



Review Article

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A Knowledge Translation Framework for Improving Concussion Education Among Medical Students and Physicians

Scott D. Bray¹, Shannon Hart¹, Ryan P. Kelly¹, Ryan M. Murray¹, Anna Nippard¹, Jared M. Ryan¹, & Roger Avery^{1,2}

¹ Faculty of Medicine, Memorial University of Newfoundland, St. John's, Newfoundland, Canada

² Department of Neurosurgery, Memorial University of Newfoundland, St. John's, Newfoundland, Canada

Abstract

Objective: The objective of this paper is to outline key principles required for a knowledge translation (KT) strategy on concussion education for medical trainees and physicians to promote knowledge retention and practice change. **Design:** Qualitative review of the literature on concussion education for medical trainees and physicians utilizing the Canadian Institute of Health Research (CIHR) Knowledge to Action (KTA) Cycle as a framework. **Results:** Medical education on concussion appears to be increasing, but many knowledge gaps persist. Although many concussion guidelines and standardized assessments have been developed, many physicians are either not aware of them, do not use them, or provide inaccurate or inconsistent discharge instructions. Focused, interactive concussion education sessions, education outreach by trained facilitators, and adoption of a spiral curriculum are preferred modalities. To facilitate concussion education, medical professionals must recognize the importance of concussion in their practice. Interventions should deliver high-yield information and be integrated into existing programs such as academic half days (AHD) and the Maintenance of Certification Program (MOC). Many KT tools and interventions have been developed, such as the Concussion Awareness Training Tool (CATT) for Medical Professionals, but evidence of their utilization and effectiveness is limited. Existing tools should be reviewed, updated, implemented, and evaluated for their effectiveness of improving both conceptual and instrumental knowledge. **Conclusion:** KT strategies for concussion medical education should utilize the CIHR KTA Cycle principles outlined in this review as a guide to design interventions that improve the concussion knowledge of medical trainees and physicians.

Keywords: Concussion, Education, Knowledge Translation, Physician, Traumatic Brain Injury.

INTRODUCTION

Concussion is a form of traumatic brain injury induced by biomechanical forces transmitted to the head and often results in the rapid onset of short-lived neurological impairment [1]. Signs and symptoms are variable and often resolve spontaneously following a sequential clinical course, but may also be prolonged and result in long-term functional impairments. There is a lack of clarity among experts around the definition of concussion, making it challenging to compare research and accurately translate information to the front lines of healthcare. However, for the purposes of this paper, we use the term concussion broadly as a catch-all term including mild traumatic brain injuries (mTBI) but excluding moderate-to-severe traumatic brain injuries (TBI).

Knowledge translation (KT) strategies play an important role in increasing knowledge and awareness of concussions and optimizing concussion education [2]. KT frameworks can be applied to develop actionable plans aimed at filling in knowledge gaps on concussions for many target populations. Medical trainees and physicians are one such population where knowledge gaps have been identified. Successfully filling this gap through concussion education is necessary to reduce the negative effects of concussions, since physicians are often the first point of contact in the healthcare system and are involved in the diagnosis, acute treatment, and long-term management of these injuries [3,4]. It is essential that physicians have accurate information as they play an important role in patient education and giving clearance for return-to-play, - school, and - work.

Using the Canadian Institutes of Health Research (CIHR) Knowledge-to-Action (KTA) Framework [5], this paper aims to outline key principles required for a KT strategy on concussion medical education. The KTA Framework is based on the KTA Cycle, which consists of seven phases of activities that are required for the

*Corresponding author:

Dr. Anna Nippard

Faculty of Medicine, Memorial University of Newfoundland, St. John's, Newfoundland, Canada
Email: apn688@mun.ca

successful implementation of knowledge. Together, these phases are redesigned to assess the information needs and preferred method of learning for a specific target audience, identify optimal educational strategies and interventions to implement knowledge, and evaluate the success or effectiveness of these strategies [5]. Based on an extensive review of the concussion education literature, we present the following KT strategy principles as a guide for stakeholders aiming to improve concussion education for medical trainees and physicians. In addition to serving as a KT tool in itself, this paper will provide the foundations for the future development of more deliberate KT interventions.

Phase 1: Identifying the Knowledge-To-Action Gaps

Many studies have identified gaps in the concussion knowledge of medical trainees and physicians that can be addressed through improved KT strategies. The Ontario Neurotrauma Foundation (ONF) stated that some inconsistencies and gaps in provider knowledge include the risk factors predisposing a patient to have persistent symptoms, the need for interdisciplinary care, evidence-based effective treatments, and the appropriateness of providers for specific elements of post-concussion care [6].

Many concussion guidelines such as the ONF's Guideline for Concussion/Mild Traumatic Brain Injury and Prolonged Symptoms [7], the International Consensus Statement on Concussion in Sport [3], and the Canadian Guideline on Concussion in Sport [8], provide guidance to physicians on how to manage concussions. However, studies have shown that many physicians are not aware of the existence of such guidelines, do not implement their recommendations, and do not use standardized assessments of concussion [9-11]. For example, the international guidelines recommended use of the Sport Concussion Assessment Tool (SCAT) for the assessment of sport-related concussion, yet it is vastly underutilized and most physicians are not aware of its existence [9-12]. However, even the guidelines acknowledge that they are not intended to replace the role of clinical judgement, knowledge, and expertise in diagnosing and treating concussion [8], so the utilization of tools may not be as important as having knowledge of their content and principles.

There is also evidence of a lack of consistent or accurate discharge instructions [13,14]. Studies indicate that many physicians do not advise on cognitive rest post-injury [9-12], provide inconsistent or inaccurate instructions on stepwise return-to-activity [15,16], or fail to provide discharge instructions at all [14]. These results are concerning because the length of sport-related concussion recovery is potentially affected by variation in the quality and consistency of management advice given by physicians early in the post-concussion treatment course [12].

A survey of medical students and residents in neurology and neurosurgery showed that a significant number of participants had deficient knowledge about concussion diagnosis and management [17]. Similar results have been reported in family medicine residents, most of whom failed to recognize red flags and serious consequences of concussion [18]. In the U.S., medical student reports revealed a similar lack of concussion education and knowledge [19]. The lack of knowledge regarding concussion management among medical trainees and physicians can be largely attributed to a lack of education in the medical school curriculum at the undergraduate and graduate level [19,20]. The medical school curriculum is lacking in teaching hours and clinical exposure, leading to substantial gaps in concussion knowledge. Focused concussion education strategies have proven to be effective at improving knowledge among medical trainees [20], yet didactic lectures tend to be the primary teaching modality in medical schools. Although didactic lectures and distribution of educational materials as independent modalities may improve knowledge they are unlikely to lead to improved physician performance and patient care. Therefore, didactic lectures and educational materials should be coupled with

later in professional practice. In 2012, only 29% of Canadian medical schools (4 out of 14) reported having dedicated concussion education, which was limited to 1-3 lectures [21]. The rest either reported having some head injury education with a concussion component or no concussion management teaching at all. However, a five-year follow-up study found that 85% of surveyed medical schools (11 out of 13) reported having concussion-specific education in their curriculum [22]. This encouraging trend shows that concussion education in medical schools is improving with the evolution and popularity of the field. However, many physicians who graduated prior to this recent surge would not have received formal concussion education, and knowledge gaps remain.

Phase 2: Adapting Knowledge to Local Context

With any KT strategy, the knowledge that is disseminated must be appropriately selected for the needs of the knowledge user, as each target audience has unique learning needs and preferences. In our case, concussion education for medical trainees and physicians must include information pertaining to the diagnosis, assessment, and medical management of concussions both in the acute setting and for prolonged symptoms. Furthermore, the roles of the physician as well as the context of the healthcare system that they work within must be considered because this will affect the duties that fall within their scope of practice and the resources available to them.

Educational modalities targeted towards the unique learning needs of physicians are important to maximize uptake, acceptance, and adherence to the KT interventions implemented. Here we examine the medical education literature to determine the optimal modalities for delivering concussion education to the medical profession. Provvindenza & Johnston [23], identified optimal education strategies for physicians, as it applies to concussion, that improve physician knowledge and performance. Among the most effective strategies identified were interactive education sessions and education outreach. Education outreach is a method of continuing education whereby a trained professional in the area of concussion meets with physicians to provide one-on-one evidence based information sessions. These sessions encourage interaction and allow participants to apply their knowledge to clinical scenarios. In comparison, passive approaches (ie. distribution of educational material) and didactic lectures were relatively ineffective at improving physician knowledge and performance as independent modalities [23].

To improve concussion education for medical trainees it is critical to determine the preferred teaching modalities among learners as well as the modalities that lead to knowledge retention. Research has shown that medical trainees prefer lectures, workshops, or seminars as a method for learning about concussions [17]. Recently, clinical experience and self-study were identified as the most common methods of concussion education amongst medical trainees [18]. However, clinical experience had no effect on knowledge scores. Focused concussion education delivered through a mentored clinical experience has been shown to be more effective at improving knowledge of concussion diagnosis and management among family, pediatric and sports medicine residents when compared to traditional residency training supplemented with concussion specific reading material [20]. These studies suggest that clinical experience alone is an insufficient modality for obtaining and retaining concussion knowledge, and therefore focused concussion education is required.

interactive discussion, such as problem based learning tutorials, to improve knowledge transfer. Recent research has explored curriculum design and its effects on the understanding and retention of concussion knowledge among Canadian medical students. Early results have shown that a spiral curriculum, which emphasizes and revisits clinical competencies, may be particularly effective in educating students on highly prevalent clinical conditions such as concussions [24].

In fact, a higher percentage of students in the spiral curriculum correctly identified the mechanism of injury and long-term sequelae of concussions when compared to students in a block curriculum [24].

Physicians are invaluable in diagnosing concussions, implementing management plans and providing patient education. Therefore, it is essential to adopt and implement effective evidence-based education strategies that lead to improved patient care when developing medical school curriculums, residency training, and continued medical education for physicians. Implementing a spiral curriculum in medical schools has the potential to improve knowledge retention among medical trainees as it revisits and reinforces the clinical diagnosis, management, and long-term impacts of concussions. Likewise, combining clinical experience with focused concussion education sessions and interactive educational outreach could strengthen the value and benefits of clinical experiences.

Phase 3: Assessing Barriers/Facilitators to Knowledge Use

Didactic teaching, clinical learning, and self-directed learning are examples of KT that help physicians obtain the education required to provide optimum care to their patients. Like all types of learning, KT of medical education presents many barriers and concussion education does not differ from this norm. Recently, Jeong *et al.* [25], outlined major barriers and facilitator domains to self-directed learning in continuing professional development (CPD) for Canadian physicians. CPD encompasses a variety of physician's competencies through diverse education and developmental activities [26]. Jeong *et al.* [25], identified the following four major barrier domains to physician's education and KT: beliefs about consequences, environmental context and resources, social influences, and behavioral regulation. Using this framework, we outline how concussion KT in physician education is impacted by each of these major domains.

A perceived lack of consequences and relevance of the knowledge is a major barrier to knowledge translation [25]. Therefore, successful concussion KT strategies must emphasize the importance of concussion as a serious clinical issue and promote the perception that participation in concussion educational interventions will improve medical practice and patient outcomes. Physicians must be aware of the importance of early symptom management and appropriate discharge instructions in the acute setting for the prevention of long-term post-concussion sequelae [27,16,28].

Medical education in Canada is largely based on the Medical Council of Canada's (MCC) learning objectives. The MCC Qualifying Examination is the examination that Canadian medical trainees are required to write at the end of medical school to qualify for a medical license. Since the MCC objectives are what medical schools largely base their curriculum on, the absence of a certain topic like concussion could lead to its omission from the curriculum. Since medical trainees are not being introduced to these learning objectives early in their education, it contributes to a perception that concussion identification and management lacks clinical significance [29]. As previously discussed [22], efforts to increase concussion-specific education in medical schools may be attributed to the growing body of literature surrounding the importance of proper concussion diagnosis and management by physicians. Although promising, until the MCC identifies concussions as a major learning objective, it will continue to pose a barrier for concussion KT. In order to overcome these barriers, greater emphasis on concussion education by the MCC would be valuable in shaping the perception that participation in concussion education interventions is essential to improve medical practice and patient outcomes. Furthermore, such changes by the MCC would help highlight the need for clear educational guidelines for medical trainees and a consistent definition of concussion for Canadian physicians.

The concussion literature is a rapidly evolving field of research. Some

may argue that this justifies the lack of formal medical education on concussions because knowledge rapidly becomes outdated. This in itself presents a major barrier to behavioral regulation as physicians are commonly reported to be reluctant to adopt a new strategy, especially if it is not well-established [25]. However, there are well-established best practices about concussion diagnosis and management that are consistent throughout published guidelines [30,1-7]. They provide evidence-based recommendations that are meant to assist in maintaining a high standard of concussion care. Furthermore, physician time constraints and competing demands are major barriers to CPD and place further stress on learning new clinical guidelines [25].

Each of these barriers to CPD contributes to an educational environment suggesting that concussion is insignificant relative to other more serious medical ailments. Therefore, when considering facilitators to concussion education interventions, they should deliver high yield information, they should not be too time-consuming, and they should be designed to accommodate evolving guidelines. Guideline updates and recommendations through email communication or newsletters can be a quick and informative resource for medical professionals. For medical trainees, academic half days (AHD) are education sessions set aside for medical residents on a weekly basis to participate in KT through case learning and didactic teaching. AHD are known to enhance learning by organizing large amounts of information and constructing knowledge to provide patient care [31]. Implementing concussion educational sessions during AHD can help overcome the barriers of time constraints and competing demands on medical trainees.

Phase 4: Selecting, Tailoring, Implementing Interventions

There are many tools and resources developed with the aim of delivering concussion education to a number of target audiences including athletes, parents, coaches, and various health professionals. Each target audience benefits from specific learning strategies suited to their unique needs. Medical trainees and physicians require educational interventions targeted toward the clinical management of concussions. In this section we examine evidence for existing interventions tailored to this purpose and make recommendations on how they could be improved for widespread implementation.

The Ontario Neurotrauma Foundation has developed concussion guidelines for both adult [7], and pediatric [32], populations, as well as a number of tools for healthcare providers. The Diagnosing and Managing Concussion Tool was developed by the Centre for Effective Practice (CEP) in collaboration with the ONF to support primary care providers in performing consistent diagnostic assessments that leads to more tailored and comprehensive management plans based on patient symptoms and needs [33].

In an effort to promote consistent concussion management among healthcare professionals, Parachute Canada – with support from the Public Health Agency of Canada – led the development of harmonized concussion management guidelines and protocols. The Canadian Guideline on Concussion in Sport was released in 2017 and outlined best practices for the evaluation and management of athletes with a suspected concussion [30]. Additionally, Parachute partnered with the BC Injury Research & Prevention Unit in the development of the Concussion Awareness Training Tool (CATT) for Medical Professionals [34]. The CATT is a free e-learning course that provides information for medical professionals to provide evidence-based care to their patients with a concussion. This activity is an Accredited Self-Assessment Program as defined by the Maintenance of Certification Program (MOC) of the Royal College of Physicians and Surgeons of Canada (RCPS), and approved by the University of British Columbia Division of Continuing Professional Development. Evaluations of the earliest version of the CATT have highlighted significant positive changes in

concussion practices and knowledge among physicians involved in the treatment of more than 10 concussion patients per year [35].

Several other interventions involving physicians have been highlighted in the literature, including a multi-faceted concussion management education program piloted by Reiser *et al.* [36], in the United States. The initiative provided pediatricians with a toolkit outlining evidence-based guidelines on how to manage adolescent and youth concussions, including access to a concussion education webcast highlighting referral and return-to-play guidelines. Results of the study demonstrated significant improvements in concussion knowledge, guideline use, and comfort level in managing concussions. This suggests that adoption of a multifaceted, evidence-based education program can produce positive changes in self-reported practice behaviour for youth concussion management.

As previously mentioned, medical trainees prefer lectures, workshops, or seminars as a method for learning about concussions [20,17]. A focused one-hour lecture endorsed by the Concussion Education and Awareness Committee of ThinkFirst Canada and the Ontario Neurotrauma Foundation was circulated to all Canadian medical schools and is recommended for use in Canadian medical student education [21]. However, it is unclear whether this is being adopted or whether it is effective in improving concussion knowledge.

There is no shortage of existing KT tools and interventions that have been developed to improve concussion knowledge among physicians. The challenge lies in implementing the existing tools and increasing uptake by medical trainees and physicians. Going forward, KT strategies must utilize and modify these previously mentioned interventions. They can either be used in concert, or new interventions may be developed using them as a resource. Methods should be developed in a way that simultaneously meet learning needs and address barriers to education reported by both medical trainees and physicians, such as the environmental context and resources, social influences, beliefs about consequences, and behavioral regulation. Having medical trainees and physicians involved in the intervention development process will help identify gaps in KT and promote clear learning objectives. It is important that these tools be accessible to trainees and physicians in a number of settings. This can be achieved by delivering concussion educational sessions through interactive learning modules for CPD. Educational outreach sessions through webinar based learning by medical experts can provide concussion educational resources, case studies, and peer-to-peer interaction at the convenience of the learner.

Phase 5: Monitoring Knowledge Use

Monitoring the use of knowledge gained through the previous steps in the action cycle is an important component of any knowledge intervention. Two forms of knowledge use, conceptual and instrumental, are most relevant for the purpose of this paper. Conceptual knowledge refers to changes in medical trainee and physician levels of knowledge, attitudes, and awareness of concussion, while instrumental knowledge refers to changes in physician behavior and practice and the concrete application of the knowledge to patient care [5]. These forms of knowledge use can be directly related to research and interventions aiming to improve the concussion knowledge of medical professionals and their clinical practices with regard to concussion management.

Monitoring knowledge use is a necessary step in KT efforts in order to understand how and to what extent knowledge has been implemented within a given field [5]. In the concussion literature, efforts have been made to evaluate the knowledge and understanding of healthcare professionals with regard to concussion recognition and management. In particular, research in Canada has focused on the knowledge of medical students, residents, and physicians. As outlined in previous

sections, this research has highlighted deficiencies in concussion knowledge of these groups [15,17,11,18,9]. The knowledge gained through this research has been used in the development of concussion education programs for healthcare professionals and to guide changes to medical school curricula [22]. Canadian medical schools have increased exposure to concussion-related teaching in response to these findings, with 85% of schools surveyed now reporting concussion-specific education compared to 29% in 2012. Additionally, there has been an increase in the mean number of dedicated teaching hours to 2.65 from 0.57 [22]. Nevertheless, there is a need to further investigate the impact of these curriculum changes nationally. To effectively monitor conceptual knowledge use, there must be broader application of validated research tools to assess changes in the level of concussion knowledge, understanding, and attitudes among trainees and clinicians.

Instrumental knowledge use is generally assessed by measuring changes in practice and adherence to clinical practice guidelines. A number of studies have assessed concussion management among clinicians, demonstrating inconsistencies in the practices of those directly involved in the assessment and treatment of concussion patients [16,9]. To date, a number of methods have been used to assess concussion management practices, including self-report questionnaires for physicians, surveys sent to hospital administrators, and questioning of parents on their recall of discharge instructions [37,16,14]. Nevertheless, instrumental knowledge use has not been frequently reported on within the concussion literature in recent years. Thus, there is a need for further monitoring of clinical practices among physicians involved in concussion management. This should involve measuring the frequency with which clinicians follow clinical practice guidelines on important considerations relating to assessment, management, and discharge advice/planning for concussions.

Phase 6: Evaluating Outcomes

Building on the previous section, the evaluation of concussion KT-interventions aims to determine whether or not the KT goals have been achieved, which in this case refers to the facilitation of knowledge and practice change among physicians. Measurement will require explicit and rigorous methods and strategies that are targeted to the various types of KT interventions implemented [5]. Measuring the success of KT interventions on physician and medical trainee knowledge should include both qualitative and quantitative strategies and measure structural, process, and outcome measures. Qualitative methods include surveys and interviews assessing the learner's perspective and satisfaction with the educational intervention. Quantitative methods are geared toward assessing knowledge through standardized tests and evaluating health system data to examine clinician behaviour and patient outcomes.

As previously discussed, our interest is focused on the instrumental and conceptual knowledge use of medical learners. An approach to measurement of instrumental knowledge would be the use of administrative healthcare databases and chart reviews to assess adherence to concussion clinical practice guidelines, along with surveys of clinical behavior change. Furthermore, an approach to evaluating conceptual knowledge would be administration of quantitative and/or qualitative surveys and interviews with medical trainees and physicians pre- and post- educational intervention.

One such survey is the concussion knowledge assessment tool (CKAT), developed by Boggild and Tator [17], for clinicians. The CKAT has been used to assess concussion knowledge among physician trainees [17,18], neurology/neurosurgery residents [17], chiropractors, and chiropractor trainees [38,39]. However, a recent study examined the psychometric properties of the CKAT and concluded that although there was evidence supporting construct validity, it did not achieve adequate test-retest reliability [40]. Furthermore, given that there have been

many updates and developments in the concussion field since the development of the CKAT, the authors also recommended that the survey be re-examined item by item to determine where improvements can be made. Developing a modified version of the CKAT with improved psychometric properties would be an important step in the evaluation of concussion KT interventions and would allow for more objective evaluation of knowledge outcomes moving forward.

Another key component of evaluating outcomes is to measure the implementation of various interventions. Measurement of this would include reach indicators, use indicators, and partnership/collaboration indicators. Reach and use indicators aim to quantify how many medical trainees and physicians have received or used the KT intervention or tool. For example, for an interactive education session provided by experts or an online interactive learning module, the number of participants who received the training should be tracked. Inquiry of this type will help ensure proper evaluation of the impact of various implementations, therefore tracking knowledge gaps and strengthening KT efforts.

Phase 7: Sustaining Knowledge Use

As previously mentioned, concussion research is an evolving field and concussion education cannot be a one-and-done type of intervention. As research updates and guidelines change, the time between knowledge development and its use in clinical practice must be minimized through ongoing KT interventions. These interventions should be continuously updated to ensure that they deliver the most current and accurate information available and meet the learning needs of medical students and physicians. Obtaining feedback on the user experience following implementation of various KT interventions will help guide future development and sustain knowledge use.

Sustainable concussion education requires self-directed learning in CPD by physicians, which as we have seen presents many barriers that must be addressed [25]. To achieve long-term buy-in from physicians they must see the relevance and benefits to clinical practice of completing the educational intervention. Furthermore, physicians should undergo periodic retraining and knowledge assessment to ensure that they are staying up to date.

The RCPSC could help support self-directed learning in concussion education by promoting and endorsing accredited interventions in their Maintenance of Certification (MOC) Program, such as the CATT for Medical Professionals.

The 6th International Conference on Concussion in Sport was scheduled to take place in October 2020. However, due to the COVID-19 pandemic it is now rescheduled for October 2021. Following this conference, the updated consensus statement from the Concussion in Sport Group (CISG) will likely have implications for the diagnosis and management of concussions and these must be taken into consideration when developing or updating concussion knowledge interventions. As the relatively new field of concussion research continues to grow and make new discoveries, so too must the concussion educational interventions to minimize the knowledge to action gap. For physicians, special attention should be given to developments in concussion diagnostics such as neuroimaging modalities and clinical biomarkers [41], treatment/rehabilitation, mental health, neuropsychology, and long-term effects such as post-concussion syndrome and chronic traumatic encephalopathy [42].

CONCLUSION

This paper has outlined many, but not all, considerations for a KT strategy on the concussion knowledge of medical trainees and physicians. Although medical education on concussion appears to be improving, many knowledge gaps exist around the medical

management of concussions. Focused interactive education sessions, educational outreach, and implementation of a spiral curriculum appear to be preferred modalities for delivering KT intervention. Many barriers to knowledge use exist related to perceptions of the importance of concussions and the social and environmental context within which medical education is delivered. Understanding of these barriers and how they can be facilitated will allow learning needs to be better identified and understood. There are also many existing KT interventions aimed at improving concussion knowledge in medicine, but there is little evidence on their uptake and utility. These should be reviewed, updated, implemented, and evaluated for their effectiveness of improving both conceptual and instrumental knowledge. Using the considerations outlined in this paper when developing KT strategies on concussion education for medical professionals should help improve clinician knowledge, and ultimately improve patient care for concussion patients.

Conflicts of interest

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