Conceptual challenges in the translation of research into practice: it's not just a matter of "communication"

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ABSTRACT

This paper identifies key barriers to the translation of science into practice and policy and makes recommendations for addressing them. It focuses on the challenges of translation within the field of tobacco control, but we argue that the insights are widely generalisable. Actor-Network Theory is used to frame an analysis, supplemented by focussed discussions with international tobacco control practitioners (service delivery and advocacy) and researchers. The central challenge to translation is that researchers and practitioners have different "practical ontologies". Researchers use findings from specific contexts to generalise to universal principles, while practitioners try to use these generalisations to inform their work in what are typically a somewhat different set of specific contexts. Neglecting the need to translate back from the general to the particular means research syntheses are not framed to meet practitioners' needs. Traditional knowledge broking roles need to be extended to better align the needs of researchers and practitioners. This may be facilitated by more creative use of "social computing" to enable real-time input into research syntheses from all interested parties, including input to the questions that research addresses. To do this systematically requires that we construct "generalisation gradients" to help practitioners apply general research conclusions to their particular situation and researchers to identify the relevance of their work. Disadvantaged communities in particular need help, since there is typically less research directly applicable to their contexts; thus, they need to generalise more.

KEYWORDS

Translational science, Actor-Network theory, Tobacco control, Knowledge broking, Action research, Social computing

INTRODUCTION

Ensuring that relevant research findings are translated into practice efficiently and effectively is a key way of enhancing public health programs and policies. However, there is a widespread belief that this translation process is not as effective as it could

Implications

Practice: The needs of practitioners are not well understood by researchers, in part because the two groups employ different "practical ontologies", therefore mechanisms are needed to ensure practice issues inform research.

Policy: Knowledge broking functions need to be expanded and "Wiki-like" systems, that can facilitate research synthesis, are a potential means of enhancing knowledge flow in a way that allows practitioners to have their questions addressed quickly.

Research: Researchers need to pay more attention to the generalization gradients of their findings; that is, the extent to which research generalizations translate into particular practice situations, and this will involve new forms of research.

be [1–5]. This paper originated from a study we carried out to try and improve the relationships between research and practice around tobacco control in the Cancer Council Victoria (CCV).

The CCV has an active program of social and behavioural research both to understand tobacco use and to develop and test new interventions [6]. The Council acts as an advocate for stronger tobacco control efforts and provides policy advice on tobacco issues to government. It also hosts Quit Victoria, the agency that delivers most of the tobacco control programs in the State of Victoria (Australia). Our aim was to better "engineer" the relationship between our research and practice groups. We use the word "engineer" in the sense of the French *ingénieur*—with its implication of both rationality and cunning (i.e., we wanted become more ingenious at managing the relationships between research and practice).

The insights reported here emerged out of analysis following a program of participant observation, individual interviews, group discussions and consultations focused on the translation of tobacco use research into practice mainly in the CCV but supported by interviews with practitioners and researchers in other countries. "Practice" as used herein includes the provision of services to smokers (directly or indirectly), mass communication and

advocacy for policy change. Many of the insights seemed unlikely to be limited to the CCV, something confirmed in presentations to conferences, including the World Congress on Tobacco or Health and the Society for Research on Nicotine and Tobacco. While the focus of our inquiry was on research to inform tobacco control interventions, we have tried to generalise to other intervention-related research. “Research” as used here refers primarily to research on mechanisms of action, including studies evaluating the effects of specific interventions. We have not considered the relationships for descriptive and epidemiological research (i.e., research demonstrating the *need* for interventions). We invite readers to further test the plausibility of what follows by applying them to the research–practice relationships they currently participate in or are trying to establish.

Knowledge transfer, at least within the CCV, is facilitated by physical collocation by an expectation that the research carried out will be relevant to cancer control (if not specifically to the needs of CCV itself) and by a history of the research and practice functions interacting for more than 20 years, resulting in a culture of mutual understanding. This should all act to enhance translation. It is therefore probable that any constraints on translational science within the CCV will apply with even more force to those participating in most research–practice relationships, translating research they have no ownership of, nor any privileged access to, since they will not share our advantages.

The observations and analyses that follow identify three sets of issues associated with the translation of research into practice and we discuss each of them in turn.

1. The social and ontological distance between research and practice
2. Problems associated with the knowledge accreditation and synthesis process
3. Challenges of generalising from research to application within specific contexts

We employed Actor-Network Theory [7, 8], also known as “The Sociology of Translation” [9] to help frame the logic of inquiry and the analysis. Actor-Network Theory (ANT) is specifically designed to study the relationship between scientific practices on the one hand and the products, programs, policies and advocacy initiatives that flow from the science on the other [10–13].

ANT assumes that the successful translation of research into practice is characterised by the existence of an “actor-network”, where all active human components (e.g., funders, researchers, practitioners, marketers, etc.) and non-human components (e.g., the innovation, research on its likely impact, budgets, etc.) come together to form a whole that, while not formally structured as an entity, can to all intents and purposes be treated as a single entity; i.e., a network that is “acting” to translate the research

evidence into new or newly refined practices. Most research–practice frameworks focus solely on one or at the most two of the stages of research–practice translation. For example, systems thinking focuses on problem identification (but not how it becomes the focus of research) and on potential solutions, while (social) diffusion theories [14, 15], knowledge management theories [16, 17] and complexity theory [18] focus on the dissemination of knowledge and its refinement in practice [5]. ANT is a broader, umbrella theory that encompasses the extended US National Institute of Health (NIH) categories of Westfall et al. [19]: Translation 1 (basic science to trials; “it should work”), 2 (trials to practice; “it can work”) and 3 (practice based refinement; “it does work–here”).

THE SOCIAL AND ONTOLOGICAL DISTANCE BETWEEN RESEARCH AND PRACTICE

The research and practice groups from which these ideas emerged both focus on tobacco control, and each area pursues its immediate operational goals more or less autonomously.

The practice group’s role is to develop and deliver services (e.g., cessation assistance, mass media campaigns) and advocate for policy shifts to achieve its aims, in this case, to reduce tobacco use in the state of Victoria. They are accountable to those who fund their services and to their clients. They are judged on the range and quality of services offered as well as how well they manage and operate the services. Therefore, they need to adapt the application of knowledge to the needs of their clients (individuals and organisations) and their requirements for knowledge reflect this focus. Although they do act both nationally and internationally, this is justified in terms of benefits flowing back to their core constituency.

The research group, by contrast, is funded by competitive research grants to carry out research to advance knowledge in tobacco control. Consequently, it has a strong international focus rather than a local one, and its knowledge is distributed globally, primarily through peer-reviewed journals and professional conferences in order to: first, accredit it, and then second, enable it to be applied. The group is judged by its performance as part of the global research community, and its research reputation is critical to ongoing support.

The different funding regimes and accountabilities of the researchers and practitioners mean that their relationship is not “core business” for either group. Even though they are part of the same organisation, there are no formal requirements or structures to ensure that they interact, only a general expectation that they will. This may also be because such structures are not appropriate. Research and practice are ordered primarily by *vocational* [20] considerations (i.e., hierarchies of skill) and administrative orderings (i.e., hierarchies of authority) are not well-

suited for managing them or their interactions. Thus, their relationship needs to be, and is, negotiated collaboratively on a project by project basis.

The researchers value close links with practice because it provides access to research opportunities (i.e., interventions and participants to study); because it helps identify practical questions to research and because it provides the satisfaction of seeing research reflected in high quality policies and programs.

The practitioners value close links with research because it provides a mix of: opportunities to evaluate their work; access to knowledge about better interventions; knowledge that is useful for advocacy; knowledge that is worth communicating to the public and access to frameworks or theories that make it easier to mobilise evidence into coherent arguments (i.e., “we need to adopt this practice because”).

Practitioners respond to needs emerging from those they serve, be it a client wanting help to quit, or a government considering further regulation of tobacco or a community concerned about passive smoking. This is largely a “bottom up” process, as demand is driven by the needs of the constituency (albeit with constraints if resources are limited). On the other hand, research is largely a “top down” process where researchers and/or their leaders generate the questions/ideas that form the basis of their subsequent work. As a result of these differences, there is little or no intrinsic harmony between the work of researchers and practitioners. This is described in ANT terminology as a “regional” (as opposed to networked) relationship [12].

ANT would argue that the above differences between the two groups are symptomatic of each having quite distinct “practical ontologies” [21] and that such ontologies emerge not because of differences between the individuals involved but because researchers and practitioners are engaged in two very different work processes, and as a consequence, they are enmeshed in different worlds.

- Research practices focus on exploration (involving hypothesized cause and effect relationships between constructed concepts), and the aim is to discover commonalities independent of individual differences. Therefore, they require an impersonal practical ontology. In terms of knowledge flows, the scientist/researcher seeks to generalise from the particular, to the general; to use the particular to talk about the general. Thus, when researchers describe what they do, they talk about protocol design, reliability or validity, conceptual rigour and especially the robustness of the causal inferences, often using statistical inference as decision rules (i.e., induction). *Personal and interpersonal processes (e.g., relating to research participants) are seen as enabling or supporting their engagement with a predominantly conceptual reality.*

- On the other hand, when practitioners talk about what they do, they talk about specific people, what they did, why they did it (including the knowledge they had in their heads) and when they did it. Causal processes are unambiguously personal and interpersonal. *Knowledge, concepts (e.g., models of cessation) and evidence (e.g., survey results) are seen as enabling or supporting their engagement with a predominantly interpersonal reality.* Thus, practice requires a generalisation process which is the opposite of that required by research; practitioners apply general principles to a particular case, they use the general to help them negotiate the particular (i.e., deduction). Good practice should be to apply the science (what is normative) via a consideration of its relationship to the particular, not simply applying the normative to all. This is often misunderstood by researchers who see practitioners deviating from “best practice” and confuses some practitioners into blindly applying guidelines without consideration of the particular case.

In their writing, scientists tend to emphasize the general to the exclusion of the particular. Practitioners often find scientific knowledge to be more accessible if it is presented in ways that go beyond the general conclusions to focus on how to use/apply the knowledge in particular cases or at least in those sub-classes of cases the practitioner is familiar with. Knowledge has to be translated to the particular before it can be applied effectively, and this process can be facilitated or hindered by the way the knowledge is communicated and the context within which it is communicated as well as by the degree of focus on the specific practice.

The central translation problem for the practitioner is “to what extent does this generalisation apply in my specific situation and when should I ignore or adapt it”. While our focus here is on such things as the potential effectiveness of interventions, the differing conceptualisations can also cause problems at the simplest descriptive level, in terms of the focal behaviour being researched (which also is the object of practice). When reporting research (e.g., Randomised Controlled Trials (RCTs)) on the effectiveness of interventions, researchers tend to treat categories as homogenous, neglecting the variability in outcomes *within* categories, and thus ignoring the possibility that the intervention might only help a subset of individuals. One positive outcome of the genetic revolution is renewed interest by researchers in looking at systematic variation in who is helped and not helped by particular interventions.

Often, researchers make what appear to be arbitrary decisions as to who will be included in their categories. Subjects included in the category “smokers”, in trials of quit-smoking medications, are typically restricted to those smoking more than some minimum number of cigarettes per day (often

10) and/or smoking within some period of waking (often 30 min). The practitioner is left in the dark as to why a 10/day smoker should get a medication while a 9/day smoker is excluded. S/he needs to make a judgement as to whether the 9 and 10/day smokers are likely to benefit and indeed, may sometimes recommend medication for the 9, but not for the 10/day person, while still acknowledging that the medication helps smokers who, on average, smoke at least 10/day. They need to make conceptual sense of what lies behind these arbitrary distinctions. While in principle mapping the conditions that underpin the choice of boundary could, and perhaps should, become the focus of scientific study; in practice, there will always be a need to make judgements related to criteria that go beyond whatever the science has established at any given time.

It is worth noting that while the different ontologies are often seen as oppositional in the research–practice relationship, they can be seen as complementary in other areas of human experience [22]. The general→specific move is often characterised as the role of mythology and metaphor. That is, both these forms of discourse involve the extraction of meanings specific to a given situation, from general “truths”. On the other hand, the specific→general move is associated with ritual and metonymy, where a highly specific, and situated chain of behaviour, word or image takes on a more general meaning. Both these moves are deeply enmeshed in artistic and religious practice, indicating that the motivation to reconcile the roles that our endeavours place us within is a source of both creative endeavour and, by implication, ongoing tension. In the case of translation science, the role expectations placed on researchers and practitioners situates them on opposite sides of the boundary (a situation not dissimilar to that described by Snow [23] for the arts and the sciences in his conjectures regarding “The two cultures”) and hence, their regional relationship means knowledge inevitably needs to be actively translated in order to be used.

This translational hurdle arising from the different ontologies needs to be recognised. More effort is required to translate across this conceptual gap. It is not sufficient to simply train practitioners in scientific methods; both researchers and practitioners need to recognise this gap between science-based knowledge and the demands of practice and continually work on ways to better bridge it. Encouraging greater collaboration between researchers and practitioners is necessary to ensure awareness and that detailed negotiation and debate can actually take place. It can be reinforced by encouraging more Action Research (i.e., research on practice that focuses on the achievement of the outcomes the practitioners seek; see below) and/or by supporting applied research units to collocate with relevant

practice groups. Both can help break down barriers and contribute to research that is better tailored to the needs of practitioners and to a better understanding of each other. While this only works directly on those actually involved, indirectly, it seeds new ideas and understandings that can spread and reduce the magnitude of the research–practice gap or at least allow each side to naturally make some moves towards the other.

Even where there is no formal requirement for interaction between researchers and practitioners, collocation can encourage researchers to think about their work differently. Using our CCV experience shows us that researchers are motivated to ask more practice-relevant questions, and thus carry out better applied research as a result of hearing the expressed needs of local practitioner colleagues and being embedded in a culture that values their concerns. Research–practice collocation is already accepted in clinical medicine; medical research facilities are typically attached to hospitals, enhancing disciplinary training, facilitating research linked to practice, and increasing the priority accorded to research that practitioners need and to its application once done. More of this should be encouraged in the behavioural and social sciences.

Where co-location or action research is not possible, there are benefits to encouraging increased levels of interaction between practitioners and researchers. These need to be relatively fluid [12] in form, if they are to result in robust communities of interest between researchers and practitioners. One such approach is finding ways to increase contribution of practitioners to the way knowledge is packaged/organised and disseminated.

PROBLEMS ASSOCIATED WITH THE KNOWLEDGE ACCREDITATION AND SYNTHESIS PROCESS

Good practitioners want to use the most up to date knowledge to inform their practice. The time delay between the research being conducted and publication is a common problem for the relationship between researchers and practitioners [5, 24]. This may be experienced more intensely where practitioners and researchers are collocated, as they are most likely to know about research that they are not yet able to use. Understanding this issue necessitates a more detailed consideration of the role of knowledge authentication and publication as key elements of knowledge translation. This topic also has direct implications for researchers.

Knowledge accreditation

The status of knowledge is determined by its level of accreditation or “authenticity”. Everybody, whether researchers or practitioners, would ideally like to mobilise knowledge as soon as it is extracted from data. However, some delay is inevitable. From the

time a new discovery is made, there is typically a process internal to the research team whereby the findings are validated, and then the results written up with whatever caveats are appropriate. For scientific publication, a second, “peer-review” stage then follows; other experts in the field review the work and often suggest refinements before it is deemed ready for publication. Once this process is complete, the research can be published.

While the main form of accreditation is peer-reviewed publication, publication in a book or government report can also be forms of accreditation, as can the processes organisations go through to ensure the validity of their in-house research. For some purposes, the accreditation produced via publication in a government report confers additional authority (typically for decisions of the government that commissioned it), but this can also be seen as a special case where some groups prefer to use private knowledge (e.g., a commercial-in-confidence report) over publicly authenticated forms.

Accredited knowledge has more potency/power than knowledge that is left unauthenticated, and the power is acquired through the relationship with bodies (e.g., professional societies, scientific journals, governments) which institutionalise the knowledge by attaching their imprimatur to it. Accreditation processes continue after knowledge has been published, through syntheses of the published knowledge into systematic reviews. In this process, research that has been replicated gains credibility, while that which cannot be replicated finds its authenticity brought into question. Where knowledge relates to the effectiveness of interventions, practitioners sometimes need the additional authentication of reviews by the guardians of their profession, expressed in the form of practice guidelines, before they feel totally comfortable applying an intervention.

Accredited knowledge has a firm ontological status, in that it is often treated as “fact”. Accreditation systems are designed to play a role in reducing error in disseminated knowledge, and thus there tends to be an assumption that accredited knowledge is somehow more authentic than knowledge that has not been so blessed. However, there can be errors, even in extensively authenticated knowledge, as although the accreditation process does play a role in finding and correcting errors, the completeness of the process can never be guaranteed.

Along with accreditation, the extent to which knowledge is in the public domain affects acceptance,

because it helps create an expectation that it can be used and that others will be informed by it. Table 1 shows how these two processes combine to give four kinds of knowledge. Truly local or private knowledge is only useful within the systems that extract and control it; in ANT terms, it creates knowledge regions, not networks, and provides a basis for individual (but not collective) action. On the other hand, public knowledge can be networked. Within a knowledge network, the same knowledge (e.g., that second-hand smoke can cause cancer in non-smokers) can be applied to different activities, in different locations (e.g., it can be applied to advertising campaigns in Australia, and to justify local smoke-free policies in California). By contrast, regionalised knowledge (e.g., confidential consultant reports) can only be used by its owners. In a competitive environment (e.g., with for-profit enterprises), this can accrue a competitive advantage, but in the pursuit of public goals, the utility of such knowledge is limited.

Where practitioners become aware of knowledge they could use (e.g., to develop or implement a new intervention or employ in public advocacy/education campaigns), they also need to consider what level of accreditation it needs before they can use it. Where a conclusion is apparent locally, but not yet sufficiently accredited, there is a tension between the pressure to satisfy local requirements in the relatively short term, so action can be taken, and waiting for the slower authentication process required for it to be justified more generally; that is, they can use it to make decisions about what they do but may not be able to fully justify those decisions if challenged.

For scientists, the gap between producing evidence and having it published is also problematic. Researchers often possess knowledge that has not yet been authenticated and they are constrained in how they use it in public and/or in other work that is being authenticated. This is an uncomfortable position, experienced by all researchers from time to time. They are in a position of having to make or support an argument in the context where something they know, but cannot use in public, will either lead to their arguments needing to be qualified or being more strongly supported.

From an ANT perspective, the most important attribute of the authentication process is that, as evidence is processed and becomes accredited knowledge, it increasingly takes the form of an *immutable mobile* [11]. That is, it has been translated into a form that confers:

Table 1 | Types of knowledge

	Non-accredited knowledge	Accredited knowledge
Public/networked knowledge	Media stories, myths ^a “common sense”	Scientific papers, scholarly and authoritative reviews
Private/regional knowledge	Personal experience, unpublished observations	Secret knowledge (e.g., consultant’s reports)

^a “Myth” is used here in its technical sense of a story that helps us make sense of the world, and not as a pejorative, meaning “untrue” or “non-existent”

- A high level of stability on the meaning of the research outcomes (“immutability”); the prerequisites for immutability are repeatability/replication and the use of accepted methodologies and reporting formats, accompanied by some authenticating process, typically peer review for individual publications, and/or inclusion in reviews that have undergone a similar authentication process.
- A high level of mobility. The evidence generated by the research is seen as generalisable to other contexts and is widely available. Publication in an international journal, rather than a local one, and framing the findings as having general application beyond the specific context studied are two ways of increasing mobility. However, this is not automatic, and some societies isolate themselves epistemologically, that is, in effect saying that we are so different that what applies elsewhere cannot be assumed to apply here (e.g., in Germany, public health knowledge is usually not seen as transferable from outside without internal confirmation [3]). We return to the important issue of knowledge generalisation in the next section.

These immutable, mobile representations of evidence (e.g., a review demonstrating the relationship between levels of second-hand smoke and the

incidence of respiratory disease made more potent by graphs that help bring the relationship to life) become positions around which an issue is framed (e.g., second-hand smoke is a major cause of ill-health), and/or upon which the credibility of solutions is anchored (e.g., therefore indoor smoking should be banned). Accredited public knowledge thus acquires the double power of “fact-story”.

Knowledge synthesis and knowledge flows

With the issues of accreditation and public/private clear, we can now turn our attention to the role of knowledge synthesis and the nature of knowledge flows between research and practice. Figure 1 identifies two key scientific processes (knowledge generation and knowledge synthesis) as well as the kinds of research–practice knowledge flows that a research group could participate in.

Practitioners employ two kinds of knowledge in support of their activities. On a day-to-day basis, they make significant use of experiential knowledge acquired from their practice. This is private knowledge that is (sometimes incorrectly) assumed to be in common currency. It is derived from their direct experiences (including observations of co-workers) and from their stories about their work. In addition,

Fig 1 | Model of knowledge flows between research and practice groups

they also make use of knowledge from external sources, both accredited and not. Some accredited knowledge they use may emerge from the scientific study and evaluation of their own practice, or of similar practices, but much will not.

Figure 1 also illustrates three pathways by which knowledge can flow between researchers and practitioners. However, before describing these, a distinction needs to be made between two stages of knowledge dissemination; awareness *of* knowledge (that it exists), and information *about* it (i.e., what it means, how, where, and with what limitations it can be applied). In this paper, we are interested in knowledge that reaches the second stage.

Practitioners often become aware of the existence of new public knowledge informally, via news reports or online specialised services that summarise research within their domain (e.g., *Globalink* [25] for tobacco control). At other times, they only become aware of it when it is incorporated into formal reviews (e.g., the *Cochrane Reviews* [26]). Awareness may provoke practitioners to seek out the original research, or they merely rely on the summaries that are provided. The source of the knowledge affects both the depth of understanding and the capacity for misinterpretation.

The first knowledge pathway is where accredited public knowledge flows indirectly between researchers and practitioners via longer-term knowledge pools (i.e., via institutional channels of knowledge accreditation and dissemination such as scientific journals). This includes more than just research findings that relate to the practice itself; it includes both disciplinary (e.g., psychology) and thematic (e.g., issues of inequality) knowledge and theory that can be used to provide a rationale or context for practice.

The second pathway is where knowledge flows directly from a research unit to a practice unit, and it can take three forms.

- Already accredited knowledge, sometimes packaged to be more relevant and sometimes with additional detail, including unaccredited supplementary material that could be published, but might never be.
- Advanced access to research that will, or is likely to, become public. A local/collocated practice group has the advantage that it can access results, implications and conclusions informally (albeit in a significantly constrained manner) ahead of publication (as well when it is published). This allows it to act internally, but as noted earlier, it may not be able to publicly justify its actions until the relevant knowledge becomes public.
- Practice-commissioned knowledge. In this case, knowledge is both focused and refined by the needs of the local practice group, and application of such knowledge is relatively fast because the research is designed to directly service the practice unit (e.g., a flavour research group

within a tobacco company, a molecular biology research unit within a pharmaceutical company). One important form of such research is where the practice is the focus of the research/evaluation, with the goal of improving the practice. This is Action Research (AR) [27–30]; research explicitly designed to meet the needs of both practitioners and researchers. NB; AR is not just qualitative, as some current usage would have it; the essence is the commitment to use the research to both generate knowledge and advance the practice, something that is typically done iteratively.

In AR, practitioners or their representatives are co-owners of the research, so there is minimal time delay in finding out the results; the research and practice cycles are synchronised. Indeed, sometimes, the conclusions become apparent to the participants before they become institutionalised in reports, papers, etc. In this way, the general conclusions of the research are usually extracted and published after the local implications of the work are identified, and in some cases, acted on.

This analysis suggests that with the exception of AR, there is no inbuilt or necessary translation process incorporated within the knowledge flows between research and practice, nor is translation an inevitable consequence of the accreditation process. Rigorous Action Research generates actor-networks that make the boundary between research and practice permeable, breaking down the regional structure, making effective translation easy. However, few practitioners, especially in disadvantaged countries or communities, have the opportunity to improve their practice by participating in AR; most need to rely on generalising from external research (including AR involving other practice groups) and thus, for them, there is an inevitable translational challenge.

Some progress is being made towards ensuring that available evidence is widely available. Initiatives like PLOS, Pub Med, etc., are using the internet to greatly improve access to primary sources. In areas like tobacco control, services like *Globalink* are actively pushing summaries of published research out to their communities, enabling advocates, policy developers and researchers everywhere, including in less affluent countries, to access evidence-based tactical/strategic knowledge and, moreover, to discuss and debate the issues involved. Linking people doing similar work in different places is facilitating ongoing discussions of what works and how to apply it in different settings [13].

CHALLENGES OF GENERALISING FROM RESEARCH TO APPLICATIONS IN SPECIFIC CONTEXTS

The essential role of research is to give us information about the world that is generalisable, obviating the need for the interminable, context-dependent

rigours of trial and error learning. However, insufficient thought has been given to the extent to which research findings can be generalised in practice. The translation of research into practice is a special case of a more general issue: identifying and generalising from research that specifically addresses the exact challenge being confronted and identifying the constraints on generalisation associated with research that differs in respects that are potentially important. From this perspective, Action Research is the paradigm case where translation should be easiest, since the research is as close to day-to-day practice as possible. Here, the only issues to address are potential effects of any meaningful changes in the context, including potential effects of the research on the practice (i.e., effects on practice of having it observed), so even in this case, there is some generalising. However, this is an aspect of generalisation, so it is considered as part of the more general discussion below.

We pointed out above that the generalisation processes for research and practice can be viewed as complements, with researchers seeking to generalise from the particular to the general, and practitioners seeking the reverse. Generalising from research to practice requires a theory of what can influence the applicability of research knowledge. The theory should be capable of identifying the kinds of influences that might affect the strength of the effect caused by the intervention and the kinds of influences that might make the intervention impotent, or worse still, counterproductive. It should also be capable of casting light on possible interactions between the target behaviour, the person, and the context, although it is prudent to merely assume simple additive effects unless there are grounds for doing otherwise.

For an intervention designed to affect behaviour, the target (and associated mechanism) can be any of: behaviour (e.g., through conditioning); physical functioning (e.g., through drugs); cognitions or beliefs (e.g., through cognitive restructuring, including reinterpretation of experiences); the environment in which the person lives (e.g., through legislative changes, or programs designed to produce denormalisation of the focal behaviour); and any combination of these.

For any given intervention, there exist a set of generalisation gradients that are a function of differences from the prototypic case in terms of: (a) the focal behaviour (the nature of the problem); (b) the people it is applied to; and (c) the contexts in which it might be applied. Because the mechanism of the intervention sometimes needs to change to accommodate in the context where it is applied (or for other reasons), we also need to consider (d) the extent to which changes in the intervention itself might influence its effectiveness. This takes us towards a theory of identity for interventions in context, which is in many senses, the obverse of the theory of generalisation. All of the above can be

complicated where there are differences in the theoretical or ideological frameworks from which otherwise similar interventions are conceived, so we also need to consider (e) the theoretical or ideological framework. We briefly consider each of these five issues:

- a. *The nature of the problem or issue being intervened in.* The task here is to map those characteristics of the problem that are relevant to the choice of intervention. There are two dimensions to this; variation of the focal behaviour around whatever is normative and the focal behaviour's relationship with conceptually related behaviours. The first is clearly important for all translation. For example, how does one advise a 9 per day smoker compared with a 10 per day one about use of medication, when evidence-based guidelines for the medication suggest use for those smoking 10 or more per day? Here, generalisation has imposed a binary distinction on an essentially continuous process, and the practitioner needs to decide whether it applies in the particular cases they face. Sometimes, they may recommend use for a 9 per day person, and sometimes not for the 10 per day, although we would expect this to be less common than the converse. At a broader level, we can ask what commonalities are there between addicted smokers and other addicted drug users or even people with other problematic habitual behaviours.
- b. *The characteristics of the population that is the target of the intervention.* The fundamental task here is to map those human characteristics that might make a difference. The practice population almost always differs from the researched population(s) in ways that may affect the validity of generalisations that are made. Things like the age profile of the intervention target group, their level of education, languages spoken, and their knowledge of the problem may all require some tailoring of interventions to maximise their relevance. Similarly, the socioeconomic status of the target group will influence the translation task to a significant degree. In some situations, men and women will need to be treated differently, as will those with those of different genetic makeup (N.B., these factors overlap with the problem definition). Interactions with other aspects of life that influence the behaviours, such as poverty, may also be similar enough to enable useful learnings.
- c. *The context of the intervention.* The challenge here is to map contextual differences that might affect how an intervention works. The context includes the physical, regulatory and social/cultural environments. Even when the intervention is essentially the same, how different is the context where you wish to apply it (to the ones where it has been shown to work) and what are possible effects of these differences? For example, the

normative status of smoking in the society will have a major impact on interest in quitting and probably on ease of quitting. Will a program that works in a country with a long history of tobacco control, and thus a population that is well informed on the issue, work in a country just starting to control tobacco, where most are not well informed? Does an intervention to help a heavy smoker who is surrounded by a smoking family need to differ to that for one who lives alone? Or, will an intervention that operates effectively in a high density urban area work in a rural community?

Some of the most important contextual differences are socioeconomic and cultural. What works with an affluent well-educated population might not work so well with a deprived population who are more concerned with immediate survival. The majority of the world's population live in countries that are under-resourced in a systemic sense, as do significant sub-populations in otherwise affluent, well-resourced countries (e.g., residents of rundown neighbourhoods, Aboriginal peoples); they lack the research infrastructure, the tools, and the practices to manage the causes (e.g., poverty, tobacco) and the symptoms (e.g., malnutrition, cancer) of public health problems. In addition, they often have cultural norms that are quite different from the countries/regions/sub-populations that the majority of public health research is carried out in. Together with population issues, these are also the kinds of issues that are not sufficiently addressed when practice guidelines are transferred from one context to another (e.g., transferring cessation guidelines for doctors from countries like Australia, where the culture supports GPs intervening, and most smokers are aware of the dangers, to say Indonesia, where the culture does not expect such interventions, and the majority of the smoking population is not sufficiently aware of the dangers of smoking). We need models of how such things affect the potency of interventions.

- d. *The nature of the intervention mechanism itself.* This involves consideration of what the intervention is designed to do, and how it does it. For example, in treating the addiction of individual smokers, Nicotine Replacement Therapy (NRT) is primarily aimed at physiology, while Cognitive Behaviour Therapy (CBT) is aimed at thoughts and behaviours, and public policy interventions traditionally target societal/contextual change. The intervention analysis needs to provide a non-trivial answer to the question “what differences will make a difference to the efficacy of the intervention?” For example, what is the optimum dose of NRT and how much “play” is there in this dosage. How many sessions of CBT and of what length are required, how should they be spaced, can sessions be dropped without making a difference to outcomes? What elements of the intervention are critical, and are some interchangeable? There is increasing recognition of the importance of this issue [31]. To work out

what is core and the limits of applicability ideally requires a detailed description of the intervention, articulating how it operates and mapping the levels of the focal system (target) that are engaged by it.

- e. *Framework.* This refers to the formal (e.g., theoretical) or informal (e.g., ideological) set of beliefs that frame the intervention. The key question is how can findings from different orientations be assimilated? Theories often break the world up in slightly different ways, even when they are dealing with what are ostensibly identical issues, thus to translate insights from one theoretical perspective to another, there is a need to map one to the other, and commonalities and differences established. Where concepts are essentially identical, it is useful to use common terms, leaving different terminology for areas where the boundaries are meaningfully different. For example the Theory of Planned Behaviour (TPB) divides up beliefs into attitudes and social norms, while other theories distinguish reasons for action and barriers to action. These are different distinctions, whereas the “perceived behavioural control” of the TPB is essentially the “self-efficacy” of other theories [32]. In the case of the attitudes/norms or positives/negatives distinctions, it may well be that which one is most useful varies by situation. However, if this is the case, we need some theory as to when to use each.

To generalise from any given corpus of research knowledge to practice requires consideration of generalisability along each of these five dimensions. The closer the research contexts are to the context of application, the stronger the generalisation is likely to be, and the greater the likelihood of it being found by interested parties. The more different research is from the situations it might inform (even where the potential for generalisation might be strong), the more likely the information will not be found. Thus, parallel mechanisms from other behaviours are easily missed unless someone does the work to make the links. In addition, searching for such knowledge in the absence of a systematic framework for channelling the search can generate an unmanageable range of possibilities.

There is a need to develop taxonomies or maps that articulate relevant synthesis paths; from the potentially relevant domains of research to practice. Such taxonomies will need to be ecological in nature; i.e., grounded in an understanding of the systems (which necessarily includes consideration of populations, behavioural target, intervention and framework), and the contexts, within which the research was originally conducted, and those to which it might be applied [33]. From the practitioners' perspective, such an approach can be called an “ecology of practice” and having constructed such a map of their “practice in context”, they should then be able to work out what knowledge is

potentially transferable, and/or what new/refined interventions are worth trying. From a research perspective, it suggests potentially important differences around which to test the extent of generalisation.

This extended conception of generalisation as it applies to knowledge transfer can also be used to extend the definition of what has traditionally been called *knowledge broking* [34, 35]. Knowledge broking inevitably involves judgements about the appropriateness of generalisations because where there is direct and persuasive evidence of appropriateness, it is not needed. This form of active engagement with evidence is sometimes known as *knowledge extraction*, in contrast to *knowledge revelation*, where the knowledge is communicated as an unconditional truth (e.g., the carcinogenic role of tobacco), from an active source (in this case researchers) to a passive audience (in this case practitioners) [36]. The success of extraction is affected by the clarity of the contextualizing so that the universal elements can be elucidated, and the degree to which the protagonists can see the relevance and thus “own” the knowledge that has been extracted. Ensuring this is a key reason why practitioners must play an active role in the translation process.

Collectively, the ecologies of practice can describe divergences from a particular situation and thus the nature of the paths that must be traversed to translate knowledge into an analysis of the likely effects of a new or changed intervention in a novel context. Practitioners often lack either the time and/or the skills to carry out the necessary transforms themselves, even when there is evidence of how the generalisation gradients relate to their situation. However, as we have noted, they rarely have even this advantage, especially if they are working with disadvantaged populations. We need better ways to bring the concerns of practitioners and researchers together to help work out practical guidelines for action, and/or to encourage researchers to collect new information where gaps are identified that undermine effective generalisation.

Systematising knowledge broking will have the additional benefit of providing a body of knowledge to educate researchers about how they should expect their research to be applied, and hopefully lead to them modifying their research and the ways they report it. This should further facilitate its application. The kind of knowledge broking we are talking about implies facilitation skills to ensure that practitioners and relevant researchers both participate actively in the extraction of relevant knowledge, in distinction to the passive “revelation” model, discussed above, which is currently the norm.

Developing techniques that enable practitioners to construct ecologies of practice needs to go well beyond the usual “research tracking” function and cost/benefit analyses which are both necessary, but not sufficient components of the knowledge broking

role. The reconceptualised role would focus on facilitating access to the kinds of knowledge and the tools required (including establishing monitoring systems to alert practitioners to relevant evidence and techniques) and especially on helping practitioners construct their own ecologies of practice.

Having such a framework is critical if there is to be rapid translation of knowledge gained from more advantaged populations to more disadvantaged groups and communities. Low-income countries typically lack the resources to either develop interventions and/or to systematically evaluate those from elsewhere before they apply them. Similarly, disadvantaged groups within high-income countries often lack the resources to conduct their own research and are dependent on others to support and/or provide it. To the extent that a “topography” of research generalisation can be established, there will be less need to empirically test interventions in all possible contexts. This can be facilitated by multi-setting studies which begin to spell out the limits of generalisation. Borland and Cummings [37] argue that costly study designs are not needed in areas where there is good reason to believe that generalisation will be effectively complete. Less costly evaluation methods can be used here, and only when there are unexpected findings is it sensible to call for more in depth research. Such a framing is needed to get away from the perceived need for multiple RCTs of every one of the infinite number of possible differences in population, context, aspect of the problem or intervention variant.

One example that we have been involved in is the International Tobacco Control (ITC) policy evaluation study, which is studying the effects of tobacco control policy interventions by comparing effects between countries with varying policy settings [38, 39]. It follows cohorts of smokers and applies mediational models to elucidate mechanisms of action, plus between country comparisons to assess both the impact of policies and any between country variations in effects.

The ITC collaboration began in four high-income, largely English-speaking countries: the USA, UK, Canada and Australia, where it has typically found that policies work in essentially the same ways. It was then expanded to several culturally distinct (e.g., France, Germany, The Netherlands) countries and countries that are both culturally distinct and developing (e.g., China, Thailand, Malaysia). This work is showing that while some policies appear to have essentially the same effects regardless of country (e.g., the impact of strong health warnings on packs [40, 41]), some policies appear to have quite different impacts across countries. For example, there is high value placed on, and high compliance with laws mandating smoke-free public places in many jurisdictions, but they have been problematic in others, for example, Germany. This appears to be due to some combination of cultural factors, and/or lower community understanding of

the importance of protecting non-smokers from passive smoking [3, 13].

Mechanisms may be different in some countries. For example, Hosking et al. [42] found that social norms play somewhat different roles in both Malaysia and Thailand to the roles they play in the USA, UK, Canada and Australia, where they were essentially identical. These differences can extend to distinct groups within countries, for example, we are finding that living in rural regions has differentiating effects in countries where most rural people still live traditional lives, but not in countries where rural and urban peoples are similarly modernised. As more evidence is collected, we will be in a better position to make claims about which findings generalise and which do not and about the differences that prevent generalisation. The differences seem to be falling into two classes: cultural and socioeconomic differences between countries or groups and differences in how the focal problem is treated. More recently, we have been extending that work to comparative studies to assess potential impacts of new interventions [43].

There is an increasing emphasis on conducting parallel studies in diverse settings as an important means of exploring generality of effects. This has both direct and indirect implications for translation. The direct effects are obvious, the indirect ones include:

- Having local researchers involved in studies helps in translating the science as they are often better able to translate across the cultural divide and convince local decision makers of the relevance of the science.
- It also means that policy-makers in countries where the research was not conducted can have more confidence in generalisability because there are examples of it working in countries with traditions and circumstances with varying degrees of similarity.

However, this needs to be done in a systematic way, designed to understand the relevant generalisation gradients and not result in calls for unmanageable amounts of research before any action can be contemplated.

SYNTHESIS

Better defining generalisation gradients for interventions will make a major contribution to enhancing translation, but will not be enough by itself. Knowledge about, and even acceptance of the potential effectiveness of an innovation is not sufficient to ensure adoption. What also needs to be taken into account are the different perspectives of heterogeneous stakeholders, which focus on different aspects of the intervention (for a practitioner) or the ideal (for the scientist).

Practitioners will not test research-based practice innovations unless they are aware of them and are persuaded that it is not only likely to be in their interests, and their clients interests to do so, but that their peers and (potential) funders are likely to agree that it is so too. Program funders want the efficacy of interventions translated into monetary terms to help determine if the intervention is cost effective and delivers value for money (which implies both economic analysis of demand and social assessment of motivation to use). Health economists have a formal role to play by performing economic analyses demonstrating the net value of interventions, in ways that resonate with program funders.

Program implementers also want to know about practicality and system fit (“the way we do things around here”) about the twisting path from intervention prototypes to how they can deliver within their own messy, specific reality. Despite a specific intervention having its effectiveness established, practical constraints (e.g., a lack of trained counselors or the resources to employ them) and/or straightforward resistance to the unfamiliar may prevent successful translation in low-socioeconomic and/or culturally different contexts. Consideration of practicality is beyond the scope of this paper, except to the extent that it necessitates changing the form of the intervention, where issues of generalisability will become focal.

There are potentially an infinite number of variants of a specific intervention, and generalisation cannot be made reliably until its critical features have been established; only then can “differences that make a difference” be discriminated from irrelevant changes (e.g., “can component x of the intervention be left out?”, “can we do it in 3 days instead of 4 in order to save resources?”). This requires a generalisation discourse that is interactive, and specifically, that research evidence concerning a class of interventions be subject to questions practitioners ask—not, as is the case with most reviews, only the ones that researchers ask.

All this highlights the fact that the kinds of research that it may be necessary to mobilise in order to have an intervention adopted are far broader than the research we have been focussing on here (i.e., research that suggests or generates the intervention in the first place). For example, in addition to micro- and macro-economic research to establish practicality, cost-benefit analyses involving formal needs/demand assessments are often involved, and in order to test system fit, sociological and anthropological knowledge/studies may also be required [44].

The interplay between all these considerations means the adoption of new evidence-based interventions is often contested, either openly, because of systemic inertia or because of the need to mobilise resources. Relevant research evidence and disciplinary understanding has to be mobilised and woven into a convincing discourse to recruit allies, con-

vince stakeholders and establish public support. Translation involves *persuasion and negotiation*, which by their nature are inter-disciplinary processes, involving a heterogeneous range of actors; people, institutions, ideas and resources [11, 13].

One way of increasing the level of interaction involves applying the ANT framework to the construction of ecologies of practice. Such a process would have two stages:

In stage 1, practitioners would identify the kinds of knowledge they need to mobilise to achieve their goals, the other actors who they depend on (e.g., peers, funders, clients), potential allies and competitors, and the role the public at large plays in their ability to translate evidence into practice (public attitudes can be a major constraint on public health initiatives, e.g., heroin injecting rooms). Identifying the kinds of knowledge they need to mobilise would require them to articulate the key generalisation gradients they are subject to; the nature of the behaviour (problem or issue), the characteristics of their target population, the key features of their context (especially constraints like resources, cultural beliefs, etc., and opportunities like possible sources of resources, supporting policies, etc.), the nature of the intervention mechanism itself and the relevant frameworks.

In stage 2, when new research evidence is identified, the ecology of practice can be used to place it in the pantheon of possibilities, focus attention on what is needed to both implement it, and do so in ways that achieve maximum benefit. This “research–practice synthesis” stage, which would involve interaction between practitioners and researchers, facilitated by a knowledge broker, requires answers to four questions:

1. What is the knowledge to be mobilised and how does it map onto the identified generalisation gradients; is it relevant to the target behaviour, how close are the populations, how well does it match the context, how does the intervention work/do its systemic pathways match their own, and how consistent are the frameworks employed, or implied, by the research.
2. What institutional support is required to make the kinds of practice changes suggested by that knowledge, and what ideological, theoretical and practical (e.g., economic) frameworks do they expect/are comfortable with, and therefore need to be used.
3. What allies, with what interests, are available.
4. Which public constituencies, with what criteria, will have to be persuaded.

Such an approach, grounded in our theory of generalisation, would be developing a new logic of

inquiry—one that was more likely to identify both the constraints on generalising existing knowledge and opportunities for applying new knowledge to practice improvement. Having opportunities at a distance to engage with research knowledge and work to have it generalised to your context is particularly important for disadvantaged groups and countries who rarely have the opportunity to engage in the basic work themselves. This would be especially important in low income and/or culturally isolated countries and domains, where there are whole chains of interdependent barriers to translation. Having identified the barriers, they can be placed on the agenda for action, and allies can be sought, who would also be identified by the process (see Young et al. [19] for a more detailed discussion of how ANT can be used to organise both the key knowledge that needs to be mobilised to pursue an agenda, and the key actors who need to be mobilised in order to carry that agenda forward).

We believe that we have only just begun to exploit the potential of the Internet for improving translation. The remarkable success of *Wikipedia* shows that if one provides a suitable platform, individuals with knowledge will contribute, resulting in surprisingly accurate summaries of various topics. However, such systems are vulnerable in areas where there are competing frameworks (philosophies, ideologies and interests). The optimal use of such technologies probably requires more structure, and some capacity to have experts authenticate the knowledge that is generated through collaborative review processes.

We have recently established a pilot site [45], designed to extend the kind of opportunities the web can provide by organising systematic, expert reviews around questions that site users (both practitioners and researchers) ask. Importantly, users are also encouraged to ask new questions where existing ones do not address their issues. The early signs are that this is leading to better questions being asked (or at least ones more relevant to practice), and it will hopefully encourage researchers to answer them, when the answers are not already there.

One other important aspect of the system is that it provides a space (we call a “knowledge queue”) for users to log knowledge that is not yet incorporated into the reviews. This means that a user of the site can have some idea of what new knowledge is unsynthesised, and thus of the likely completeness of the review. It also provides a useful framework for those interested in updating the review and a potential mechanism for flagging when new knowledge might challenge existing conclusions. Systems like this have the potential to reorganise reviews to be more useful to their potential audiences. They are still likely to need some authentication mechanism (peer review, expert advisory committee) to ensure users can be confident that the review is sufficiently

comprehensive and the conclusions are well-grounded.

Such a framework makes it explicit that knowledge is always “work in progress” and is subject to different framings, depending on how it is to be applied. By providing vehicles for the audience to interact with the site and its contents, it also provides a means for tuning the site to better meet the needs of its users. This will be particularly useful for those whose voices are not currently heard, e.g., the disadvantaged. By enabling practitioners to ask the questions they are interested in, social, cultural and political constraints on generalisation can also be identified and placed on the agenda.

Having an extended conception of translation, from awareness to understanding, persuasion, negotiation and, finally, to eventual adoption, is necessary to organise understanding of the actual process, and thus provide strategies to improve translation. Action research is an example where this negotiation is done in the process of setting up and implementing the research, as well as in its interpretation. This also offers the opportunity for a greater focus on within-subject changes than is typical for most intervention studies (e.g., RCT). For those not so lucky (most of us), we are left to negotiate meaning after the event, but if we do this in an interactive way, involving both practitioners and researchers, we can influence the focus of future research studies so that they more directly address the concerns of all potential users of the research.

To conclude, the translation of research into practice is not inevitable. Informed translation will be facilitated by greater understanding of the different practical ontologies of research and practice, something that requires increased interaction and/or the development of more systemic and more active knowledge broking functions. Knowledge broking may be able to be facilitated by more creative use of the social computing capacities of the internet to enable real-time input into research syntheses from all interested parties, including input to the questions to be asked. The framework developed here provides the basis of an agenda for moving forward to improve the speed and quality (appropriateness) of the translation of research into practice and for encouraging more of the kinds of research that actually facilitate this effective translation.

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