Identifying Priorities for Communicating a Large Body of Research for Impact

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Abstract

Background CAREX (CARcinogen EXposure) Canada's mandate is to communicate a body of academic research and expertise on Canadians' exposures to carcinogens, to inform efforts to reduce exposures and ultimately reduce the risk of cancer. With 80 known and suspected carcinogens in its database and over 800 estimates of how and where Canadians are exposed, CAREX's challenge has been to focus its efforts to achieve impact.

Analysis A process model for identifying and prioritizing opportunities for knowledge translation was developed. From 2012-2017 that model was used to identify exposure priorities, select and engage knowledge users with readiness to collaborate, and explore opportunities to apply CAREX's knowledge and expertise.

Conclusion and implications A total of 54 impacts were tracked, including priority setting, cancer prevention research, implementation research, and policy and practice change.

Keywords Knowledge translation; Research communication; Research impact; Priority setting; Cancer prevention

Résumé

Contexte CAREX Canada (CARcinogen EXposure) a pour mandat de communiquer la recherche et l'expertise académiques sur l'exposition des Canadiens aux cancérogènes, de soutenir les efforts pour réduire cette exposition, et en fin de compte de réduire les incidences du cancer. Dans sa base de données, CAREX recense quatre-vingts

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cancérogènes connus et soupçonnés et plus de huit cents estimations sur comment et où les Canadiens y sont exposés. Son défi principal a été de focaliser ses efforts afin d'avoir un meilleur impact.

Analyse Un modèle de processus a été développé pour identifier et prioriser les occasions d'effectuer une application des connaissances. Entre 2012 et 2017, ce modèle a servi à identifier les priorités pour l'exposition aux cancérogènes, à sélectionner et intéresser des utilisateurs des connaissances prêts à collaborer, et à explorer les occasions pour appliquer le savoir et l'expertise de CAREX.

Conclusion et implications On a relevé un total de 54 impacts, y compris l'établissement des priorités, la recherche sur la prévention du cancer, la recherche sur la mise en œuvre, et la modification de politiques et de pratiques.

Mots clés Application des connaissances; Communication de la recherche; Impact de la recherche; Établissement des priorités; Prévention du cancer

Introduction

CAREX (CARcinogen EXposure) Canada is a national research project that informs efforts to reduce exposures to known and suspected carcinogens in workplace and community environments, and ultimately reduce the risk of cancer. Until CAREX Canada research was completed and made available in 2012, Canada had no centralized repository of data on occupational and environmental carcinogens. It was unknown what carcinogens Canadians were exposed to, how many people were exposed, how and where they were exposed, and what levels of exposure they might experience.

WorkSafeBC (a statutory agency responsible for regulating workplaces in British Columbia) funded CAREX Canada as a pilot project in 2003 to estimate carcinogen exposure in BC and Ontario workplaces. This approach was modelled after CAREX EU, which was developed by the Finnish Institute of Occupational Health with several EU partners (EU-OSHA, 2014; Kauppinen, Toikkanen, Pedersen, Young, Ahrens, Boffetta, Hansen, Kromhout, Blasco, Mirabelli, de la Orden-Rivera, Pannett, Plato, Savela, Vincent, & Kogevinas, 2000). Informed by the Canadian Strategy for Cancer Control (2006), which recommended the surveillance of population exposures to carcinogens, the Canadian Partnership Against Cancer provided funding in 2007 to expand this pilot project into a national carcinogen surveillance program for Canada: CAREX Canada. Between 2008 and 2012, CAREX Canada worked with scientific advisory committees to develop over 800 estimates of how and in what contexts Canadians are exposed to carcinogens in workplace and community environments (Demers, Peters, Setton, Hystad, & Nicol, 2008; Peters, Palmer, Telfer, Ge, Hall, Davies, Pahwa, & Demers, 2018). The CAREX Canada website was launched in 2012 to share these results, along with profiles for 80 known and suspected carcinogens and tools to support knowledge users in exploring, interpreting, and applying the results. Details on how the CAREX Canada estimates and tools were developed are outlined in various publications (Peters, Ge, Hall, Davies, & Demers, 2014; Setton, Hystad, Poplawski, Cheasley, Cervantes-larios, Keller, & Demers, 2013).

In 2012, CAREX Canada received a renewed five-year mandate from the Canadian Partnership Against Cancer to shift efforts from surveillance and knowledge generation to knowledge translation (KT). As defined by the Canadian Institutes of Health

Research (CIHR), KT is "a dynamic and iterative process that includes synthesis, dissemination, exchange and ethically-sound application of knowledge to improve the health of Canadians, provide more effective health services and products and strengthen the health care system" (Graham, 2012 p. 1).

Given the vast and complex body of CAREX Canada research, and a long and varied list of potential knowledge users, the objective was to develop a KT plan to guide communication about CAREX research for maximum impact. Impact is defined as seeing CAREX Canada estimates and tools inform programs, policies, and practices related to occupational and environmental carcinogen exposures, with the ultimate goal of helping to prevent exposures and reduce the risk of cancer. This impact includes agenda- or priority-setting, the first step in the policy development process whereby the topic is of public interest and becomes a governmental issue (National Collaborating Centre for Healthy Public Policies, 2013). The sought-after behaviour change was for stakeholders in cancer prevention to apply CAREX Canada exposure estimates in their work. The associated outcomes and the activities and inputs that enable these outcomes, excerpted from the CAREX Canada Logic Model (CAREX Canada 2013) are in Table 1.

Table 1: Proposed outcomes identified in CAREX Canada's logic model (2012–2017)

Short-term outcomes	Mid-term outcomes	Long-term outcomes/Impact
Enhanced access to occupational and environmental carcinogen exposure estimates in Canada Enhanced knowledge among stakeholders of occupational and environmental carcinogen exposures Enhanced awareness of CAREX Canada initiative and knowledge products	Enhanced skills among stakeholders to apply occupational and environmental carcinogen exposure estimates to work (capacity strengthened) Enhanced use of CAREX Canada's occupational and environmental exposure estimates to guide and evaluate decisions about cancer prevention research, programs, and policies (includes agenda-setting)	For CAREX Canada estimates and tools to inform programs, policies, and practices related to occupational and environmental carcinogen exposures (includes agenda-setting); ultimately these efforts will help to prevent exposures and reduce the risk of cancer

The challenge was to identify priorities; which programs, policies, and practices could this body of work influence? What corresponding audiences could be targeted? KT frameworks and guides provide practical support for mobilizing specific results or approaching an integrated process at the outset of a research project (Barwick, 2013; Graham, 2012; Graham, Logan, Harrison, Straus, Tetroe, Caswell, & Robinson, 2006; Grimshaw, Eccles, Lavis, Hill, & Squires, 2012; Lemire, Souffez, & Laurendeau, 2013; Nilsen, 2015; Public Health Agency of Canada, 2012; Lavis, Gibson, Reardon, 2006; Riley, Robinson, Gamble, Finegood, Sheppard, Penney, & Best, 2015). However, their application to identifying priorities for mobilizing a completed body of work as complex and unique as CAREX Canada was limited. The Knowledge-to-Action (KTA) framework was deemed most adaptable to this scenario (Graham et al. 2006). The challenge was how to address the first phase of the cycle—"Identify problem/identify, review, select knowledge"—which involves identifying and consulting with stakeholders

and target audience(s), defining the need and the expected outcomes, and identifying the knowledge to disseminate. Put in priority-setting terms, this step focuses on determining the "right people," the "right issues," and the corresponding KT opportunities.

In its ideal interpretive form, priority setting selects the right people to brainstorm on the right issues to determine what a society's, a system's, or an institution's priorities are (Campbell, 2010). Various deliberative priority-setting models for research have been outlined by CIHR, the Canadian Coalition for Global Health Research, and the National Institute for Occupational Safety and Health (NIOSH) (Campbell, 2010, 2012; Gillen, 2010; Rosenstock, Olenec, & Wagner, 1998). The challenge in applying these models related to the end-of-grant nature of this KT effort; it was not about setting a research agenda but rather about setting priorities for KT based on an existing and complex body of knowledge. Given that this knowledge touched on a wide range of audiences and issues, the deliberative dialogue process for priority setting was also difficult to apply, particularly with a limited budget and, as researchers, limited authority to gather all stakeholders for input. The technical nature of the knowledge also posed a barrier; potential knowledge users often had an insufficient or unbalanced understanding of occupational and environmental exposures, which made assessing their capacity and readiness to apply CAREX knowledge difficult.

To address these challenges and support KT planning, a process model (Nilsen 2015) was developed that defines the steps in the process of identifying priorities for KT. This model was applied to bridge the priority-setting models for research outlined by CIHR and others and the action cycle of the KTA framework. This article presents the process model for priority setting so that other research teams may use and/or adapt it.

Methods

The theory of change driving the KT strategy was that giving priority audiences awareness of, access to, knowledge of, and the skills to apply (and support in applying) CAREX exposure evidence will lead them to consider or incorporate it in their work. At the outset of planning, a logic model was developed to identify the steps involved in this theory of change (CAREX Canada 2013). It was informed by a broad scan of individual-level barriers and facilitators to achieving the goal, as described above (Innvær, Vist, Trommald, & Oxman, 2002; Lavis, Davies, Oxman, Denis, Golden-Biddle, & Ferlie, 2005; Oliver, Innvar, Lorenc, Woodman, & Thomas, 2014; Orton, Lloyd-Williams, Taylor-Robinson, O'Flaherty, & Capewell, 2011). The Theoretical Domains Framework, a comprehensive, theory-informed approach to identify determinants of behaviour (Francis, O'Connor, & Curran, 2012; Michie, Johnston, Abraham, Lawton, Parker, & Walker, 2005), was mapped onto the COM-B system, a framework for analyzing behaviour, to organize these barriers and facilitators (Michie, 2014; Michie, van Stralen, & West, 2011). These barriers and facilitators were used to determine the long-, medium-, and short-term outcomes, which were graphically linked to activities and inputs through the logic model (Centers for Disease Control and Prevention, 2018).

Next, a KT plan was developed that identified target audiences and more specific opportunities to pursue the desired outcomes. To support the development of this plan, a KT advisory committee was developed; it was composed of ten members represent-

ing knowledge users and KT scientists from across Canada. This committee met twice a year between 2013 and 2015 to support KT planning and to champion the uptake of CAREX Canada data among practice, policy, and research specialists. Together, the committee developed a KT plan that centred on a tailored process model for prioritizing opportunities to mobilize CAREX Canada's large body of data (see Figure 1). This model featured three phases, each with associated methods and supporting theories: identifying priority exposures or the "right issues" (2012–2013), engaging priority audience(s) or the "right people" (2014–2015), and identifying and pursuing corresponding KT opportunities via the KTA action cycle (2016–2017). A key feature illustrated here is the model's continuous improvement cycle; throughout the latter two phases, a robust evaluation plan was implemented that included surveys and key-informant interviews to inform how to improve engagement via KT products, activities, and projects, and better support the goal of application and impact via the KTA action cycle.

Figure 1. CAREX Canada's process model for identifying KT priorities (2012-2017)
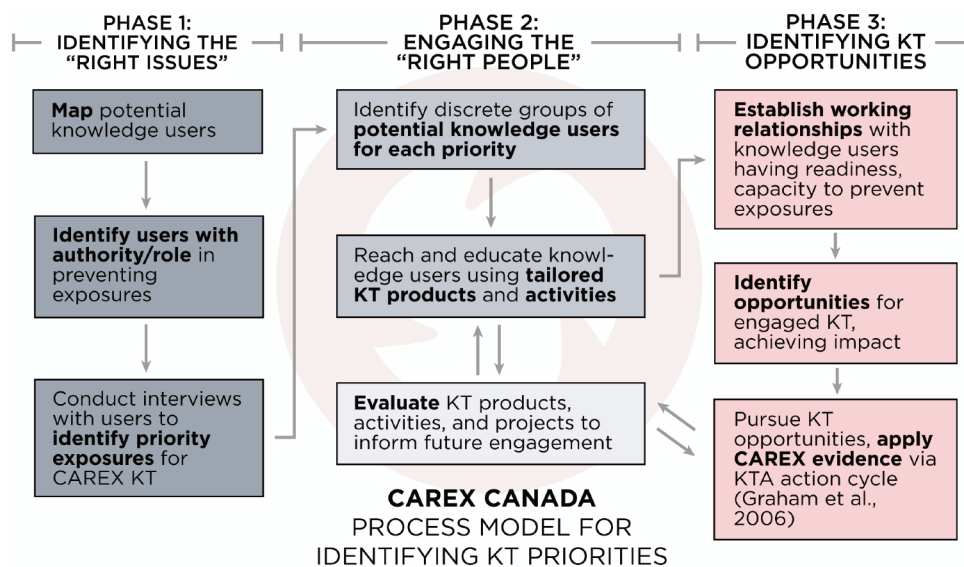
PHASE 1: IDENTIFYING PRIORITY EXPOSURES (THE "RIGHT ISSUES")
The first phase of the process model for KT was focused on stakeholder research and issue assessment, with two main goals: 1) to identify potential knowledge users with authority in preventing exposures, and 2) based on interviews with those knowledge users, to identify potential priority exposures to pursue in CAREX KT work.

Map potential knowledge users
This phase involved an initial step in 2012 of mapping over 50 potential knowledge users using an approach similar to stakeholder analysis, which is used in business or project management practice (Bryson, 2004; Campbell, 2010; Project Management Institute, 2013). This involved gathering detailed information about potential knowledge users at national and provincial levels. The users represented federal and provincial governments and agencies (including various layers of complex institutions), health authorities, non-governmental organizations (NGOs), labour groups, and professional associations. The information included organizational authority as it relates to making decisions about cancer prevention programs, policies, and practices, influence

on other groups, priority topics or issues, and what carcinogens and CAREX Canada resources were relevant to each user's work. Each type of information was a column in a table. This information was gleaned via the Canadian Legal Information Institute's database of governing legislation (2020), organization websites, policy statements, and relevant reports.

Identify users with authority/role in preventing exposures
The information captured in the knowledge user map was analyzed to reveal which potential knowledge users were best suited to inform programs, policies, and practices related to occupational and environmental carcinogen exposures, including setting the agenda for cancer prevention practice and policy in Canada. Users involved in making, implementing, or influencing decisions about Canadians' exposures to carcinogens were targeted. These users were identified by sorting the table in a manner similar to a power-versus-interest grid (Bryson, 2004; Campbell, 2010). In this case, power was defined as having decision-making authority related to the known and suspected carcinogens in the CAREX Canada database; and interest was defined as identifying carcinogens as a priority topic or issue in current or previous work. It aimed to identify the "players," those with both interest and significant authority to make decisions and protect populations from exposures to carcinogens (e.g., government agencies), and "subjects," those with interest but little authority who either implement or enforce decisions (e.g., health authorities) or influence them (e.g., labour advocates, NGOs). A formal influence-mapping exercise was not undertaken at this stage, given that the degree of influence an organization has varies depending on factors including which carcinogen is being considered, and this had not yet been established. A sample of "player" and "subject" knowledge users were chosen as interviewees.

Conduct interviews, identify priority exposures
In 2013, semi-structured telephone interviews were conducted with 15 potential knowledge users who represented regional, provincial, and national organizations involved in making, implementing, or influencing decisions regarding Canadians' exposures to carcinogens. The questions aimed to assess their interests and priority carcinogen exposures, their precise role in reducing the risk of carcinogen exposures, as well as their awareness, comprehension, and application of CAREX Canada data and resources. They were also asked about their uptake of exposure-related evidence as well as organizational and individual barriers and facilitators to using exposure data. Those with decision-making authority were also asked about the information that is gathered and considered to make decisions related to exposures to carcinogens. The questions were informed by the KT advisory committee, the Theoretical Domains Framework (Michie et al., 2005), social network analysis interview surveys (Varda, Chandra, Stern, & Lurie, 2008), and input from similar assessments conducted at other KT-oriented agencies (Chociolko, Waldorf, Copes, Kosatsky, Shum, Verhille, & Harrison 2009).

The transcribed responses were organized using a spreadsheet and thematic content analysis was used to analyze the results (Bernard, Wutich, & Ryan, 2009). The themes identified were strongly linked to the questions and responses, and to the type of target audience. As a result, an inductive approach to data analysis was used whereby it was possible to draw high-level conclusions regarding prevention priorities for CAREX KT

without needing to fit the data into a pre-existing theory or framework for analysis. It was also possible to mine the data for feedback and guidance regarding KT strategies and activities for the target audiences, and to gain context around the barriers identified at the outset of the KT planning (access, knowledge, awareness, and skills).

To supplement these data and to address the observation that many potential knowledge users benefited from an overview on CAREX Canada's offerings and knowledge to enable fruitful discussion on potential priorities, multi-level stakeholder discussions were also explored via provincial workshops in Ontario (42 attendees) and Nova Scotia (24 attendees). These workshops, which included staff from various provincial government departments as well as representatives from NGOs and labour organizations, made it possible to pose some of the same questions explored in the interviews to those involved in making, implementing, or influencing decisions related to exposures to carcinogens in those provinces. The responses collected via the workshops were considered in the process of identifying potential priorities. The workshops also served to establish relationships to potentially pursue in the subsequent phases.

Discussions were facilitated with the CAREX Canada research team in order to determine which CAREX substances to prioritize. These discussions were informed by the NIOSH experience, using a consensus-building process to develop priorities for a National Occupational Research Agenda (NORA). The criteria that NIOSH considered included the seriousness of the hazard, numbers of workers exposed, potential for reducing risk, sufficiency of existing research, expected trend in the importance of topic, and probability that research will make a difference (Rosenstock et al. 1998). Input was sought on which known and suspected carcinogens were deemed high priority in workplace environments (for example, with either high numbers of workers exposed at high exposure levels or low number of workers exposed at high exposure levels) or carried the highest risk of cancer in community environments (for example, had the highest lifetime excess cancer risk estimate for a particular exposure pathway). Priority industries, occupations, exposure pathways, and exposure sources were also considered. Team members were asked to consider which results had the greatest potential for influencing action on exposure control; for example, it was taken into consideration which exposures had clear and widely accepted controls. This acknowledged the fact that the most prevalent exposures were not necessarily the most preventable. Finally, bi-monthly scans of Carcinogens in the News (CAREX Canada, 2020a) were undertaken to determine which results were most prominently mentioned in media articles, government reports, and academic literature, and to identify whether any momentum was building in Canada or elsewhere around awareness and/or action on particular exposures.

PHASE 2: ENGAGING PRIORITY AUDIENCES (THE "RIGHT PEOPLE")

This phase focused on the priority exposures that emerged from the stakeholder research and needs assessment work, with two main goals: 1) identifying a discrete groups of potential knowledge users for each priority exposure, and 2) reaching and hopefully engaging and educating those groups using tailored KT products and activities. This phase was crucial to ensuring potential knowledge users understood the large body of knowledge that CAREX had to offer, to support the next phase of identifying those with the capacity and readiness to apply CAREX evidence via the KTA cycle.

*Identify discrete groups of potential knowledge users for
each priority exposure*

The knowledge user map was revisited to develop a discrete list of five or more potential knowledge users for each priority exposure. This process could be considered another stakeholder analysis, where once again "players" and "subjects" were considered, as per the power-versus-influence grid approach, to include those involved in making, implementing, and influencing decisions related to Canadians' exposures to carcinogens (Bryson, 2004; Campbell, 2010). In this case, the focus area or priorities of each user's organization, and its alignment with the exposures prioritized in the first phase was taken into account. Some of the knowledge users interviewed in the first phase were included in these discrete lists of potential knowledge users.

*Reach and educate knowledge users using tailored
KT products and activities*

Various engagement strategies, chosen to address the barriers identified at the outset of KT planning, were employed to reach out to these potential knowledge users. The goal of these strategies was not to engage in the KTA action cycle as of yet but rather to balance participant understanding of priority carcinogens and the knowledge and expertise that CAREX Canada had to offer to support application. The strategies included small-group discussions, tailored presentations and webinars (including training), and package summaries (an accessible knowledge product that presents CAREX results, tools, and resources on the exposure priorities for target audiences) (CAREX Canada, 2020b).

Knowledge users representing ten organizations were engaged to assess their readiness to apply CAREX Canada data and to explore opportunities to move the organizations along to the third phase. Organizational readiness has been correlated with the likelihood of facilitating KT in implementing changes (Holt, Helfrich, Hall, & Weiner, 2010). The definition of readiness used was "the degree to which those involved are individually and collectively primed, motivated and technically capable of executing the change" (Holt et al., 2010 p. S50). User readiness was assessed using five criteria adapted from a systematic review of organizational readiness for KT in chronic care: organizational dynamics, change process, innovation readiness, institutional readiness, and personal readiness (Attieh, Gagnon, Estabrooks, Légaré, Ouimet, Vazquez, & Nuño, 2014).

Evaluate KT products and activities

Evaluation surveys were used for most of the 20 tailored presentations. The surveys posed questions about the users and their experience related to the presentation. Questions included: Was the presentation worth their time to attend? Was it credible? Was it relevant to a challenge they were facing? Was it presented in a way they could understand? Did it increase their knowledge and skills to use exposure data? Did they intend to share the information with colleagues, use it in decision-making, etc.? Informal interviews were also conducted with knowledge users to solicit feedback about the accessibility, usability, and relevance of the package summaries knowledge product.

PHASE 3: IDENTIFYING KT OPPORTUNITIES

The goals of this phase were to: 1) establish working relationships with the ten knowledge users, 2) identify opportunities for engaged KT, and 3) pursue KT opportunities

and apply CAREX Canada evidence via the action cycle of the KTA framework (Graham et al. 2006).

Establish working relationships

The established relationships took the form of working groups, research teams, and networks (Wenger and Snyder 2000). In the CAREX Canada context, a working group is a formal entity led (or co-led) by CAREX with terms of reference that outline membership, meeting schedule, responsibilities, and collaborative goals. A research team is a group of academic researchers, often at various institutions, working on a project with clear goals and deliverables set out in a work plan or funding proposal. Networks in this case are not managed by CAREX Canada but are supported and strengthened by CAREX Canada through ongoing communication and dissemination activities.

Identify KT opportunities

These relationships were used to explore opportunities to apply CAREX Canada data to impact policies, practices, and programs related to the priority exposures identified in the first phase. These relationships were approached by prioritizing high-quality interpersonal connections, building trust, and sharing authority in determining goals and direction (Bowen, Martens, & The Need to Know Team, 2005). This approach is based on the understanding that research uptake is a social process, where interpersonal connections between people are crucial to determining whether research becomes integrated into users' understanding and practice (Van Eerd & Saunders, 2017). These relationships often required extra funding, long timeframes to develop, and an investment in regular connection and dialogue.

Pursue KT opportunities, apply CAREX evidence via the KTA cycle

For each KT opportunity pursued, the action cycle of the KTA framework was used to apply CAREX evidence in collaboration. This involved: adapting CAREX knowledge to the user context; assessing organizational and individual barriers and facilitators to knowledge use (including motivation and opportunity); and selecting and tailoring KT strategies to suit the knowledge user(s) and intended impact (Graham et al. 2006). The KT strategies were distinct for each one of the collaborations, and they are described as case studies in the results section. Knowledge use and the application of CAREX evidence were monitored through these case studies, and they were charted in a policy-impact tracking database.

In 2016, near the end of the application phase, efforts to date were evaluated through semi-structured interviews with 14 individuals, from partners and collaborators directly involved in the case studies to more peripheral communicators and researchers. The interviews focused on evaluating the activities in the third phase, but they also looked to future priorities, asking about gaps and emerging opportunities. Practical feedback, new ideas (including identifying knowledge gaps in the KTA cycle), and ways to pursue sustainability were sought through these conversations.

Results

PHASE 1: IDENTIFYING PRIORITY EXPOSURES (THE "RIGHT ISSUES")

At the outset of the KT planning process, the broad, individual-level barriers and facilita-

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tors that had been identified and organized were oriented around capability and opportunity (knowledge, environmental context and resources, skills). They included users':

- access to data on occupational and environmental exposures to carcinogens;
- knowledge of occupational and environmental exposures;
- awareness of the CAREX Canada initiative and knowledge products; and
- skills to apply CAREX exposure estimates to work.

(More specific assessments of barriers and facilitators were undertaken for each KT opportunity identified in phase three and pursued via the KTA cycle, including additional assessments of capability, opportunity, and motivation.)

The interview and multi-stakeholder workshop data obtained in the research phase became a rich source of information about potential knowledge users. It supported the identification of several exposure priorities to pursue for CAREX Canada KT (listed in Table 2). A gap in capacity and understanding regarding the carcinogens studied by CAREX Canada was also identified. It was determined that, to have meaningful and focused conversations about opportunities to apply CAREX Canada evidence for impact, it was necessary to educate users on the concepts of exposure and cancer-causing substances in addition to conveying CAREX Canada's research and offerings.

Table 2: Exposure priorities that emerged from Phase 1

Priority type	Priority list
Carcinogen	Radon, solar ultraviolet (UV) radiation, diesel engine exhaust, and antineoplastic drugs (drugs used to treat cancer)
Exposure pathway/source	Outdoor air (specifically traffic-related air pollution)
Population	Environmental exposures among First Nations peoples in Canada (note that work related to this priority is the subject of another publication under development and is outside the scope of this article)

PHASE 2: ENGAGING PRIORITY AUDIENCE(S) (THE "RIGHT PEOPLE")
This phase made it possible to take the exposure priorities from the first phase (see Table 2) and identify knowledge users with the potential to apply CAREX Canada research related to those priorities, and then engage and educate them. The intent was to move knowledge users with capacity and readiness through the process model toward the third phase: identifying and pursuing KT opportunities. In a few instances the right collaborator was found right away, with the readiness to work together and mobilize many CAREX Canada results (described in the case study section). In other instances, the engagement and education phase was used to balance potential knowledge users' understanding about CAREX knowledge and expertise, while clarifying potential opportunities for impact.

Through small-group discussions, tailored presentations and webinars, and package summaries, conversations were generated on the exposure priorities outlined in Table 2. Discussion results, event surveys, and interview results for these activities offered information to illustrate whether the right audiences had been engaged, whether and how

they might use CAREX Canada data and resources related to the priority exposures, and how offerings could be better tailored to users. They also made it possible to assess readiness (using the criteria of organizational dynamics, change process, innovation readiness, institutional readiness, and personal readiness), and to identify needs for additional evidence to overcome the many challenges users faced in applying this research.

For example, a need to offer more information related to radon policy and law, and the extent of testing in various types of buildings was identified. Opportunities to study interventions related to solar UV radiation exposure among outdoor workers were discovered. It was revealed that concern was emerging about antineoplastic drugs, and that new data sets were available to inform emerging discussions. The opportunities that were pursued to build on some of these learnings are described in the next section (Phase 3).

The prevention priority areas that were not pursued into the application phase included diesel engine exhaust in workplaces and traffic-related outdoor air pollution. In the case of diesel engine exhaust, the results revealed that policy and industry communities were not ready to pursue this; as a result, it was tabled for the future (this changed in 2018 and the priority was included in 2018-2019 CAREX activities as well as in future-planned activities). In terms of exposures to traffic-related air pollution, interview results revealed that CAREX's potential influence on policy related to this topic was limited given the scope of the offerings (for example, identified data gaps for assessing exposure to particulate matter), and the large number of other groups focusing on this priority.

The population-based prevention priority, First Nations peoples in Canada, was one that CAREX had been engaged in for many years. Results indicated an ongoing need to pursue this priority. Related work is the subject of another publication.

PHASE 3: IDENTIFYING KT OPPORTUNITIES, APPLYING CAREX EVIDENCE VIA THE KTA CYCLE

The organizations identified through the second phase as being ready to apply CAREX data via the KTA cycle included the Risk Analysis Unit (formerly Prevention and Occupational Disease Initiatives) at WorkSafeBC, which is responsible for the workers' compensation system and for regulating workplace health and safety in the province of BC; the Occupational Cancer Research Centre at Cancer Care Ontario, which is responsible for conducting research to inform occupational cancer prevention programs and policies; the Canadian Environmental Law Association, an NGO that works to protect human health and the environment by advocating for policy change; and partners working on an intervention for outdoor workers called Sun Safety at Work Canada. The collaborations are described as case studies in Table 3. The impacts column describes a sample of the changes to programs, policies, and practices related to occupational and environmental carcinogen exposures resulting from the application of CAREX evidence and expertise. These include agenda- and priority-setting and organizational or governmental shifts in operations or decision-making. The changes were direct or indirect results of the KTA cycle; there were legally binding, voluntary, or signalled a shift in prioritization of efforts.

Table 3: Selected case studies and impacts

Organization/Goals for working together	Case study of collaborative work (history and activities)	Key impacts
WorkSafeBC Goals: enhancing capacity, exploring emerging risks	The working group with WorkSafeBC was established in 2012 to help the organization use CAREX Canada evidence to prioritize exposures to occupational carcinogens in BC workplaces. WorkSafeBC seeks to prevent occupational injury and occupational disease through education, consultation, and enforcement. CAREX Canada prioritized the organization – given its "player" status and its readiness and capacity to work with a research group in an engaged way – with a unique role as both decision-maker (regulating risks) and informer (communicating risks). CAREX Canada and WorkSafeBC have co-presented at various conferences and offered joint webinars on antineoplastic drugs, solar UV radiation, and other topics, expanding the reach of their collaborative work to hundreds of health and safety professionals and engaging them in discussions about occupational exposures and how they can best be reduced. Beyond this, both organizations have acknowledged that the working group has had a profound influence on the way their respective activities are conducted. The working group has helped to clarify the landscape of occupational health and safety regulation, and what opportunities exist to mobilize research most effectively within that landscape. The organizations continue to meet on a bi-annual basis as a working group, where emerging issues and new projects related to antineoplastic drugs, diesel engine exhaust, and sun safety are discussed.	• WorkSafeBC (2016) updated regulations for workplace exposure to crystalline silica. • WorkSafeBC (2018) developed a new program for enhancing awareness about sun safety on the job. • CAREX updated estimates of workers' exposure to antineoplastic drugs (Hall, Demers, Astrakianakis, Ge, & Peters, , 2017) an emerging risk. These estimates supported WorkSafeBC (2019) in updating its regulations related to antineoplastic exposures to consider workplaces where CAREX Canada research showed controls were lacking. These updated regulations were presented for public consultation in 2019. • The collaboration helped WorkSafeBC take a more risk-based approach to its strategic planning to prevent occupational cancer; it now has the capacity to profile exposures in a systematic and pro-active way.

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Table 3 (continued)

Organization/Goals for working together	Case study of collaborative work (history and activities)	Key impacts
The Occupational Cancer Research Centre (OCRC) Goals: enhancing capacity, informing research	The main collaboration with the OCRC involved a number of CAREX Canada team members acting as co-investigators on the Burden of Occupational Cancer Study, which applied CAREX Canada estimates to generate information crucial to informing policy change related to workplace exposures. The Burden of Occupational Cancer Study (supported by the Canadian Cancer Society Research Institute from 2012–2016) was the first study of its kind in Canada to estimate the number of newly diagnosed and fatal cancers that could have been prevented by reducing exposure to workplace carcinogens (Occupational Cancer Research Centre 2017). The approach to this study was based on a similar project conducted in the United Kingdom; however, the Canadian research team enhanced the methodology of these types of studies. The study was made possible through CAREX Canada's estimates of workplace exposure, which were directly applied in the burden calculations and involved close collaboration between OCRC and CAREX Canada staff. The two organizations not only worked closely on the research for this project but also on the KT approach and activities. They co-hosted workshops in Toronto, Vancouver, and Montreal to share preliminary results, solicit input on how best to disseminate them, and determine promising opportunities for how the estimates could inform changes in practice and policy. CAREX Canada continues to work with OCRC and partners to visualize and mobilize the Burden of Occupational Cancer Study. Based on CAREX Canada's experience with WorkSafeBC, it also established a more formal working group with OCRC to advance the organizations' collaborative interests, including burden KT.	• The Canadian Cancer Society awarded a four-year, $1 million team grant for the Burden of Occupational Cancer Study. • The Burden Study estimate for asbestos was used to inform the Government of Canada's (2018) asbestos ban, which was proposed in late 2016 and came into effect in late 2018. • OCRC increased capacity for research on occupational carcinogens; CAREX Canada embedded an associate analyst within the OCRC team. • An OCRC report featuring CAREX data on various occupational exposures was used to inform the Ontario Ministry of Labour's Occupational Disease Action Plan (ODAP), which prioritizes diesel engine exhaust (Occupational Health Clinics for Ontario Workers & Health and Safety Associations of Ontario, 2017).

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Table 3 (continued)

Organization/Goals for working together	Case study of collaborative work (history and activities)	Key impacts
The Canadian Environmental Law Association (CELA) Goals: strengthening networks, informing policy action on radon	CELA has been a key partner and influencer in the effort to mobilize CAREX Canada research on radon. This work began with CAREX Canada supporting CELA to develop "Radon in Indoor Air: A Review of Policy and Law in Canada" in November 2014 (Dunn and Cooper 2014). In addition to summarizing existing policy and law, the CELA report made 14 recommendations for addressing radon risks and filling gaps in research, policy, and law. Funding was later obtained from Health Canada to continue this radon policy work, developing "Environmental Scan of Radon Law and Policy: Best Practices in Canada and the European Union" (Quastel, Nicol, Siersbaek, & Cooper, 2018), a report to Health Canada that compared Canada to European jurisdictions and proposed new best practices for Canada.

CAREX Canada developed visuals to accompany these reports and helped to disseminate them, in addition to CAREX Canada maps of exposure, in order to inform discussions with various provinces containing regions where radon levels have been measured as high and to inform Health Canada priorities.

Those conversations also identified an opportunity to fill a knowledge gap related to testing for radon in schools. The CAREX Canada (2017) team developed a radon in schools report, documenting where school testing has taken place across the country. Collaborators such as CELA, as well as the British Columbia Teachers' Federation, have helped to disseminate this work and influence radon testing efforts.

As a result of this collaboration, CELA has been able to continue including radon as one of its priorities for the last several years and going forward. This has involved CELA launching a radon policy challenge, using CAREX Canada evidence to support a campaign to prompt action at the provincial and territorial level related to radon building codes and other policy levers. CELA has also gone on to collaborate with the Canadian Partnership for Children's Health and the Environment and others to develop a report on policy measures to address radon in the childcare sector (Cooper, Giesbrecht, & Phipps, 2017). CAREX Canada now has a working group established with CELA that continues to coordinate efforts related to radon exposure in various settings (including rental and social housing), and also discuss approaches to assessing the risk of exposure to pesticides in environmental settings and pesticide legislation and governance across jurisdictions in Canada. | • CELA had not previously prioritized radon in its advocacy work; this collaboration supported capacity development at CELA related to radon policy and law.

• Health Canada provided funds to support the 2018 report on law and policy, and later hired a policy analyst to review and enact many of the report recommendations.

• CAREX and CELA have helped to strengthen radon networks in various provinces including BC, Alberta, Saskatchewan, Manitoba, and Nova Scotia. This engagement has led to changes to various building codes in BC and Alberta.

• CELA and other partners such as the British Columbia Teachers' Federation helped to disseminate the Radon in Schools report, which influenced a series of school districts to test their schools for radon. |

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Table 3 (continued)

Organization/Goals for working together	Case study of collaborative work (history and activities)	Key impacts
Sun Safety at Work Canada (SSAWC) Goals: strengthening networks, informing policy action	Another initiative in the application phase involved multiple partners from across Canada working to prevent outdoor workers' exposure to the known carcinogen solar UV radiation. Led by Ryerson University and supported by the Canadian Partnership Against Cancer (via its Coalitions Linking Action and Science for Prevention program), the SSAWC project was designed to create an effective and sustainable sun safety program for outdoor workers (Kramer, Tenkate, Strahlendorf, Kushner, Gardner, & Holness, 2015). By working closely with workplaces in BC, the Atlantic Provinces, and Ontario (in this case the decision-makers), the interdisciplinary project team tailored sun safety programs to the specific characteristics of each worksite, and embedded the program into their existing prevention and occupational health and safety efforts. CAREX had strong involvement in the project from the beginning as members of the project coordinating team, offering both scientific and KT expertise and support throughout. When the funding for SSAWC expired in September 2016, CAREX Canada took on the coordinating role of its evolution into a national working group. This working group is comprised of individuals and organizations interested in collaboratively enhancing sun safety for outdoor workers across Canada. It is a volunteer group representing research, policy, and practice (in terms of health and safety as well as dermatology) interests and expertise, and provides a platform for national collaboration and networking. Working group members discuss approaches to further influencing and informing policy to protect outdoor workers from solar UV radiation exposure, and coordinate efforts to raise awareness of occupational sun exposure, particularly during annual Sun Awareness Week. CAREX Canada also works with working group members to pursue grant applications to support and fund continued efforts to better conduct monitoring and convey messages about exposure to solar UV radiation at work.	• CAREX data was applied to obtain two years of funding for the Sun Safety at Work Canada project via the Coalitions Linking Action and Science for Prevention program. • The project's successes include recruiting 17 workplaces across Canada, influencing 23 policy changes and 137 practice changes in those workplaces, and developing 97 resources to support efforts to reduce occupational sun exposure (a subset of these impacts are also considered CAREX Canada impacts) (Haynes, Kramer, Strahlendorf, Holness, Kushner, & Tenkate, 2018). • The SSAWC website was created to help workplaces across Canada implement their own effective and sustainable sun safety policies and practices. • The working group developed out of the SSAWC project sees research, policy, and practice professionals dedicate capacity toward national collaboration and networking. Members of this group have obtained several funding grants to continue research on sun safety in Canadian workplaces.

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Discussion

HOW THIS ACHIEVED THE AIMS AND OBJECTIVES

The challenge of this project was the volume of data that had to be communicated – over 800 estimates of how and in what contexts Canadians are exposed to known and suspected carcinogens – and the fact that the opportunities and audiences varied greatly depending on which of the 80 carcinogens and which of the many data sets were the subject of communication. With the support of the KT advisory committee, a tailored and dynamic process model was developed to summarize the approach to narrowing priority exposures (the "right issues") and audiences (the "right people"), and identifying KT opportunities through which to collaborate toward application and impact (see Figure 1).

The first phase of the model involved interviews and multi-stakeholder workshops with potential audiences and CAREX Canada research team members. The second phase involved engagement and education with selected audiences based on the priority topics that emerged from that assessment. The third phase was about collaborating with those audiences with readiness and capacity to apply CAREX Canada research via the KTA cycle. These collaborations informed priority setting, cancer prevention research, implementation research, and policy and practice change. Between 2012 and 2017, 54 impacts or ways that CAREX Canada estimates and tools informed changes to programs, policies, and practices related to occupational and environmental carcinogen exposures were tracked. Impacts include organizational or governmental changes that result in a shift in operations or decision-making. The change must have a population-level effect on those within the jurisdiction, organization, or groups targeted by the change. A change can be legally binding, voluntary, or signal a shift in prioritization of efforts.

HOW IT IMPROVES ON PREVIOUS PRACTICE

When CAREX Canada embarked on this KT mandate, the challenge was to identify priorities. Which programs, policies, and practices related to occupational and environmental carcinogen exposures could be influenced? What corresponding audiences should be targeted? There was no practical guide for developing a KT plan broad enough to help answer these questions (see Table 1). The often-cited Knowledge-to-Action (KTA) framework was deemed most adaptable and well-suited to the mandate (Graham et al. 2006). However, the first phase in the action cycle of the framework – "Identify problem/identify, review, select knowledge" – posed a significant challenge, given that the completed body of work intended for mobilization was so large and complex, and the possibilities for KT were so vast. This project sought to develop a process to guide this entry into the KTA cycle, which would include the steps for this phase as per the literature (i.e., identifying and consulting with stakeholders and target audience(s), defining the need and the expected outcomes, and identifying the knowledge to disseminate), but be expanded to include priority-setting guidance and address the particular challenges of KT planning. The process model that was developed helped to identify the priority exposures (the "right issues"), priority audiences (the "right people"), and the corresponding priority KT opportunities for applying CAREX evidence for impact via the KTA cycle. In this way, the process model serves to narrow the focus at the outset of planning, and supports an audience-informed transition to KT for

impact. This is useful where the body of research to be communicated is complex, the audiences are highly varied, and/or the opportunities for impact are ill-defined or yet to be determined.

STRENGTHS AND LIMITATIONS

While the process model helped to narrow the scope of KT and identify opportunities for impact, there were various limitations. The first concerns the diversity of the consultations and subsequently, the diversity of priorities generated through the process model. Phase one sought to consult a range of potential knowledge users to assess properly which exposures should be prioritized for KT. Despite these efforts, the sample size for interviews and multi-stakeholder workshops was limited. This was the result of various factors, including a lack of authority to convene target knowledge users and a pressure to move swiftly to achieve impact as per the mandate. This limitation could have been overcome in part by identifying champions early to support the engagement of target knowledge users, having a larger budget for face-to-face consultation, and consulting over a longer timeframe.

The second limitation relates to the fact that the process model, while informed by the priority-setting and KT literature, involved a certain degree of improvisation. No ready-made framework or model was found to guide this unique KT planning process. With the guidance of the KT advisory committee, insights were gathered in a phased fashion and deliberated to determine next steps. The result is a process model that may appear disjointed. For example, several activities in the process model also appear in the KTA framework, and barriers and facilitators to knowledge uptake are assessed at various stages. The process could have been more direct and more coherent. However, taking into account the large and complex body of knowledge to be mobilized and the other challenges that were encountered, all of these activities were considered crucial to narrowing priorities and audiences, and getting to KT via the KTA cycle. For example, a major challenge was the insufficient or unbalanced knowledge among potential knowledge users, which required education as a key activity of the engagement phase, as described above.

CAREX Canada also overestimated the expertise available among potential knowledge users for how best to address the exposures that were being raised as evidence-based priorities for exposure reduction. In the engagement phase, requests for tailored recommendations on how to control exposures based on the latest research and evidence were regularly received. This knowledge was beyond the scope of CAREX Canada, which focused on assessing, rather than addressing, exposures. In Phase 3, time was taken whenever possible to establish and leverage collaborations with partners able to meet this need for specialized recommendations and support.

OTHER CHALLENGES

KT efforts also required an engineered change in team culture. This manifested into a major strength of the KT mandate. Given the specialized nature of the estimates – as well as the potential for misinterpreting the findings – this change in culture required the close involvement of the researchers, "the K," in all KT activities. The challenge was to re-orient the CAREX team, whose main interest for the previous mandate of the

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project was strictly to produce knowledge and advance research, to create a culture of KT. This was achieved by breaking down the project's silos of specialization and collaborating on strategy and implementation; enhancing capacity within the team for clear, concise, and tailored communication; and establishing an openness to build on estimates and resources (for example, filling gaps in knowledge) to best meet the needs of key users. This shift in culture supported the team in educating audiences. It also helped them enhance the capacity of collaborators and other knowledge users to apply CAREX Canada knowledge in their cancer prevention research, practice, and policy efforts.

FUTURE WORK

Based on the experience described here, CAREX Canada opted to focus its renewed KT mandate (2018-2022) on working with knowledge users to address the knowledge gaps identified in applying CAREX Canada research for impact. From the CAREX Canada perspective, these gaps are the knowledge paired with CAREX Canada exposure evidence to inform a change in policy or practice. In other words, the renewed KT mandate focuses on developing additional evidence to overcome some of the specific challenges knowledge users face in applying CAREX Canada research to address exposures to carcinogens. These gaps were identified at various stages in the process, for example through interviews, specifically asking, "What other information do you need to apply this data?" as well as through collaborative working groups, partnerships, and small-group discussions. Some examples of these gaps and the work being pursued to fill them include

- Radon: Building on previous work on radon in schools, case studies of testing initiatives in childcare facilities are being investigated and documented;
- Diesel engine exhaust: Building on advances in testing technology and increased readiness among decision-makers to discuss a potential occupational exposure limit, a report on what a health-based occupational exposure limit could look like has been developed and is being mobilized;
- Antineoplastic drugs: With the dissemination of CAREX Canada's updated exposure estimates identifying a need to better control exposures in environments such as pharmacy and home care, a policy lever and best practices compendium for handling these drugs has been developed.

Conclusion

Researchers and KT practitioners looking to communicate a complex body of research and seeking support to identify priorities for doing so may find this process model useful to inform their efforts and overcome challenges. Identifying priority exposures and target audiences, and distilling a large body of research into clear and fruitful opportunities for KT could easily be adapted to other research projects and initiatives. Given the challenges that research staff often face in disseminating specialized knowledge to a broad set of potential users, this work provides a practical case study to inform KT planning and efforts to generate research impact.

Acknowledgements

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