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# Implementation Science for the Environment

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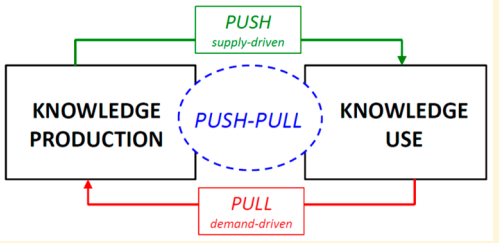
**ABSTRACT:** The establishment of the field of implementation science was motivated by the understanding that medical and health research alone is insufficient to generate better health outcomes. With strong support from funding agencies for medical research, implementation science promotes the application of a *structured* framework or model in the implementation of research-based results, specifically evidence-based practices (EBPs). Furthermore, explicit consideration is given to the *context* of EBP implementation (i.e., socio-economic, political, cultural, and institutional factors that could affect the implementation process). Finally, implementation is *monitored* in a robust and rigorous way. Today, the field of implementation science supports conferences and professional societies as well as one dedicated journal and numerous others with related content. The goal of these various activities is to reduce the estimated, average "bench to bedside" time lag of 17 years for uptake of EBPs from health research into routine practice. Despite similar time lags and impediments to uptake in the environmental domain, a parallel field of implementation science for the environment has not (yet) emerged. Although some parallels in needs and opportunities can easily be drawn between the health and environmental domains, a detailed mapping exercise is needed to understand which aspects of implementation science could be applied in the environmental domain either directly or in a modified form. This would allow an accelerated development of implementation science for the environment.






## INTRODUCTION

How long does it take for environmental research findings to be taken up into policy (at regional, national, and global levels) so that impacts and harm to the environment and human health can be mitigated? It has been estimated that global policy action to protect the ozone layer lagged scientific understanding by about 30 years and even longer time lags have been estimated for contaminants such as mercury, lead and PCBs.[1] Similar observations in medicine and public health have led to an estimate of 17 years for the average "bench to bedside" time lag for health research.[2] Frustrations over these delays motivated concerted efforts to facilitate the dissemination and implementation (D&I) of clinical research through translational medicine and implementation science, which are now well-established fields. In 2010, a parallel was drawn between translational medicine and translational ecology, with the former connecting "the patient to new basic research" and the latter connecting "end-users of environmental science to the field research carried out by scientists who study the basis of environmental problems".[3] This call was echoed last year in a special issue of *Frontiers in Ecology and the Environment* that cited some of the literature on translational medicine.[4,5] Implementation science, however, was not mentioned, thus missing the opportunity to leverage synergies with this field.

## IMPLEMENTATION SCIENCE

Implementation science has been defined as "the scientific study of methods to promote the systematic uptake of research findings and other evidence-based practices into routine practice, and, hence, to improve the quality and effectiveness of health services and care".[6] This definition appeared in the inaugural issue of the open access journal *Implementation Science* in 2006.

Implementation science is motivated by the recognition that concerted efforts are needed to improve the likelihood that research results, specifically evidence-based practices (EBPs), are taken up.[7,8] These efforts involve multiple actors including health care professionals and patients in the case of medical practice or legislators and regulators in the case of health policy. Standardized processes and frameworks based on conceptual models and theories have been developed to promote these efforts[9] and systemized curricula and training materials are available.[10−12] Tables 1 and 2 provide (noncomprehensive) overviews of the range of organizations and resources that are available under the umbrella of implementation science. The range of these resources and activities (e.g., conferences) reflects the strong interest of national and international agencies funding health research, in particular the U.S. National Institutes of Health (NIH).[11]

To summarize very briefly, there are three key aspects of implementation science. The first is that a *structured* framework or model is applied to the process of implementing an EBP. The second is that the *context* of EBP implementation is explicitly considered (where context includes socio-economic, political, cultural and institutional aspects). The third is that

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**Table 1. Professional Networks (Societies and Consortia) And Conferences for Implementation Science (Not Comprehensive)**

| name | type[a] | web site |
|---|---|---|
| Annual Conference on the Science of Dissemination and Implementation for Health | C | https://www.academyhealth.org/events/site/10th-annual-conference-science-dissemination-and-implementation-health |
| Consortium for Implementation Science | N | http://consortiumforis.org/ |
| European Implementation Collaborative | N | http://www.implementation.eu/ |
| Global Evidence and Implementation Summit | C | https://www.geis2018.org/ |
| Global Implementation Initiative and Conference | N, C | https://gic.globalimplementation.org/ |
| National Implementation Research Network | N | http://nirn.fpg.unc.edu/ |
| Nordic Implementation Conference | N, C | http://nordicimplementation.net/ |
| Society for Implementation Research Collaboration | N | https://societyforimplementationresearchcollaboration.org/ |
| UK Implementation Society | N | https://www.ukimplementation.org.uk/ |
| WHO Alliance for Health Policy and Systems Research | N | http://www.who.int/alliance-hpsr/en/ |

[a]C = conference, N = network (including societies and consortia).

**Table 2. Implementation Science Resources (Not Comprehensive)**

| name | type[a] | web site |
|---|---|---|
| Centre for Evidence and Implementation | S | http://www.ceiglobal.org/ |
| Consolidated Framework for Implementation Research | F | http://www.cfirguide.org/ |
| Dissemination and Implementation Models | T | http://dissemination-implementation.org/index.aspx |
| Implementation Science Exchange (ImpSciX) | C | https://impsci.tracs.unc.edu/ |
| Integration and Implementation Science (I2S) | E | http://i2s.anu.edu.au/ |
| Knowledge Mobilization Toolkit | T | http://www.kmbtoolkit.ca/the-toolkit |
| NIH Fogarty International Center Implementation Science Information and Resources | E | https://www.fic.nih.gov/ResearchTopics/Pages/ImplementationScience.aspx |
| NIH Office of Disease Prevention Dissemination and Implementation | E | https://www.prevention.nih.gov/prevention-research/research-highlights/dissemination-and-implementation |
| NIRN Active Implementation Hub | C | http://implementation.fpg.unc.edu/?o=nirn |
| Research Impact | C | http://researchimpact.ca/ |
| TDR Implementation Science Toolkit | T | http://www.who.int/tdr/publications/topics/ir-toolkit/en/ |
| http://adphealth.org/irtoolkit/ | | |
| Toolkit: Implementation of Best Practice Guidelines (2nd edition) | T | http://rnao.ca/bpg/resources/toolkit-implementation-best-practice-guidelines-second-edition |
| Toolkit: Overcoming Barriers to Implementation in Global Health | T | https://www.fic.nih.gov/About/center-global-health-studies/neuroscience-implementation-toolkit/Pages/default.aspx |

[a]C = collection of resources, E = entry point for resources on external sites, F = framework, S = services, T = toolkit and models.

implementation is *monitored* in a robust and rigorous way. This structured approach provides a basis for the assessment of the potential for EBP implementation under the existing conditions (i.e., context) relevant to a specific application.[13] Implementation science goes beyond traditional clinical medicine by "focusing not only at the patient level but also at the provider, organization and policy levels of healthcare".[7]

Despite this explicit mention of health policy, many, if not most, of the resources listed in Tables 1 and 2 focus on the implementation of EBPs in (clinical) practice rather than their influence on health policy. Barriers to evidence-based policy-making in the field of public health have been ascribed to the incompatible attitudes and conflicting interests and incentives of medical scientists and policy makers.[14] A further complexity is that health policies themselves require implementation to have impact outside the policy sphere (i.e., policy implementation.) Both policy implementation research and implementation science deal with the common challenge of "translating intentions into desired changes".[15]

## IMPLEMENTATION SCIENCE BEYOND THE HEALTH DOMAIN

Implementation science is most strongly established within the domain of the health sciences, as reflected in the bounds explicitly set in journal bearing this name as well as in the strong medical focus of journals presenting related work (illustrated by the reference list of this paper). Implementation science has, however, been extended to other fields with a focus on human welfare, including mental health, social services, juvenile justice, education, unemployment and substance abuse and prevention.[8] Implementation science has also been applied (or at least advocated) in the field of public and environmental health, which likely reflects the influence of the NIH on its subsidiary agency the National Institutes of Environmental Health Sciences (NIEHS). For example, an implementation science approach has been advocated as a means to promote uptake of clean cooking technologies (i.e., to avoid the indoor air pollution problems associated with traditional cooking practices).[16]

## COMPARABLE AND CONTRASTING ISSUES IN THE HEALTH AND ENVIRONMENTAL DOMAINS

As already mentioned, the time lags that motivated the development of implementation sciences for health research are also observed in the environmental domain (here used broadly to include environmental science and engineering, natural resources management and climate science). There are, however, some important differences between the health and environmental domains that have resulted in different approaches being taken in these domains.



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**Different Positioning of Individual Actors and Institutional Settings.** Implementation of health research has the ultimate goal of improving health outcomes for individual patients and thus, in the aggregate, for communities. There are no direct conflicts between the interests of individual patients or between patients and unaffected individuals. Interactions with patients are often mediated through hospitals or health services. In contrast, environmental problems, such as contaminated sites or polluting industries, often involve different, conflicting interests between stakeholders or even for individual stakeholders (e.g., employees of a polluting industry versus adjacent homeowners).[17] The institutional settings in which environmental issues are addressed and individuals or communities engage with regulatory authorities are very variable. Mandated public engagement on environmental issues occurs more often at the community than at the individual level[18,19] though individual decision-making can be important for household-based environmental exposure (e.g., vapor intrusion)[20] or in agriculture, fisheries management and forestry.[21−25] The increasing implementation of decentralized water and wastewater treatment systems in urban settings is likely to increase the need for direct interaction with members of the public.[26,27]

**Differences in Scale.** A particular challenge in the environmental domain is that both environmental problems and possible measures to mitigate them occur on scales ranging from the global to the local. Manifestations on different scales (simultaneously) can lead to conflicts of interest; potential remedies may be ineffective if mismatches in scale are not resolved.[28] A focus on the global scale (e.g., for climate change, biodiversity or water management) can be useful to highlight commonalities and the urgency of the problem but may be counter-productive if effective solutions can only be identified, agreed upon and implemented at a more local scale.[29−31]

**Stronger Focus on Environmental Policy.** In both the health and environmental domains, there is a recognition of the need for the exchange of knowledge between researchers and decision-makers.[14,31−35] In the health domain, however, there has been a focus on practice (i.e., patients as individual decision-makers and healthcare providers as decision-makers within an institutional setting). Particular challenges to evidence-based policy making that relate to conflicting cultures and expectations have been identified within the health domain[14] and are echoed in the literature on environmental policy-making.[25,31,36−38] The stronger focus on the uptake of research results in environmental policy-making process reflects the more collective nature of decision-making in the environmental domain.[25,31,34] In addition, some implementation in environmental management and remediation (i.e., in practice) also involves participation of regulators or other (e.g., municipal or regional) authorities.[18,19] Some environmental regulations (e.g., the U.S. Safe Drinking Water Act) require periodic, science-based updating (e.g., inclusion of new substances to the Contaminant Candidate List).[39]

**Diffuse Engagement of Environmental Funding Agencies.** Strong interests from authorities and funding agencies are evident in both the health and environmental domains. Such interests, particularly when accompanied by (financial) support, can motivate and facilitate the engagement of researchers in knowledge exchange. Research projects conducted within the U.S. Superfund Basic Research Program (funded by the NIEHS) are required to include research translation and community engagement.[24,40,41] The European Commission has also supported various initiatives and projects to promote knowledge exchange,[42] for example, in the context of the Water Framework Directive.[43] The Australian Centre for Ecological Analysis and Synthesis was funded by national and state governments from 2009 to mid-2014 to support evidence-based environmental management and policy.[44] Over 100 nations came together in 2012 to establish the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, IPBES (https://www.ipbes.net/), under the auspices of the United Nations.[38] This diversity of environmental agency engagement as well as in the range of topics (e.g., site remediation, water management, biodiversity, climate change) has resulted in corresponding diversity in the approaches taken to promote implementation of research findings in environmental policy and practice.

**Varying Approaches Taken in the Environmental Domain.** Issues in the environmental domain have motivated a variety of approaches to engage stakeholders and promote evidence-based policy and practice. This has been accompanied by a proliferation of methods and techniques established within multiple subcommunities (e.g., action-, community-based-, inter- and transdisciplinary-, participatory-, and sustainability research as well as systems- and complexity science).[45] Although some structured approaches have been proposed in the environmental domain,[46−48] the criticism has been levied that knowledge exchange in this domain is often conducted "with little theoretical, methodological, or empirical grounding, and without any systematic evaluation".[46]

One common understanding in the environmental domain, however, is the need for knowledge brokering. This is a demanding task that involves mediating between knowledge producers and (potential) users and requiring a range of interpersonal and communication skills as well as some relevant technical expertise.[35,40,49−51] Knowledge brokers, who perform such tasks, must often learn their skills on the job and perform them without the type of structured support or the professional community that is offered by implementation science in the health domain.

## IMPLEMENTATION SCIENCE FOR THE ENVIRONMENT

With their coordinated emphasis on the need for knowledge exchange as well as the dedicated support provided by major funding agencies, the health sciences provide a valuable model for the environmental sciences. With minor modifications, the 2006 definition of implementation science could equally well applied to the environmental sciences; a modified version could read "the scientific study of methods to promote the systematic uptake of research findings and other evidence-based practices into *policy and practice*, and, hence, to improve the quality and effectiveness of the *management of the environment and natural resources for the protection of ecosystem services and public health*". It seems equally likely that many of the concepts and tools developed for implementation science (Table 2) could be applied in the environmental domain, taking advantage of some structured approaches that have been proposed to address environmental issues.[46,47] To overcome the fragmentation of approaches that characterize the environmental domain, it could be beneficial to adopt some additional aspects of implementation science.

**Professionalizing Implementation Science for the Environment.** It is too often the case that knowledge brokering activities are an under-funded component of



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environmental research projects. The expectation that knowledge brokering can be accomplished as a "side activity" by researchers subject to conflicting demands is unrealistic.[35,40,49,52,53] Knowledge brokering as a practical activity should be supported by a community of environmental implementation scientists and educators who can design and offer training in concepts and skills needed for knowledge brokering. This should leverage as much as possible the theories, concepts and tools of implementation science in the health domain (Table 2). Such training may be fruitfully incorporated in university curricula in environmental programs and/or offered as continuing education.[54,55] Engagement of skilled knowledge brokers in projects or by institutions must be supported not only financially but through establishment of career tracks.[5] Long-term career perspectives, rather than short-term, project-based employment, are needed to ensure continuity and build trust.[56]

**Leveraging Synergies among Individual and Institutional Actors.** In the environmental domain, much (if not most) of the knowledge brokering activities takes place outside of academic research institutions. Boundary organizations, whether governmental, industry, or civil society organizations, invest significantly to make scientific results accessible to target decision-makers.[23] Cooperation among academic researchers, their home institutions and (external) boundary organizations could promote stability and continuity in knowledge brokering activities and diversify professional opportunities for knowledge brokers as well as leveraging (scarce) resources and minimizing duplication of effort.[24,34] Engagement with environmental managers and/or regulators could be particularly valuable in developing reciprocal interactions between the producers and users of knowledge (shown in blue in Figure 1).[36,44,57] In

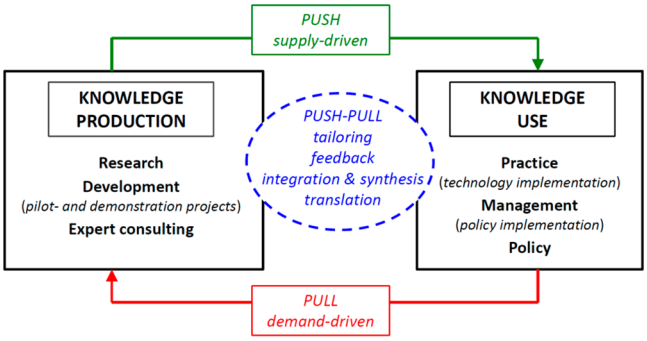


**Figure 1.** A schematic view of the iterative and interactive exchange of knowledge between those who produce knowledge through research, development and expert consulting and those who implement knowledge in practice, management and policy. This graphic licensed to the public under a Creative Commons Attributions 4.0 license.

contrast, the "supply-driven" model for knowledge transfer (shown in green in Figure 1) is often favored by researchers even if needs in policy and practice are not adequately met and the "demand-driven" model (shown in red in Figure 1) is often resisted by researchers as imposing excessive constraints on their academic interests. Engagement (whether direct or brokered) between environmental researchers and decision-makers would help to foster the uptake of research results in policy, management and practice.[29,58] A structured framework developed through environmental implementation science could provide support for context-specific uptake of research results.[13]

## NEXT STEPS

This perspective posits that the uptake of environmental research results into policy, practice (i.e., technology implementation) and management (i.e., policy implementation) could benefit from the approaches taken in implementation science as applied (mainly) in the health domain. Specifically, this means having *structured* processes that explicitly incorporate *context* and are *monitored* during implementation. The experience gained from past and ongoing activities relating to the uptake of environmental research could be extremely valuable. A critical review and integration of such past experience could be used to delineate implementation science for the environment and identify research gaps that arise from the differing needs and conditions in the health and environmental domains.

**Mapping.** This perspective provides only an overview of implementation science and a preliminary comparison with corresponding activities in the environmental domain. A more thorough and detailed mapping exercise would be needed to understand which aspects of implementation science could be applied in the environmental domain either directly or in a modified form. It would be equally important to identify limits to the transferability of concepts, tools, and approaches from the health to the environmental domain.

**Institutional Embedding.** The mapping exercise should also contrast the positioning of implementation scientists in the health domain with individuals working at the interface of science with policy and practice on environmental issues. It would be important to identify the institutional structures have been successful in supporting implementation science in the health domain as a basis for determining whether comparable structures and support could be developed in the environmental domain. A key question is how expertise that has been developed within environmental research projects can be institutionalized.

**Training and Professional Development.** One way to embed environmental implementation science into academic research institutions is through programs of education and professional development. Courses or course modules (including online courses) could be developed for different educational stages and needs. Experiences from applied environmental research projects that involved stakeholder engagement could be used as case studies, ideally with some interaction with former project participants.

**Leveraging Knowledge and Experience.** It is a particular challenge to the leveraging of knowledge and experience that methods and approaches in implementation science are elaborated mainly in the context of medicine and public health and that knowledge brokering tends to be aligned with specific applications in subdomains of environmental science and engineering and natural resource management. Cross-referencing across these various problem areas and their associated research and stakeholder communities is not common. Data and information sharing and reuse across application and platform boundaries are hindered by the lack of interoperability and open access that would support data-mining and machine-learning.[59] These impediments should be easily overcome with recent and ongoing advances in information technology.

**Concluding Comment.** The investments made in implementation science in the health domain have resulted in a portfolio of concepts, approaches and tools that could also be


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applicable in the environmental domain. Adapting implementation science for the environment could minimize duplication of effort and allow resources to be used more effectively.

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### Notes

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