the types of projects that belong in the category. Given the difficulty of conducting portfolio analysis, the complexity of the RePORTER database, and the fact that the RCDC algorithm is not openly available to the public without a Freedom of Information Act (FOIA) request, extensive consultation with an NIH representative from one IC was used to refine keyword search terms. A FOIA request was not made at the start of data coding and analysis owing to perceived time delay. Thus, to identify research projects potentially not captured by the algorithm and to test the sensitivity of the current algorithm, studies from 22 relevant disease-specific RCDC categories (e.g., cancer) and non-disease RCDC categories (e.g., behavioral science) were extracted (Figure 2). Numbers were assigned to the three categories (1=Prevention RCDC, 2=Non-disease RCDCs, 3=Disease-specific RCDCs), and Categories 2 and 3 were combined ("Other RCDCs") because of the small sample in Category 2 (n=108). To limit the sample to prevention research and the NCDs of interest, the following relevant keywords were used:

> Disease-specific RCDCs—*Obesity prevention* or *cancer prevention* or *diabetes prevention* or *hypertension prevention* or *coronary heart prevention* or *stroke prevention* or *chronic disease prevention* or *health promotion* or *health education* or *primary prevention* or *secondary prevention*.
> Non-disease RCDCs—*Chronic disease prevention* or *health promotion* or *health education* or *primary prevention* or *secondary prevention* or *behavioral modification* or *intervention program* or *lifestyle modification*.

Although environmental factors are important determinants of health, they were excluded because of the large anticipated sample size.

Data Selection

Data were retrieved in July 2013 from eight of 27 ICs, and information on project number, project title, financial year, award amount, and Administrative IC was extracted. Searches were restricted to domestic extramural Research Project Grants because these types of grants comprise the majority of NIH funding.[29] Projects funded in FY2010 by the American Recovery and Reinvestment Act were excluded, which would otherwise have inflated the results for that year. Initial extraction yielded 7,898 projects; de-duplication, giving priority to the Prevention RCDC grants, yielded 4,305 unique projects and 3,593 duplicates (Figure 2). A total of 559 projects were excluded and 2,015 projects comprised basic biomedical, animal, and genetic studies (Non-Behavioral Studies), leaving 1,731 abstracts meeting the inclusion criteria of domestic human trial interventions aimed at preventing NCDs and promoting healthy behaviors related to tobacco, diet, physical activity, alcohol, drugs, and mental health (Behavioral Studies) (Appendix Table 2). Non-Behavioral Studies were retained for comparison with Behavioral Studies in terms of number of awards and award amount. Interventions that studied other risk factors or determinants of health (e.g., SES) were included and coded as "Other." Public health surveillance studies that were not specifically aimed at preventive interventions were excluded; however, specific statistical and economic studies linked to prevention or specific risk factors were included and coded according to risk factor. These included economic studies, for example, that investigated the effects of price or price elasticity of demand for tobacco and sugar-sweetened beverages on consumption behavior. Using title and abstract keyword review, one author excluded studies that did not meet the inclusion criteria and a second author independently assessed the exclusions. Differences were reconciled by discussion and consensus (inter-rater reliability, 92%–98%).

Data Coding and Analysis

Data were analyzed in 2013–2014. Two authors independently and manually assessed abstracts of the Behavioral Studies (n=1,731) and coded them according to five dimensions: prevention type, scope, setting, modifiable risk behaviors, and economic analysis. For prevention setting, a category for "technology" was included, which comprised interventions that were designed to be solely delivered via Internet, electronic voice, or mobile platforms. Data were entered into a database (Microsoft Excel, version 2011, Microsoft Corporation, Redmond WA) and differences were reconciled by discussion and consensus (inter-rater reliability, 82%–84%). Excel data were imported into Stata, version 12, and analyzed. Descriptive statistics were used to calculate counts, frequencies, and means. Pearson chi-square tests were used to assess annual variations for categorical variables. For continuous variables, ANOVA and paired t-tests assessed the statistical significance between observed differences in means.

Results

Overview

There were no statistically significant variations across FYs for all coded characteristics apart from Administrative IC; thus, only mean annual data are reported. The selected sample comprised an estimated $647 million in annual prevention funding: $277 million (43%) for Behavioral Studies and $370 million (57%) for Non-Behavioral Studies (Table 1). When Other RCDC projects were excluded (i.e., the sample contained only what the NIH currently classifies as Prevention), the proportion of Behavioral Studies declined to 37% versus 63% for Non-Behavioral Studies. Keyword selection and exclusion criteria meant that not all NCDs and prevention projects funded by the eight ICs were analyzed; instead, the selection yielded a study sample comprising between 30% and 42% of the total number of prevention research projects funded annually by the eight ICs (Appendix Table 3). Of note, these are the percentage of projects within the group of selected ICs, not the percentage of projects that the eight ICs represented in Figure 1 based

Table 1. Average Annual Funding (FY2010–FY2012)

	Behavioral			Non-behavioral			% behavioral
	n	$M	SE	*n*	$M	SE	(Total $M)[a]
NCI	150	70	4.4	348	121	3.0	37
NHLBI	80	52	2.1	124	69	4.1	43
NIDDK	88	51	6.5	154	68	3.5	43
NIMH	83	30	1.1	59	28	1.4	52
NICHD	45	19	1.0	64	38	3.4	33
NIA	28	13	1.2	46	21	1.3	39
NIDA	65	27	1.2	34	14	1.0	65
NIAAA	38	15	0.8	28	11	0.7	58
Total	577	277		857	370		

[a]Proportions based on total grant amount, not total number of grants awarded.
FY, financial year; NCI, National Cancer Institute; NHLBI, National Heart Lung and Blood Institute; NIA, National Institute on Aging; NIAAA, National Institute on Alcohol Abuse and Alcoholism; NICHD, National Institute of Child Health Development; NIDA, National Institute on Drug Abuse; NIDDK, National Institute of Diabetes and Digestive and Kidney Diseases; NIMH, National Institute of Mental Health; $M, million dollars.

on the total NIH prevention portfolio. Although the National Cancer Institute funded the most Behavioral Studies in absolute dollars ($70 million annually), this comprised only 37% of its Prevention portfolio. In contrast, the National Institute for Drug Addiction funded $27 million annually for Behavioral Studies, which represented 65% of its Prevention budget—the largest proportion of all ICs in our sample (Table 1). Based on observed proportions, the NIH currently invests an estimated $2.2–2.6 billion in behavioral interventions to prevent NCDs, which comprises roughly 7%–9% of total annual expenditures. This estimate is similar to previous estimates of the proportion of prevention funding within the federal research portfolio for breast cancer (10%–11%) and the proportion of funding provided by the National Institute of Mental Health in FY2006 to prevent mental, emotional, and behavioral disorders in adolescents (<7%).[27,33]

Prevention Characteristics

The majority of behavioral interventions were secondary prevention interventions (65%), compared with primary prevention (23%) (Table 2). Secondary prevention studies included Internet-based education for cancer screening in racial and ethnic subpopulations, cost-reduction strategies (e.g., using lay health educators for behavioral modification), or Internet-based health promotion to reduce behaviors such as college drinking. Primary prevention strategies included changing food and physical activity policies in schools, and early childhood education programs that promoted healthy eating and physical activity from a very young age. The National Institute for Child Health Development funded the largest proportion of primary prevention studies (50%), whereas the National Institute of Mental Health funded the smallest proportion (6%) (Table 3).

Projects were overwhelmingly focused on the individual or family level (71%), compared to the population level (22%) (Table 2), and significant variation by IC was observed (Table 3). Population-level approaches included chemoprevention trials testing the efficacy of dietary supplements and web-based health promotion interventions. The National Cancer Institute funded the highest proportion of population-level studies (50%), whereas the National Institute of Mental Health funded the smallest proportion (4%) (Table 4). The majority of behavioral interventions were delivered in multiple settings (32%), which comprised clinical–community linkages, followed by healthcare organizations (31%) (Table 2). The lowest percentage (2%) was observed for workplace settings, although "workplace wellness" was not a specific keyword search term. The percentage of interventions delivered by technology-only platforms (12%) was noteworthy. Few studies conducted economic analysis (12%). Economic studies consisted mostly of cost-effectiveness studies comparing new interventions or policies with standard care. New interventions included web-based programs (e.g., smoking cessation or weight management) that augmented or replaced intensive lifestyle modification.

Table 2. Mean Distribution and Funding of Behavioral Studies

Characteristic	Mean (FY2010–FY2012)			
	n	$M	SE	%[a]
Type of prevention				
Primary	122	64	3.1	23
Secondary	404	180	3.8	65
NA/not specified	51	33	6.9	12
Scope of prevention				
Population-level	132	60	3.1	22
Individual-level	430	198	4.3	71
NA/not specified	15	20	6.5	7
Setting of prevention				
Health care organization	196	86	2.8	31
Home	42	22	2.5	8
School	28	12	0.7	4
Workplace	11	5	0.3	2
Community	53	22	1.1	8
Multiple settings	161	90	6.8	32
Technology	64	32	3.2	12
NA/not specified	22	8	0.7	3
Risk factors				
Mental health	104	38	1.2	14
Tobacco	41	18	0.8	6
Alcohol	23	9	0.6	3
Diet and exercise	193	114	7.2	41
Drugs	11	5	0.6	2
Multiple risk factors (2+)	77	33	1.3	12
Other (health disparities, SES)	129	61	3.7	22
Economic analysis				
Yes	62	32	1.5	12
No	457	212	7.6	76
NA/not specified	59	33	3.4	12

[a]Mean proportion based on mean annual funding, not mean annual number of awards
FY, financial year; $M, million dollars; NA, not applicable.

Risk Factors

The highest proportion of projects investigated diet and exercise (41%) followed by other factors (22%), mainly social determinants of health such as SES and health disparities (Table 2). When multiple risk factors (i.e., two or more risk factors, 12%) were taken into consideration, the proportion of funding for studies by modifiable risk factor broadly aligned with the current distribution of the burden of disease in the U.S. population data as measured by disability-adjusted life years (DALYs).[6] Funding for tobacco-only studies (6%) was somewhat low, as tobacco contributes roughly 12% to U.S. DALYs.[6] Tobacco use was, however, included in the multiple–risk factor studies. The National Institute of Drug Addiction funded the highest proportion of multiple–risk factor studies (52%) in the selected sample (Appendix Table 4). When results were stratified by IC, statistically significant variation and clustering in funding was seen. This was expected because ICs are structured according to specific diseases and conditions. For example, the National Institute on Alcohol Abuse and Alcoholism was the only IC that funded alcohol-only studies.

Discussion

This study is the first comprehensive descriptive analysis of NIH funding for human behavioral interventions to prevent six of the most costly NCDs—cancer, coronary heart disease, hypertension, stroke, diabetes, and obesity. Between FY2010 and FY2012, more than one third (36%) of the NIH Prevention portfolio supported human behavioral interventions that targeted the modifiable behavioral risk factors of NCDs, whereas 63% funded basic biomedical, animal, and genetic research. The proportion of behavioral studies increased to 43% when prevention projects were added that were not identified by the current NIH algorithm.

This analysis found that the upper range of funding for human-trial behavioral research within the prevention portfolio (i.e., 43%) was close to the estimated 50% of premature deaths attributed to the modifiable behavioral risk factors of NCDs.[6–9] The observed proportions in the prevention research portfolio likely reflect the ongoing funding priority given to basic biomedical and genomic science. Current NIH funding for genomics far exceeds funding for social and behavioral science, and some researchers have argued that exaggerated expectations and uncritical evaluations of genomic research may divert funding from other promising approaches to disease prevention.[37] Furthermore, absolute funding for prevention has remained stable and substantially lower versus funding for biomedical treatments and cures (averaging roughly 20% of total NIH expenditures between FY2009 and FY2013).[32]

These funding levels do not reflect the opportunities for disease prevention and health promotion to improve population health.[18] The NIH Office of Disease Prevention Strategic Plan 2014–2018[38] recently identified six

Table 3. Average Annual Funding (FY2010–FY2012), by Type

	Primary prevention			Secondary prevention		
	n	$M (%)[a]	SE	*n*	$M (%)[a]	SE
NCI	44	25 (43)	2.6	88	33 (57)	1.4
NHLBI	20	12 (26)	0.9	53	35 (74)	1.8
NIDDK	11	5 (13)	0.5	71	35 (87)	2.0
NIMH	6	2 (6)	0.3	75	27 (94)	1.1
NICHD	18	9 (50)	0.8	21	9 (50)	0.6
NIA	5	2 (16)	0.2	19	10 (84)	1.1
NIDA	13	7 (25)	0.7	51	20 (75)	0.9
NIAAA	7	3 (20)	0.3	26	11 (80)	0.6
Total	124	65		404	180	

[a]Row percentages (primary vs secondary); therefore, column percentages do not add up to 100.

FY, financial year; NCI, National Cancer Institute; NHLBI, National Heart Lung and Blood Institute; NIA, National Institute on Aging; NIAAA, National Institute on Alcohol Abuse and Alcoholism; NICHD, National Institute of Child Health Development; NIDA, National Institute on Drug Abuse; NIDDK, National Institute of Diabetes and Digestive and Kidney Diseases; NIMH, National Institute of Mental Health; $M, million dollars (excludes NA/not specified); NA, not applicable.

strategic priorities for national prevention research, including developing a detailed taxonomy to systematically monitor the NIH's investment in prevention research and increase the visibility of prevention research. The Strategic Plan will help to advance prevention science (the systematic application of scientific methods to the causes and prevention of diseases in populations); however, increased levels of funding will also be necessary to take advantage of the untapped potential of the preventability of NCDs. We recommend that the NIH Office of Disease Prevention is adequately staffed and has the necessary internal political support to ensure that all ICs increase their support for prevention science.

In addition to increased funding, specific knowledge gaps also need to be addressed. Policymakers and health officials need credible information on the cost effectiveness of prevention strategies in different populations and settings in order to make informed decisions about resource allocation. In its 2012 Report to Congress,[17] the Community Preventive Services Task Force highlighted the importance of cost and economic outcomes as part of determining intervention effectiveness. Our analysis showed that only 12% of the current NIH prevention portfolio includes economic analyses. Although some scholars have argued that greater investments in prevention may not reduce cost,[19,20] policymakers want economic estimates to guide resource allocation. According to these data, future funding should include economic analyses where appropriate and the NIH should collaborate with other agencies conducting similar research to better coordinate federal funding efforts.

This study showed that the vast majority of studies investigated secondary prevention strategies (65%) targeted at the individual or family level (71%). Several expert scientific panels have issued recommendations about the urgent need to test, evaluate, and scale up evidence-based interventions directed at populations and that seek to address both behavioral factors and improve policies, systems, and environments.[39,40] Although there is no prescribed optimal investment level for population-based, primary prevention of specific diseases and conditions, ICs should critically assess their portfolios and increase funding opportunities where necessary.

Reducing the burden of disease at the population level will also require scaling up interventions that are shown to be efficacious and effective by prevention science, yet NIH funding for dissemination and implementation research (estimated to be $80 million between 2005 and 2012)[41] is scant compared to the total dollars spent on scientific discovery.[42] Although dissemination activity is distinct from dissemination research, testing the different

Table 4. Average Annual Funding (FY2010–FY2012), by Scope

	Population-level			Individual-level		
	n	$M (%)[a]	SE	*n*	$M (%)[a]	SE
NCI	69	31 (50)	2.8	77	32 (50)	2.1
NHLBI	15	8 (16)	0.5	62	42 (84)	2.0
NIDDK	11	5 (11)	0.5	75	38 (89)	2.0
NIMH	3	1 (4)	0.2	78	28 (96)	1.1
NICHD	10	4 (23)	0.4	32	14 (77)	0.9
NIA	9	5 (37)	0.8	19	8 (63)	0.8
NIDA	7	3 (13)	0.5	57	23 (87)	1.1
NIAAA	6	2 (13)	0.2	31	13 (87)	0.7
Total	130	59		431	198	

[a]Row percentages (population-level vs individual-level); therefore, column percentages do not add up to 100.

FY, financial year; NCI, National Cancer Institute; NHLBI, National Heart Lung and Blood Institute; NIA, National Institute on Aging; NIAAA, National Institute on Alcohol Abuse and Alcoholism; NICHD, National Institute of Child Health Development; NIDA, National Institute on Drug Abuse; NIDDK, National Institute of Diabetes and Digestive and Kidney Diseases; NIMH, National Institute of Mental Health; $M, million dollars (excludes NA/not specified); NA, not applicable.

contextual factors that constrain or enable scale-up can inform practical action and is one of the identified knowledge gaps.[17,18,27] One noteworthy example in the sample is the Diabetes Prevention Program Outcomes Study,[43] an ongoing observational study of participants from the Diabetes Prevention Program (DPP) RCT, which was led by the NIH and supported by CDC.[44] The DPP showed conclusively that intensive lifestyle modification was more effective than metformin treatment in the prevention or delay of type 2 diabetes by reducing progression from pre-diabetes to diabetes by 58%. The national dissemination of the DPP is being accomplished through the CDC-established National DPP that began in 2011.[45] This coordinated endeavor brings together private sector health insurers, third-party administrators, healthcare and community organizations such as the Young Men's Christian Association (YMCA), and government agencies to widely implement DPP. In 2012, CDC awarded $6.75 million in grants to six national organizations to disseminate the program nationally. By June 2014, the YMCA's DPP had served more than 22,300 participants at more than 940 sites in 41 states across the country (M Longjohn, National Health Officer, YMCA of the U.S., personal communication, 2014). The scale-up process currently underway demonstrates that business models for prevention programs and services are feasible; however, the "market for disease prevention" and the financial incentives necessary to create sustainable businesses are still in the early stages of development. Given that private sector investment in promoting the wider uptake of profitable NCD prevention "products" is still modest, we recommend that the NIH supports collaborations that can help to catalyze this nascent market.

Other agencies besides the NIH are involved in prevention science, cost effectiveness, and dissemination and implementation research. For example, the Affordable Care Act mandated the creation of Patient-Centered Outcomes Research Institute (PCORI), which is expected to receive $3.5 billion through September 2019. PCORI could be an important funding source to help bolster the evidence base for cost-effective preventive interventions.[46] The sheer scale of NIH funding, however, results in impacts that go well beyond knowledge creation. NIH funding of indirect costs supports the general facility and administrative expenses of grantees, which can approach 70%, and approximately $730 million supported training and career development grants in FY2012.[47,48] Encouraging skilled researchers to stay in prevention research requires robust funding that will create sustainable career paths, especially for junior scholars. The scale and scope of NIH funding also affects the nature of public–private partnerships. NIH funding for biomedicine is the foundation of the U.S. private medical innovation sector, which generated an estimated $84 billion in wages and $90 billion in exported goods and services in FY2011.[31]

The convergence of behavioral science, economics, and new technologies is generating novel products and systems that could help sustain behavioral change, often a key criticism of lifestyle modification programs. Indeed, behavioral economics is only just starting to influence public policy, and a growing number of interventions using behavioral nudges, financial incentives, and new prevention-focused devices are showing promise in improving patient engagement and adherence in a range of health promotion programs.[49,50] Private sector healthcare companies are responding to these market trends by making significant investments in digital enabling technology, spending roughly $14 billion annually—almost half of the annual NIH budget.[51] Increased federal research in these areas would help accelerate progress and build a stronger coalition of private sector supporters for the NIH. Stronger consideration should be given to implementing the NIH Office of Disease Prevention Strategic Plan's objective to promote collaborations between ICs and with external stakeholders. Establishing private–public partnerships and working more closely with private entities not usually engaged with the NIH may accelerate opportunities in prevention science.[52]

Limitations

Owing to time and resource limitations, this study did not include all ICs, NCDs, and other funding mechanisms. Including these additional funding mechanisms would likely alter the proportions presented in this paper. We opted not to make a FOIA request to obtain the current NIH Prevention algorithm, because we were advised that our keyword search terms were appropriate reflections of the current algorithm and owing to perceived time constraints. Obtaining the algorithm may have simplified our analysis; however, our findings indicate that the current algorithm may not be capturing all prevention projects. Finally, using the Administrative IC as the unit of analysis, the total award amount could be captured, but it masked interagency funding for projects. Despite these limitations, the findings highlight a need for additional investment in prevention science and provide a basis for future research to delineate how U.S. federal funding portfolios are aligned with the U.S. burden of disease and the major modifiable risk factors attributed to chronic NCDs.

Conclusions

Chronic underfunding for disease prevention is the result of historic trends and persistent negative perceptions of the value of prevention. Mayes and Oliver[53] have cogently analyzed the structural disadvantages of public

health and prevention in the U.S. compared with healthcare services, which include the dispersed and delayed benefits of prevention. However, the progressive shift in the disease burden profile in the U.S. has profound implications for the types of resources, education curricula, and multisectoral partnerships that are now urgently needed to control the rapidly rising costs of NCDs. Investing in prevention should be a strategic national priority to help improve the lagging population health of the U.S. compared with other industrialized nations.[14,54] The NIH should be encouraged to increase its investments in prevention science focused on reducing the future burden of chronic diseases.

The sponsor of the study provided limited input on the study design and had no role in the data collection, analysis, or interpretation. The senior author (D. Yach), employed by the sponsor of the study, contributed to the conceptualization and writing of the report. The corresponding author (C. Calitz) had full access to all the data in the study and had final authority for submission for publication. Two authors (Calitz and Millard) conducted the research while at the Institute for Health and Social Policy, Department of Health Policy and Management, Bloomberg School of Public Health, Johns Hopkins University. The opinions expressed in this paper by the lead author (Calitz) are personal and do not reflect the official policy of the American Heart Association. The authors thank Gerard Anderson, PhD (Johns Hopkins University), Olakunle Alonge, PhD (Johns Hopkins University), Carey Borkoski, PhD (Johns Hopkins University), Melissa Antman, PhD (National Heart, Lung, and Blood Institute, NIH), Terry Huang, PhD (University of Nebraska Medical Center), and Jeff Levi, PhD (Trust for America's Health) for their comments on earlier drafts of this paper. The authors also thank copy editor M.L. Carter, Bowery Consulting, New York NY.

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Appendix

Supplementary Data

Supplementary data associated with this article can be found at http://dx.doi.org/10.1016/j.amepre.2014.10.015.