Dissemination and Implementation Research at the National Cancer Institute: A Review of Funded Studies (2006–2019) and Opportunities to Advance the Field

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ABSTRACT

Background: To ensure investment in cancer research reaches populations who can benefit, the NCI has funded implementation science grants since the Dissemination and Implementation Research in Health (DIRH) funding opportunities launched in 2006. We analyzed NCI-funded DIRH grants to provide a snapshot of implementation science conducted across the cancer care continuum and highlight areas ripe for exploration.

Methods: NCI-funded DIRH grants between fiscal years 2006 and 2019 were identified using the iSearch database. Two coders classified each grant by topic, populations studied, intervention and setting characteristics, strategies tested, study designs and methods used, and outcomes measured.

Results: Seventy-one grants were awarded addressing cancer prevention ($n = 33$), screening ($n = 33$), diagnosis ($n = 4$), treatment ($n = 9$), and/or survivorship ($n = 11$). Colorectal ($n = 20$), breast ($n = 15$), and cervical ($n = 11$) were the most studied cancers. Most grants focused on delivery of guidelines ($n = 36$) or behavioral change interventions ($n = 18$) in health care settings ($n = 47$), studying implementation processes ($n = 37$) and/or testing implementation strategies ($n = 43$) using experimental ($n = 35$) and quasi-experimental ($n = 6$) designs. Few studied sustainability ($n = 7$), scale-up ($n = 2$), deimplementation ($n = 4$), measure development ($n = 6$), or policy-level implementation ($n = 6$).

Conclusions: Current funding suggests researchers are studying implementation of cancer control interventions across the care continuum. However, research gaps remain in strategies for sustainability, scale-up, and deimplementation. More emphasis is needed on cancer treatment and survivorship. Additional focus on policy implementation and measure development is warranted.

Impact: Understanding the breadth of NCI-funded implementation science can inform future efforts to build the knowledge base on how to improve dissemination and implementation of evidence in cancer control.

Introduction

To ensure investment in cancer research reaches the populations who can benefit, the NCI has been funding implementation science grants since 2006. As this relatively nascent field has evolved over the past 15 years, NCI's spending in implementation science has significantly increased. While most of these efforts have been concentrated within certain areas of cancer prevention and control, there is growing commitment to implementation science across the cancer continuum. Namely, the Cancer Moonshot[SM], launched in 2016, includes implementation science as a key priority across several Moonshot initiatives from prevention to treatment and survivorship. The recently released NCI Annual Plan and Budget Proposal to Congress for fiscal year 2021 highlights implementation science as one of three priority areas for investment, giving further impetus for implementation science activities in cancer to continue to grow (1).

The growing interest in implementation science in cancer control has been demonstrated by the increasing number of funding opportunities, grant applications, conference attendees, and job openings in this area. However, there remains variation in the depth of understanding of this field. Here we provide a brief orientation to implementation science on cancer control and, through an analysis of the NCI-funded grants, a lens on how the field has evolved and prioritizes topics in cancer control.

Implementation science is the scientific study of methods or strategies to promote the systematic uptake of evidence and evidence-based practices, programs, and policies into routine practice (2). The field is predicated on the fact that there is a substantial gap between research and practice, and a recognition that our health care delivery system has consistently struggled to translate knowledge into care (3). Thus, implementation science seeks to build the knowledge base on effective strategies for improving the dissemination, implementation, integration, sustainability, and scale-up of evidence-based practices.

The primary mechanisms through which NCI has supported implementation science throughout the past fifteen years are the funding opportunity announcements in Dissemination and Implementation Research in Health (DIRH), which support large, small, and exploratory research projects (4–6). As described in these funding opportunities, NCI seeks to support research that will bridge the gap between research, practice, and policy by building a knowledge base about how health information, effective interventions, and clinical practices, guidelines and policies can be effectively communicated and integrated for public health and health care service use. In addition, studies to advance the field's understanding of how best to stop or reduce (deimplement) the use of practices that are ineffective, unproven, low-value, or harmful, are also encouraged. These program announcements also serve to support the advancement of implementation science methods and measures. For the purposes of these funding announcements, we make a distinction between

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Note: Supplementary data for this article are available at Cancer Epidemiology, Biomarkers & Prevention Online (http://cebp.aacrjournals.org/).

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implementation research and dissemination research as two distinct areas within implementation science broadly (7). Dissemination research is focused on understanding how best to communicate and integrate knowledge and the associated evidence-based interventions (EBI) to targeted public health and clinical practice audiences, to maximize the reach of EBIs. Implementation research is focused on understanding the use of strategies to maximize adoption and integration of EBIs into clinical and community settings. Both dissemination and implementation research ultimately aim to improve health and healthcare and benefit population health.

A previously published analysis of NCI-funded grant awards described trends in implementation science between 2000 and 2012 (8). Since 2012, new priority areas, including measures development, sustainability, deimplementation, scale-up and adaptation, have been highlighted in sequential reissuances of the program announcements, and the number of grants has more than doubled. The purpose of this article is to describe NCI's expanded investment to date in implementation science funded through the Dissemination and Implementation Research in Health program announcements and highlight the gaps and opportunities for future research to advance cancer control.

Materials and Methods

We sought to analyze all NCI-funded grants awarded through the DIRH funding announcements since their inception in 2005. We used an internal NIH portfolio analysis platform, iSearch, which is a dynamic platform that can continually update portfolios with new grant submissions that meet the criteria specified. In this analysis, we included newly awarded grants through September 2019 (Supplementary Table S1).

We developed a codebook in collaboration with the trans-NIH dissemination and implementation (D&I) working group (made up of health scientists across the NIH engaged in implementation science activities), designed to ascertain information including broad research topic area, cancer site, stage in the cancer care continuum, demographics of the study population, details regarding the intervention and how it is delivered, as well as the implementation strategies used (9), study settings, the use of theories, models, and frameworks (10), implementation outcomes (11), implementation measures, and study design and methods (12, 13). The codebook was piloted by members of the D&I working group on a representative sample ($n = 15$) of grants across the NIH (including NCI and six other institutes and centers who collectively fund the vast majority of DIRH grants). After further refinement, the codebook was used to code all NCI-funded grants. Additional fields were added to the codebook for this project related to health disparities research (14). All grants were independently coded directly in iSearch by two reviewers (G. Neta and M. Clyne), with any discrepancies resolved through discussion and/or a third coder (D.A. Chambers). Multiple coding assignments within classification categories were allowed within each grant award where applicable.

In addition to data collected using the codebook, we also ascertained total funding, fiscal year awarded, funding mechanism, new investigator awardees, and awardee institutional type. Summary analyses were performed using iSearch, Microsoft Access, and Excel.

Results

Seventy-one new DIRH grants were awarded by the NCI between 2006 and September 2019. The majority were large research projects (R01s), one-third were exploratory or developmental research projects (R21s), and 8% were small grants (R03s; see **Table 1**). This analysis reflects an additional 39 projects funded since our prior portfolio analysis, which had included 32 DIRH grants. **Figure 1** illustrates total NCI dollars spent on DIRH grants for all three funding mechanisms (R01, R21, R03) across the study period, with a notable surge in fiscal year 2012 followed by an overall increasing trend through 2019.

Table 1. NCI-funded DIRH awards by grant mechanism, grouped by fiscal year ranges of 2006–2012 and 2013–2019, and total funding.

Mechanism/ fiscal year range	Funds in U.S. dollars	Number of new awards (%)
R01		
Total	95,366,595	42 (59)
2006–2012	51,214,174	20 (28)
2013–2019	44,152,421[a]	22 (31)
R21		
Total	8,091,049	23 (32)
2006–2012	2,951,556	8 (11)
2013–2019	5,139,493	15 (21)
R03		
Total	875,911	6 (8)
2006–2012	563,911	4 (6)
2013–2019	312,000	2 (3)
Overall	104,333,555	71
2006–2012	54,729,641	32 (45)
2013–2019	49,603,914[a]	39 (55)

[a]Lower R01 funding level in 2013–2019 reflects inclusion of active grants that have yet to be funded in future years.

Over three-quarters (84%) of all awarded grants were submitted through universities across 37 institutions, with the remaining funded through research organizations (7%), independent hospitals (4%), and other organizations involved in health-related activities (4%). Eighteen grants were awarded to new investigators, which were equally distributed over all years in which new grants were awarded. One grant was awarded to a foreign investigator.

Table 2 describes the demographic characteristics of the study populations in NCI-funded DIRH grants. Most grants studied populations in the United States ($n = 60$), with low and middle-income countries (LMIC) represented in 12% of grants ($n = 8$). LMIC countries included Argentina, Brazil, India, Kenya, Peru, Vietnam, Zambia, South Africa, Botswana, and Uganda. Of those grants set solely in the United States ($n = 60$), most ($n = 45$) included more than one racial group and both Hispanic and non-Hispanic populations ($n = 39$). Twenty-four grants targeted all races.

Table 3 describes the characteristics of the intervention under study. The cancer site most studied was colorectal ($n = 20$), with breast ($n = 15$) and cervical ($n = 11$) being the second and third most common. Other cancer sites included prostate ($n = 5$), lung ($n = 4$), skin ($n = 3$), and pancreatic, endometrial, and ovarian cancers ($n = 1$ each). Thirty-nine grant applications were nonspecific to cancer type, and either addressed implementation science applicable to cancer in general (e.g., cancer survivor care, state-level cancer control plan), or a preventive or risk intervention that did not mention any specific cancer types as outcome measures [e.g., physical activity, human papillomavirus (HPV) vaccination]. Health disparities were addressed in 72% ($n = 43$ of 60) of grants set in the United States, with the majority of these solely focused on medically underserved

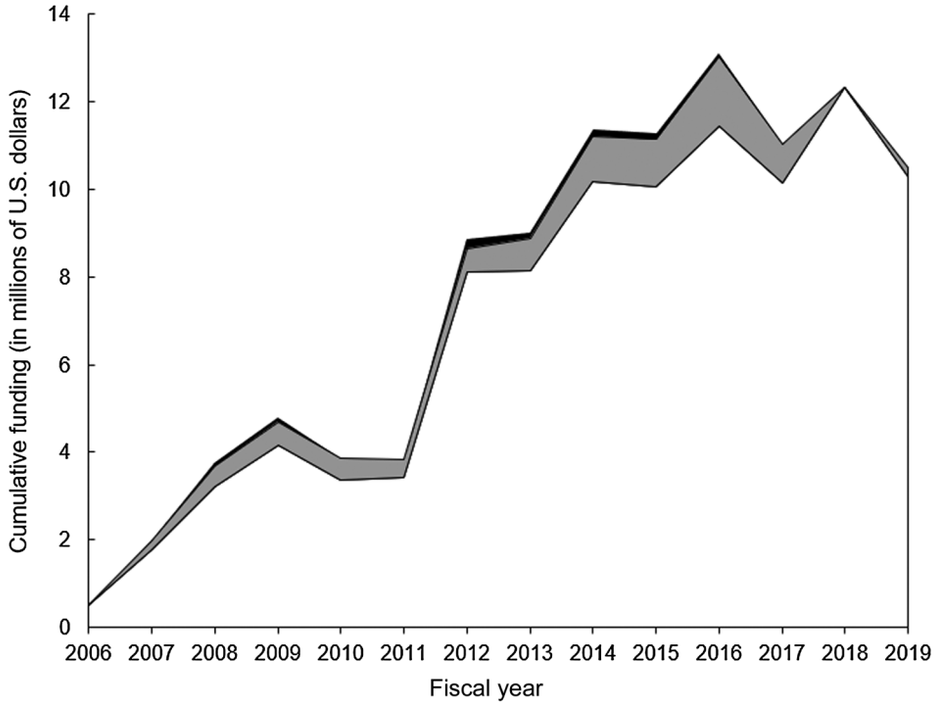

Figure 1.
Funding trends of NCI-funded grants through the Dissemination and Implementation Research in Health program announcements by funding mechanism for fiscal years 2006–2019. Graph shows trends in cumulative funding from fiscal year 2006 through 2019, with proportion of funding separated by R03 (black), R21 (gray), and R01 (white) funding mechanisms.

populations ($n = 28$). The remaining grants either compared disparate groups ($n = 7$) or made comparisons within medically underserved populations ($n = 8$).

Across the cancer care continuum, we identified NCI-funded DIRH grants that addressed prevention ($n = 33$), screening ($n = 33$), diagnosis ($n = 4$), treatment ($n = 9$), survivorship ($n = 11$), and/or end-of-life ($n = 2$). Of those grants that focused on only one area of the continuum, the most common were prevention ($n = 23$) and screening ($n = 22$), which were also addressed together ($n = 9$). Notably, the number of grants that focused on diagnosis, treatment, and survivorship more than doubled after 2012; 5 grants between 2006 and 2012, and 12 between 2013 and 2019.

The most commonly addressed content areas were cancer screening ($n = 29$), tobacco control ($n = 18$), physical activity ($n = 10$), and diet ($n = 10$). Additional topics included decision support ($n = 6$), UV protection ($n = 6$), obesity ($n = 5$), HPV vaccination ($n = 5$), genomics ($n = 3$), surveillance ($n = 3$), and mental health ($n = 2$). The most common types of interventions delivered were evidence-based guidelines ($n = 36$), behavioral change interventions ($n = 18$), best practices[1] ($n = 13$) (15), organizational change ($n = 4$), and patient navigation ($n = 4$). **Table 3** also lists the delivery methods used for these interventions. Face-to-face methods for delivering interventions was most frequently used ($n = 42$), followed by online delivery, but was often combined with other delivery methods involving technology ($n = 24$), including mobile technology, electronic health record, text message, social media, and email.

Broadly, both dissemination and implementation research activities were proposed in 20% of grants ($n = 14$), whereas over 70% ($n = 50$) only implementation, and 10% ($n = 7$) only dissemination. **Table 4** describes the characteristics of the studies regarding implementation science theories, frameworks, and models, phases of implementation, strategies, levels of implementation, settings, study designs, methods, and outcome measures. The following paragraphs summarize these findings.

Implementation science theories, models, and/or frameworks were used in 75% ($n = 53$) of grants. Most frequently used were RE-AIM ($n = 30$), Diffusion of Innovations ($n = 19$), and Consolidated Framework for Implementation Research (CFIR; $n = 13$). Most grants described an implementation process ($n = 37$) and/or tested an implementation strategy ($n = 43$). Grants focused on preimplementation ($n = 21$) were primarily awarded prior to 2015. Relatively few grants focused on sustainability ($n = 7$), deimplementation ($n = 4$), or measures development ($n = 6$). Over half of grants proposed testing of implementation strategies ($n = 43$), while few addressed dissemination strategies ($n = 5$), deimplementation ($n = 4$), and scale-up ($n = 2$). Although testing scale-up strategies was only proposed in 3%, studies designed to inform future scale-up were represented in 12% ($n = 8$). Among the six studies that addressed measure development, only one was exclusively focused on developing and validating an implementation science measure, namely an assessment of organizational readiness.

Implementation was assessed at the clinic-level ($n = 29$) and community-level ($n = 21$) in most grants, with more than half ($n = 12$) of the community-level projects awarded after 2012. Only 7 grants addressed implementation at multiple levels. Health care settings were the most common settings ($n = 47$). Sixteen grants included multiple health care settings (e.g., academic medical center, federally qualified health center, and community health center). Health departments were the second most common setting ($n = 12$), and policy-level implementation was addressed in half of these ($n = 6$). The underrepresentation of policy-level implementation in our portfolio is consistent with Purtle and colleagues'

[1]Best practice was defined as an evidence-based intervention that did not fall into one of the other categories but met criteria set forth by Perleth et al. [15].

findings that policy-level implementation across the NIH is sparse (16).

Table 4 also describes study methods and designs used in NCI-funded DIRH grants. Most grants used both qualitative and quantitative methods ($n = 60$), of which only 25 used mixed methods approaches of integrating both qualitative and quantitative analyses. Study designs included primarily experimental ($n = 35$) and observational ($n = 27$), as well as quasi-experimental ($n = 6$), modeling (e.g., agent-based modeling, system dynamics; $n = 8$), case studies ($n = 8$), and pre–post ($n = 4$) designs. A hybrid effectiveness–implementation design (17) was used in 17% of grants ($n = 12$), and of these, 75% ($n = 9$) were grants newly awarded since 2013. Not presented in the table but noteworthy, five studies used community engaged research methods, and five used social network analysis.

Finally, the most commonly assessed implementation outcomes, as described by Proctor and colleagues (11), included adoption ($n = 37$), costs ($n = 34$), fidelity ($n = 32$), reach ($n = 29$), acceptability ($n = 23$), sustainability ($n = 22$), feasibility ($n = 17$), and acceptance ($n = 12$). The full list of implementation outcomes assessed across all 71 NCI-funded DIRH grants are listed in **Table 4**.

Figure 2 illustrates the history of the DIRH PARs, highlighting newly emphasized areas of research in subsequent reissuances of these funding announcements. The first set of these, first issued in 2005 and 2006, primarily focused on improving the implementation of specific evidence-based practices across clinical and community settings (18). Most of these studies were prospective. The second iteration of the DIRH PARs, released in December 2009, had an enhanced focus on improving measures and measurement in the field, and began to draw more attention to sustainability. Furthermore, clinical topics were expanded to include dental, complimentary medicine, and complex patients, and a broader array of designs and methods were used, including experimental, quasi-experimental, and observational designs (18). In January 2013, the DIRH PARs reissuance included an explicit emphasis on sustainability and scale-up; and in May 2016, the importance of deimplementation was highlighted. Finally, the most recent reissuance in 2019 continued to emphasize studies on adaptation, sustainability, scale-up, and deimplementation as well as measures development, but with an added emphasis on the varieties of settings in which health interventions may be delivered.

Discussion

NCI's investment in implementation science has significantly increased from 2006 to 2019 through funding primarily large but also small research grants in response to the DIRH PARs. Because a previously published portfolio analysis of grants funded through fiscal year 2012, both the number of grants and the total dollars spent has more than doubled in the second half of the DIRH PARs lifespan. Furthermore, since 2012 the number of grants that have addressed key gap areas identified in the previous analysis have increased, including measure development, de-implementation, and grants focused on cancer diagnosis, treatment, and survivorship. Although the majority of grants still focus on cancer prevention and screening, these analyses demonstrate that grants now span the cancer control continuum, including grants focused for the first time on cancer diagnosis as well as a substantial increase in the number of grants focused on cancer survivorship. A steady but small focus on cancer treatment remains, with roughly one funded grant per year since 2011. While several grants have addressed cancer treatment, none have focused on how to implement more broadly next-generation treatments like immunotherapy or gene-targeted therapy. Given the "silver tsunami" of cancer patients and survivors (19), the implementation of effective cancer treatments to all patients in need is also a key priority area. Grants focused on cancer prevention and screening continue to make up most funded projects, with an increased focus on cervical cancer and implementation of HPV vaccination. There also has been an increase in the number of grants focused on rural populations. Of the 30 total grants that included rural populations, the vast majority ($n = 23$) of them were awarded after 2012.

While more studies address gap areas identified in a previous analysis of grants funded through 2012 (8), many gaps remain. Namely, there is a paucity of studies focused on sustainability, scale-up, and deimplementation, as well as studies addressing implementation of genomic interventions. The need to focus on sustainability and scale up is to ensure that we understand the best ways not only to implement an intervention in a specific context but to ensure implementation can be sustained over time and scaled up across multiple settings so as to have enduring value to improving health in all populations who could benefit. The need to focus on deimplementation comes from an increasing appreciation for the need to reduce or stop the use of interventions that are harmful or wasteful, as recognized by Choosing Wisely and other initiatives (20).

Table 2. Demographics of the study populations.

	Number (%) of grants ($N = 71$)
Continent	
North America	62 (87%)
USA only	60 (85)
USA and Canada	2 (3)
South America	3 (4)
Africa	2 (3)
Asia	2 (3)
Multiple continents	2 (3)
Race[a]	
Black	46 (65)
White	47 (66)
Asian	38 (54)
American Indian/Alaska Native	27 (38)
Native Hawaiian/Pacific Islander	20 (28)
Not specified	7 (10)
Ethnicity[b]	
Both Hispanic and non-Hispanic	39 (55)
Non-Hispanic only	12 (17)
Not specified	8 (11)
Gender	
Both male and female	51 (72%)
Female only	13 (18)
Male only	0
Not specified	4 (6)
Not relevant[c]	3 (4)
Geographic area	
Both urban and rural	26 (37)
Urban	8 (11)
Rural	5 (7)
Not specified	32 (45)

[a]Race was coded only for grants set solely in the United States. These categories are not mutually exclusive.
[b]Ethnicity was coded only for grants set solely in the United States.
[c]Not relevant grants include grants that used administrative data and observational designs.

Table 3. Characteristics of the interventions under study in NCI-funded DIRH grants.

Characteristics	Number (%) of grants ($N = 71$)
Target cancer site[a]	
Colorectal	20 (28)
Breast	15 (21)
Cervical	11 (15)
Prostate	5 (7)
Lung	4 (6)
Skin	3 (4)
Childhood	2 (3)
Ovarian	1 (1)
Endometrial	1 (1)
Pancreatic	1 (1)
Not specified	39 (55)
Cancer care continuum[a]	
Prevention	33 (46)
Screening	33 (46)
Diagnosis	4 (6)
Treatment	9 (13)
Survivorship	11 (15)
End of life	2 (3)
Content area[a]	
Cancer screening	29 (41)
Tobacco control	18 (25)
Physical activity	10 (14)
Diet	10 (14)
Decision support	6 (8)
UV protection	6 (8)
Obesity	5 (7)
HPV vaccination	5 (7)
Genomics	3 (4)
Surveillance	3 (4)
Mental health	2 (3)
Palliative care	2 (3)
Other	6 (8)
Type of intervention[a]	
Behavioral change intervention	18 (25)
Evidence-based guideline	36 (51)
Best practice[b]	13 (18)
Care delivery model	3 (4)
Organizational change	4 (6)
Quality measures	1 (1)
Patient navigation	3 (4)
Policy	4 (6)
Not stated	1 (1)
Delivery method[a]	
Face-to-face	42 (59)
Online	16 (23)
Phone	15 (21)
Mobile technology	12 (17)
Electronic health records	8 (11)
Printed material	6 (8)
Mail	5 (7)
Text message	2 (3)
Social media	2 (3)
E-mail	2 (3)
Social marketing	2 (3)
Other	4 (6)
Not applicable	9 (13)
Not stated	4 (6)
Health disparities research[c]	
Yes	43 (61)
Medically underserved populations[d]	28 (39)
Health disparities[e]	7 (10)
Both	8 (11)
No	20 (28)
Not applicable[f]	8 (11)

[a]Categories not mutually exclusive.
[b]Best Practice defined as an evidence-based intervention that did not fall into one of the other categories but still met criteria set forth in Perleth and colleagues (15).
[c]See https://maps.cancer.gov/overview/DCCPSGrants/explanationHD.jsp for definitions.
[d]Studies that are not comparative but focused on specific populations based on gender, age, race, ethnicity, education, income, social class, disability, geographic location, or sexual orientation are listed as "medically underserved" (e.g., a study based on cancer care in a low-income community).
[e]Studies that are comparative based on gender, age, race, ethnicity, education, income, social class, disability, geographic location, or sexual orientation are listed as "health disparities" (e.g., a study delineating differences in health care access and utilization for cancer control between rural and urban areas).
[f]Not applicable if outside the United States.

In addition, few studies focus on policy-level implementation, consistent with findings from previous portfolio analyses (16, 18), and although some studies focus on measure development, these are still very few; only one NCI grant has had an explicit focus on developing a standardized measure that could be used across studies and topic areas. Another notable gap is a focus on addressing health disparities. Although most grants address health disparities primarily by focusing on medically underserved populations, relatively few studies are comparative between groups, and thus lack the ability to examine whether implementation efforts are in fact reducing or exacerbating inequities in access or quality of care.

Studies have used a variety of implementation science methods, measures, and designs, as well as a large assortment of different theories, frameworks, and models. Since the publication in 2012 by Geoff Curran and colleagues on hybrid effectiveness-implementation research designs, NCI has funded several hybrid studies. These include three different types of hybrid effectiveness–implementation designs depending on the degree to which the primary aim of the study is intervention effectiveness versus testing implementation strategies. NCI has funded six type 1 studies, in which the primary aim of the study is testing intervention effectiveness with a secondary aim of collecting data on implementation, five type 3 studies, in which the primary aim is testing an implementation strategy with a secondary aim of collecting data on effectiveness, and one type 2 study which tests both effectiveness and implementation as dual primary aims. However, given the plethora of effective interventions and opportunities for expanding the use of these across a variety of settings, particularly low resource settings, we would like to see increased focus on the use of type 3 hybrid designs, as well as additional focus on sustainability, scale-

Table 4. Characteristics of NCI-funded DIRH grants, 2006–2019.

Characteristics[a]	Number (%) of grants ($N = 71$)
Theories, models, frameworks used	
RE-AIM	30 (42)
Diffusion of Innovations	19 (27)
CFIR	13 (18)
Organizational readiness for change	4 (6)
PARIHS	2 (3)
Interactive systems framework	2 (3)
Other	11 (15)
None	18 (25)
Phase of implementation	
Preimplementation	21 (30)
Describe implementation process	37 (52)
Test implementation strategy	43 (61)
Test dissemination strategy	5 (7)
Sustainability	7 (10)
Deimplementation	4 (6)
Measure development	6 (8)
Scale-up	2 (3)
D&I strategies[b]	
Planning	13 (18)
Educating	41 (58)
Restructuring	15 (21)
Financing	6 (8)
Managing quality	33 (46)
Attending to policy context	4 (6)
Target level of implementation	
Patient level	10 (14)
Provider level	13 (18)
Clinic level	29 (41)
Community level	21 (30)
Policy level	6 (8)
Setting	
Health care setting	47 (66)
Health department	12 (17)
Community-based organization	7 (10)
Workplace	4 (6)
Recreation	1 (1)
School	2 (3)
Church	5 (7)
Home	2 (3)
Online (Facebook, Quitline)	2 (3)
Methods used	
Quantitative only	11 (15)
Qualitative only	0
Qualitative and quantitative	60 (85)
Mixed methods[c]	25 (35)
Study designs	
Experimental	35 (49)
Quasi-experimental	6 (8)
Observational	27 (38)
Modeling	8 (11)
Case study	8 (11)
Pre—post	4 (6)
Type of hybrid design	
Hybrid type 1	6 (8)
Hybrid type 2	1 (1)
Hybrid type 3	5 (7)
D&I outcomes	
Acceptability	23 (32)
Acceptance	12 (17)
Adaptability	1 (1)
Adaptation	1 (1)
Adherence	1 (1)
Adoption	37 (52)
Appropriateness	7 (10)
Awareness	9 (13)
Costs	34 (48)
Dose	4 (6)
Feasibility	17 (24)
Fidelity	32 (45)
Maintenance	2 (3)
Penetration	4 (6)
Reach	29 (41)
Scalability	1 (1)
Scale-up	2 (3)
Sustainability	22 (31)

(Continued on the following column)

Table 4. Characteristics of NCI-funded DIRH grants, 2006–2019. (Cont'd)

Abbreviations: CFIR; Consolidated Framework for Implementation Research; PARIHS, Promoting Action on Research Implementation in Health Services; RE-AIM, Reach, Effectiveness, Adoption, Implementation, Maintenance.

[a]Categories are not mutually exclusive unless indicated otherwise.

[b]Implementation strategy categories based on Powell 2012, and assessed only for grants conducting implementation research. Dissemination strategies not included.

[c]Mixed methods defined as the integration of quantitative and qualitative methods in the same study or project (13).

up, and deimplementation. New in the latest reissuance of these funding announcements is an explicit attention to the need for understanding how implementation strategies work, and thus, we have added a focus on studies of understanding the mechanisms, mediators, and moderators of implementation.

A limitation of this manuscript is that it only reflects NCI's investment in IS through the specific DIRH funding announcements. Other NCI funding opportunities, such as the Moonshot initiatives, include an implementation science focus, and these may fill some of the noted gaps in research. Specifically, Moonshot initiatives have focused additional attention on minimizing the debilitating side effects of cancer treatment through implementation of symptom management interventions as well as on prevention and early detection of hereditary cancers. In addition, other NIH institutes have funded cancer-relevant research through the DIRH announcements ($n = 12$ grants). These grants focused on HPV vaccination ($n = 2$), tobacco cessation ($n = 3$), oral cancer screening ($n = 1$), reducing obesity through physical activity and healthy eating ($n = 4$), and symptom management for cancer survivors ($n = 2$). Because these grants focus on topics that overlap with those that NCI has funded, it reinforces our findings of existing gaps. Because we do not have administrative control of these awards, we did not include them as part of the research that NCI oversees. Furthermore, this is data only on proposed and funded research, not on what was accomplished through the conduct of the funded studies. Analyzing publications of research outcomes resulting from these grants are warranted. The curation of grant applications was performed in duplicate with thorough review of discrepant results; however, there may have been unintended omissions or misinterpretation. Should this have occurred, it would not be expected to change overall findings significantly.

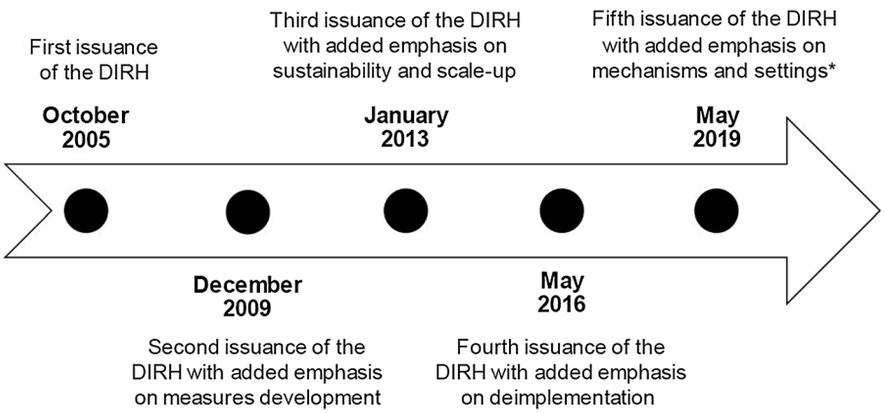

Figure 2.
Timeline of the Trans-NIH DIRH program announcements with noted issuance dates and topics of added emphasis. Timeline shows the newly highlighted topic areas addressed in the respective funding announcements for each of five issuances over time. *Variety of settings includes community, public health, and health care settings.

The NCI's investment in implementation science has increased substantially since the creation of the funding announcements in Dissemination and Implementation Research in Health in 2006. While implementation science proposals now span the cancer control continuum, we continue to see a dearth of studies addressing critical challenges of sustainability, scale-up, and deimplementation, and in settings beyond healthcare. Within healthcare settings more research is needed in cancer treatment and survivorship. Furthermore, we hope to see additional proposals focused on building capacity in the field by developing rigorous, relevant, and rapid methods and measures that can be used across study topics and contexts. To assist in these efforts, NCI launched an Implementation Science Consortium in Cancer (ISCC; ref. 21) which is an annual forum for implementation scientists focused on cancer control to discuss theoretical, methodologic, and empirical challenges and gaps in the field and to develop initiatives or "public goods" that can address those gaps.

Authors' Disclosures

No disclosures were reported.

Authors' Contributions

G. Neta: Conceptualization, data curation, software, formal analysis, supervision, validation, investigation, writing-original draft, project administration, writing-review and editing. **M. Clyne:** Data curation, software, formal analysis, investigation, writing-original draft, project administration, writing-review and editing. **D.A. Chambers:** Conceptualization, formal analysis, supervision, writing-review and editing.

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