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Knowledge Translation Strategies Used by Healthcare Professionals in Child Health Settings: An Updated Systematic Review

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ABSTRACT

Problem: Strategies assisting healthcare professionals to make evidence-based decisions are crucial for quality patient care and outcomes. To date, there is one systematic review (Albrecht et al., 2016) examining knowledge translation (KT) efforts in child health settings. This systematic review aims to provide an update on current evidence identifying KT interventions implementing research into child health settings.
Eligibility criteria: Nine electronic databases were searched, restricted by date (2011–2018) and language (English). Eligibility included: 1) randomized controlled trials (RCT), controlled clinical trials (CCT), or controlled before-and-after (CBA) studies; 2) interventions implementing research into child health practice; and 3) outcomes were measured at the healthcare professional/process, patient, or economic level.
Sample: Health care professionals working in child health settings.
Results: 48 studies (38 RCT, 7 CBA, 3 CCT) were included. Studies employed single ($n = 34$) and multiple ($n = 14$) interventions. The methodological quality of studies was moderate ($n = 18$), strong ($n = 16$) and weak ($n = 14$). Studies showing significant, positive effects included ($n = 9$) RCTs, ($n = 3$) CBAs and ($n = 2$) CCTs. These studies employed ($n = 11$) single KT interventions and ($n = 3$) multiple KT interventions. Interventions included educational ($n = 6$), reminders ($n = 3$), computerized decision supports ($n = 2$), multidisciplinary teams (n = 2) and financial and educational interventions combined ($n = 1$).
Conclusions: Effective KT strategies used by health care professionals in child health settings were found to be online education curriculums and computerized decision supports or reminders.
Implications: This review update serves as an up-to-date 'state of the science' on KT strategies used in pediatric health professionals' clinical practice, assessed by the most rigorous research designs.

Background

There continues to be a consistent finding among clinical and health service research acknowledging a gap between what is known to be effective in practice, based on the best available evidence and research, and what actually occurs. Such variations can result in poor health outcomes, unnecessary medical treatments, and increased strain on the healthcare system (Scott, Grimshaw, Klassen, Nettel-Aguirre, & Johnson, 2011). Child health settings unfortunately, are not exempt from these challenges. Despite billions spent annually in Canada on high-quality healthcare research (Canadian Institutes of Health Research, 2018) it can take more than a decade to implement research results into clinical practice. This is critical, as patients thereby fail to receive the best treatment and care available (Kristensen, Nymann, & Konradsen, 2016). It is estimated that up to 50% of care provided is not needed, or not based on current best evidence (Albrecht, Archibald, Snelgrove-Clarke, & Scott, 2016; Grimshaw, Eccles, Lavis, Hill, & Squires, 2012; Hunt et al., 2016; McCabe & Kuppermann, 2015; Straus, Tetroe, & Graham, 2011).

In an attempt to confront this issue, knowledge translation (KT) strategies have been developed, tested and implemented. KT efforts, can be effective in promoting health care professionals' use of clinical research evidence to enhance clinical practice and improve patient outcomes (Scott et al., 2018). Reasons for clinical practice variations are diverse and complex and therefore KT efforts to improve research uptake must be multi-dimensional and collaborative in nature (Kennedy, Leathley, & Hughes, 2010). Former systematic reviews have examined KT strategies based on professional group, clinical practice area (Lougheed & Olajos-Clow, 2010) or clinical condition (Gagnon, Hadjistavropoulos, Hampton, & Stinson, 2016) (Kovesi, Giles, & Pasterkamp, 2012), however this approach is incongruent with the multidisciplinary and diverse nature of healthcare. As child health settings are multidisciplinary in nature, encompassing a wide-range of healthcare professions, it is imperative to explore KT strategies from multiple disciplines. While there is a rapidly growing body of evidence to inform pediatric clinical practice, a disconnect between research and its implementation to practice in child health prevails. This

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disconnect demonstrates a need for KT strategies specifically tailored for pediatrics.

Additionally, in order to facilitate an efficient move of research into practice, it is essential that child health researchers have an evidence-based toolkit of potential, effective KT strategies. This can be achieved through the development of a research standard for KT strategies in child health settings.

To date, there is only one systematic review examining KT strategies used by healthcare professionals in child health settings which reflects studies up to and including 2011 (Albrecht et al., 2016). Given the increased emphasis on KT in the last decade, there has been notable growth in the literature and as a result, this review requires an update. Thus, in this paper we update the evidence on KT strategies used by healthcare professionals in child health settings by adding the results of studies published between 2011 and 2018 to the evidence reported in the previous review (Albrecht et al., 2016).

Methods

Literature search

In consultation with the team content experts and by analyzing the terms used in the studies included in the original review (Albrecht et al., 2016), a health sciences librarian developed a comprehensive search strategy that modified the strategy developed for that review and executed the strategy in the following databases: Ovid MEDLINE, PubMed, Cochrane Library, Ovid EMBASE, CINAHL Plus with Full-text, Ovid PsycInfo and ProQuest Sociological Abstracts. Results were limited to studies published in English from 2011 to 2018. Reference lists of relevant articles were also examined. Results were uploaded into EndNote (v. X5, Clarivate Analytics, Philadephia, PA) and duplicates were removed. See Appendix A for MEDLINE strategy.

Inclusion criteria

Studies were included if they met the following pre-determined inclusion criteria:

1) Primary research study employing either RCT, CCT, or CBA study design;
2) Target population was healthcare professionals (i.e., physicians, nurses, allied health professionals) working in child health settings;
3) Interventions had a primary purpose of implementing research into pediatric practice; and
4) Outcomes measured the change at the professional/process, patient or economic level.

Study selection

Using a standardized screening form, reviewers followed a two-stage process to select articles for inclusion. First, one reviewer screened the title and abstracts of the search results to determine whether the study met the inclusion criteria. Each article was rated as include, exclude, or unclear. The full texts of all articles classified as include or unclear were then retrieved for review. Two reviewers then independently assessed the full reports of each potentially relevant study. The reviewers resolved disagreements about which records should be included by discussion, or by consulting a third reviewer.

Data extraction

Using a research design algorithm (Hartling, Bond, Santaguida, Viswanathan, & Dryden, 2011) and the Cochrane Effective Practice and Organisation of Care Review Group (2015) two reviewers independently extracted data from the included studies. Key data extracted were study design, subjects, setting, interventions and outcomes (Appendix B). Discrepancies were resolved by discussion and third party consultation if required.

Three broad categories were used to classify primary outcomes; professional/process, patient and economic. Consistent with the original review, it was common for studies in the update to identify a primary outcome, measured in multiple ways [e.g. (Bogetz et al., 2015)]. This practice often led to inconsistent (mixed) results on the primary outcome(s). To address this, we followed the steps employed in the original review and looked for consistency only within the results and methods sections of the studies included in the update. Studies showing all positive, or all negative effects for the same outcome were classified as having a consistent effect. Studies were classified as having inconsistent (mixed) effects on the primary outcome if they met one of the following three criteria. First, the study demonstrated statistically significant improvement in some of the outcomes identified as primary, but not in others. Second, the number of outcome measures was unclear, or only some of the outcome measures achieved statistically significant changes [e.g. (Lemiengre et al., 2018; Shah et al., 2018)]. Third, all groups, including the control group, showed a change in behavior and therefore the change could not be attributed to the KT intervention. Studies where the results were not clearly linked to an identified outcome(s) were classified as "unclear".

Methodological quality appraisal

Two independent reviewers, using the Quality Assessment Tool for Quantitative Studies (Effective Public Health Practice Project, 2009) appraised the quality of included studies (Appendix C). Each study was assigned a global quality rating of weak, moderate or strong based on eight component rating sections: selection bias, study design, confounders, blinding, data collection methods, withdrawals and dropouts, intervention integrity and analysis. Reviewers resolved disagreements through discussion. As with the original review, studies were not excluded in the update based on methodological quality as we aimed to capture the current state of this science in child health settings.

Data analysis

We synthesized the extracted data using a descriptive analytic approach. Study outcome data were combined and analyzed according to the type of KT strategy(ies) using the EPOC Data Collection Checklist (Cochrane Effective Practice and Organisation of Care Review Group, 2015). The KT strategies were classified using descriptive statistics. Descriptive (narrative) analysis was also used to identify potential patterns in the data in terms of targeted behaviors, study outcomes and intervention effectiveness. Due to the methodological and clinical heterogeneity of the studies, meta-analyses could not be conducted.

Results

Included studies

The electronic database search yielded 62,715 unique records with 20,323 from the update. Of the 20,323 records from the update we assessed the full text of 552 and 27 studies were added to the 21 studies included in the original review. Therefore, a total of 48 studies (21 originals and 27 updated) were included. Fig. 1 (Appendix D) illustrates the selection process of articles for the review update and the original review. Of the overall studies included (update and original) there were 30 RCTs, 7 CBAs and 3 CCTs.

Table 1 (Appendix E) provides a detailed overview of the studies including author, year of publication, country of origin, profession, intervention(s), type of targeted behavior, primary outcome and intervention effect of primary outcome. Studies in Table 1 (Appendix E) are organized by research design, with authors listed in alphabetical order within each research design category.

Methodological quality

The methodological quality for included studies was assessed using the Quality Assessment Tool for Quantitative Studies (Effective Public Health Practice Project, 2009) (Table 2, Appendix F). Studies were classified as strong ($n = 16$), moderate ($n = 18$) and weak ($n = 14$). Sixteen RCT studies were rated as strong, 14 RCT studies, one CCT and three CBA studies were rated as moderate. Eight RCTs, two CCTs and four CBAs were rated as weak.

KT interventions

Thirty-four studies employed single KT interventions, while 11 studies employed multiple KT interventions. The remaining three studies were three-arm trials with one trial comparing two different single KT interventions to a non-intervention control (Clarkson et al., 2008), another trial compared two different single KT interventions to a multiple KT intervention group (Hillman et al., 1999) and the other trial compared a single KT intervention to two different multiple KT intervention groups (Lemiengre et al., 2018). The majority of interventions included an educational component ($n = 32$) (e.g. educational material, educational outreach, educational meeting). Other interventions included personal audit and feedback ($n = 4$), reminders (n = 4), computerized decision support ($n = 5$), multi-disciplinary teams (n = 4), financial ($n = 2$) and patient mediated ($n = 1$).

Primary outcomes

Of the 48 included studies, the most common primary outcomes were healthcare professional/process outcomes (n = 32). Seven studies reported patient outcomes as the primary outcome and one study reported economic. Four studies reported healthcare professional/process and patient outcomes both as primary outcomes, one study reported healthcare professional/process, patient and economic outcomes as primary outcomes and three study's primary outcomes were unclear.

Effect of intervention (s)

Table 3 (Appendix G) shows less than half of the included studies demonstrated a consistent effect (positive or negative) on the primary outcome(s) ($n = 21$). The remaining 27 studies reported inconsistent (mixed) or unclear effects on the primary outcome. Nine studies demonstrating a consistent, positive effect used a single measure to determine the effect of one primary outcome and five used multiple measures to determine the effect of one primary outcome. The majority of studies demonstrating inconsistent (mixed) effects used multiple measures to determine the effect of one primary outcome ($n = 17$).

Overall studies demonstrating consistent, positive effects

Nine RCTs (Bernstein et al., 2013; Carroll et al., 2012; Christakis et al., 2001; Davis et al., 2007; Gordon, Chandratilake, & Baker, 2011; Keitel et al., 2017; Real et al., 2017; Tebb, Shafer, Neuhaus, & Wibbelsman, 2009; Zurovac et al., 2011), three CBA (Horky, Andreola, Black, & Lossius, 2017; Naimoli, Rowe, Lyaghfouri, Larbi, & Lamrani, 2006; Smabrekke et al., 2002) and two CCTs (Clarkson et al., 2008; Shafer et al., 2002) reported consistent, statistically significant effects. All nine RCTs, one CCT (Shafer et al., 2002) and one CBA (Horky et al., 2017) employed a single KT intervention. One CCT (Clarkson et al., 2008) was a three-arm trial comparing two different single KT interventions to a non-intervention control. Two CBA studies (Naimoli et al., 2006; Smabrekke et al., 2002) employed multiple KT interventions. Six of these studies showing statistically significant positive effects were educational interventions (Bernstein et al., 2013; Gordon et al., 2011; Horky et al., 2017; Naimoli et al., 2006; Real et al., 2017; Smabrekke et al., 2002), two were computerized decision supports (Carroll et al., 2012; Keitel et al., 2017), three used reminders (Christakis et al., 2001; Davis et al., 2007; Zurovac et al., 2011), two used multi-disciplinary teams (Shafer et al., 2002; Tebb et al., 2009) and one used both financial and education interventions (Clarkson et al., 2008). Eleven studies assessed healthcare professional/process outcomes (Bernstein et al., 2013; Christakis et al., 2001; Clarkson et al., 2008; Davis et al., 2007; Gordon et al., 2011; Horky et al., 2017; Naimoli et al., 2006; Real et al., 2017; Shafer et al., 2002; Smabrekke et al., 2002; Tebb et al., 2009) and three studies assessed patient outcomes as primary outcomes (Carroll et al., 2012; Keitel et al., 2017; Zurovac et al., 2011).

Updated studies demonstrating consistent, positive effects

The following sections describe a detailed overview of the studies from the update demonstrating consistent positive effects (Bernstein et al., 2013; Carroll et al., 2012; Gordon et al., 2011; Horky et al., 2017; Keitel et al., 2017; Real et al., 2017; Zurovac et al., 2011). A detailed description of the studies demonstrating consistent positive effects from the original review are published elsewhere (Albrecht et al., 2016).

RCTs demonstrating consistent, positive effects

Carroll et al. (2012) used a parent-mediated survey linked to physician prompts using a computerized clinical decision support system to increase physician recognition and diagnosis of asthma among children. Intervention success was measured using a patient outcome of improved asthma detection rates measured by a diagnostic code for asthma recorded on the patient's chart. Statistically significant increases in the rates of asthma diagnoses were found in the intervention group who received the physician prompts.

A virtual reality curriculum consisting of simulated scenarios, in which a caregiver was hesitant to accept an influenza vaccine for their child was used by Real et al. (2017). The intervention aimed to improve residents' vaccine education and communication skills to parents. Intervention success was measured as a decreased rate of parents refusing influenza vaccine (healthcare professional/process outcome). Residents who underwent the virtual reality curriculum had significantly decreased rates of vaccine refusal.

Zurovac et al. (2011) used text-message reminders about pediatric malaria case management sent to health workers' mobile phones. Intervention success was measured as the percentage of children who were correctly managed for malaria (patient outcome) based on 8 predetermined medication dispensing and counselling tasks. Results showed a significantly higher percentage of children correctly managed for malaria by health workers who received the text-message reminders compared to those who did not.

An e-learning education course on pediatric prescribing practices was implemented by Gordon et al. (2011). The e-learning course included self-assessment exercises, video files and animations. Success of the intervention was measured using a healthcare professional/process outcome; specifically, the total correct responses on three prescribing assessments. Prescribing scores significantly increased in the intervention group at both four and six weeks after the intervention.

Bernstein et al. (2013) implemented an online health promotion curriculum aimed at improving pediatric residents' confidence, knowledge and clinical performance in oral health practices. Intervention success was measured by the improvement in resident confidence, knowledge and skills in pediatric oral health practices (professional/process outcome). The online curriculum significantly increased resident scores in all three domains.

Keitel et al. (2017) used a novel smart-phone based algorithm that uses tests performed at the patient care site (point-of care tests), to treat children with fever. Intervention success was measured using a patient outcome; specifically defined as risk for clinical failure by day 7 post intervention based on pre-determined criteria. There was a

statistically significant reduction in children with clinical failure by day 7 post intervention when following the novel smart-phone based algorithm.

CBA demonstrating consistent, positive effect

An e-learning education course was developed and implemented by Horky et al. (2017) for pediatric cultural competency. The e-learning course consisted of six online modules designed to change resident's knowledge, attitudes and skills in cultural competence. Intervention success was measured as improved self-reported assessments in all three domains (healthcare professional/process outcome).

Discussion

This systematic review update assessed the evidence on KT strategies aimed at integrating research into healthcare professionals' practice in child health settings. By extending the search of the previous review, 27 additional studies were identified for inclusion in this update. This significantly increases the evidence available for review specifically examining KT strategy uptake by health care professionals in child health settings. We have organized our discussion by first speaking to effective KT interventions, followed by notable changes in the review update.

Effective KT interventions

Twenty-one studies showed consistent effects on outcome measures, 14 of which displayed statistically significant, positive effects. Interestingly, these studies were all single KT interventions. A commonly held view is that multi component KT interventions are more effective than single component interventions (Institute of Medicine, 2011). This view is compelling, as multi-component interventions should (in theory) address multiple barriers to behavior change, thus being more effective than single component interventions, addressing only one barrier to behavior change (Squires, Sullivan, Eccles, Worswick, & Grimshaw, 2014). However, despite this widely held belief, findings of our review in conjunction with other knowledge syntheses examining multi versus single component KT interventions indicate that single KT interventions may be as effective or more effective than multicomponent interventions (Squires et al., 2014) (Grimshaw et al., 2008). This is important to consider in the design and implementation of KT interventions for healthcare providers, especially in examining cost-effectiveness and intervention complexity.

Two studies showing statistically significant positive effects utilized computerized decision support (CDS) in the form of treatment algorithms or decision aids, specifically related to the diagnosis of asthma and treatment of fever (Carroll et al., 2012; Keitel et al., 2017). Rates of health information technology (IT) adoption in both inpatient and outpatient settings are increasing, with CDS being the most commonly implemented health IT intervention. This is likely due to its inherent nature as a software-based intervention that can be turned on and off, making it well suited for RCTs or CBA studies. Both studies in our review employing CDS were RCTs (Brenner et al., 2016).

Interestingly, previous systematic reviews have noted that while CDS evaluations have shown to be effective in changing healthcare provider behavior, few have found benefits on patient outcomes (Jaspers, Smeulers, Vermeulen, & Peute, 2011). However, both studies in this review demonstrated statistically significant positive outcomes after implementation of a CDS measured patient outcomes, specifically rates of newly diagnosed asthma and being cured of fever. The positive effect shown in these studies may be attributed to larger sample sizes, giving the study more statistical power, in comparison to previous studies demonstrating little or no effect on patient outcomes. Additionally, this finding may be attributed to the need for patient outcomes to be measured in order to justify the full effect and potential of CDS. However, despite two studies in our review showing benefits to patient outcomes, it should still be cautioned to draw definitive conclusions on their effectiveness in this capacity because of heterogeneity in systems, settings, and outcomes assessed (Souza et al., 2011). Furthermore, lack of patient-important outcomes reported in previous studies may be a result of insufficient reporting of these outcomes. In comparison to the original review, studies in our review generally have proven better adherence to reporting standards and guidelines. The nature of the CDS itself (i.e. technological features, ease of use, user training) may affect clinician adherence to the CDS, thus having an effect on desired outcome measures.

One study (Real et al., 2017) used virtual reality (VR) simulation scenarios as a KT intervention. This finding aligns with recent studies that have used virtual reality simulation as a practical technique to improve skills training of various health care professionals (Gunn, Jones, Bridge, Rowntree, & Nissen, 2018; Isaranuwatchai, Brydges, Carnahan, Backstein, & Dubrowski, 2014; Jiang, Ju, Zhao, Feng, & Yao, 2018; Levac et al., 2016). Rather than assuming that trainees will receive sufficient exposure to an appropriate range of situations throughout their training, virtual reality simulation can standardize their exposure to routine, frequently occurring situations, reinforcing critical skills, making VR a promising KT intervention (Fritz, Gray, & Flanagan, 2008).

The majority of studies in this review applied an educational component as an intervention ($n = 33$). Twenty-five passive educational interventions or materials (PEMS), such as printed educational materials or educational meetings were utilized. Evidence does support the use of PEMs as a common method of disseminating information to healthcare professionals as they can be distributed to large numbers and are relatively inexpensive (Johnson & May, 2015). A recent Cochrane Review (Giguere et al., 2012) examining the effects of PEMS in healthcare found that PEMS show modest, but potentially important improvements in professional practice. However, more active approaches to educational interventions such as materials or websites for active self-study, may be more effective in changing professional behaviors (Wensing, Bosch, & Grol, 2010). Thirteen educational interventions in this review were considered to be active approaches, with 12 interventions having an online or technology component. As more evidence and new technologies are developed within healthcare allowing for greater dissemination of information to broader populations, it is not surprising that educational interventions are beginning to adopt a more active approach.

In this cohort of studies with consistent, statistically significant effects, three studies used reminders or “prompts”. This finding reflects current evidence that reminders are effective in changing health professional behaviors (Cheung et al., 2012; Wensing et al., 2010).

Notable changes in review update

While some findings were consistent with the original review (i.e. majority of interventions being educational), others were not. For example, no studies in this review employed multidisciplinary teams as a KT intervention. Despite governments around the world investing significant resources to improve collaboration among health care professionals, results of this review show they continue to be underutilized. This may be attributed to insufficient evidence on how to develop multidisciplinary interventions and to what extent these interventions are effective (Reeves, Pelone, Harrison, Goldman, & Zwarenstein, 2017). Common barriers to inter-professional collaboration such as professional hierarchies, personal values and expectations and care complexity may also hinder the creation and implementation of multidisciplinary team based interventions (Supper et al., 2014). Furthermore, although there appears to be an increase in the number of studies examining the effects of multidisciplinary interventions, this number remains small. While these studies offer preliminary findings on the effectiveness of multidisciplinary interventions to improve healthcare processes and outcomes, the small number and methodological limitations preclude definitive conclusions (Reeves et al., 2017).

More than half of the studies from the review update reported inconsistent (mixed) results ($n = 16$). This phenomenon has been previously noted in other multidisciplinary reviews in the health sciences (Scott et al., 2012) and is consistent with the findings of the original review (Albrecht et al., 2016). However, in contrast to the original review, only one study included from the update reported unclear or unreported results (Lemiengre et al., 2018) compared to three in the original review, and seven studies from the update showed statistically significant positive results compared to only five in the original review. This is promising as more studies may be following standardized reporting guidelines, making results more credible and replicable.

The now larger body of evidence provided by this review update suggests some promising trends for pediatric research. For example, the majority of studies from the update were rated as having strong methodological quality ($n = 14$) versus $n = 2$ in the original review. Interestingly, the majority of studies from the update rated as strong were published within the last three years. There is a growing body of literature documenting the methodological limitations of published RCTs in pediatrics. There is particular concern that RCTs in child health are susceptible to a high risk of bias increasing the likelihood that reported treatment benefits and/or harms are being exaggerated (Hamm, Scott, Klassen, Moher, & Hartling, 2012). However, a review by Thomson et al. (2010) examining the methodological quality of 578 pediatric RCTs and CCTs from 1946 to 2006 noted significant increases in the quality of these trials overtime, specifically in relation to methodological quality and reporting. Also noted in Thomson et al.'s (2010) review, was an increase in the number of RCTs and CCTs conducted, with more multi-center testing. Similarly, the majority of studies from the update were RCTs of strong methodological quality and minimal reporting biases. Additionally, $n = 8$ were multi-center trials.

An update of Thomson et al.'s (2010) review (Gates et al., 2018) showed that from 2007 to 2012, there was a significant increase in the number of RCTs specifying the primary outcomes of their studies. However, there continued to be poor reporting standards in relation to random sequence generation and allocations (Gates et al., 2018). In our update, there were no studies in which the primary outcome was unclear and in contrast to Gates et al. (2018) randomization procedures were typically noted.

With the majority of the studies from the update being RCTs, of high methodological quality, results can be interpreted as more valid and clinically relevant. An increase in the validity of pediatric research reduces the amount of research waste and will potentially improve overall pediatric care.

Potential reasons for the increasing improvement in the quality and quantity of RCTs in pediatric research may be due to an increasing recognition of the need for high quality research in this population (Hamm et al., 2012). Additionally, an increase in the number of international pediatric trial networks, including the Standards for Research in Child Health may also contribute to this improvement (Caldwell et al., 2012; Ellenberg et al., 2012; Hartling et al., 2012; Sinha et al., 2012; Van Der Tweel et al., 2012; Van't Hoff & Offringa, 2015; Williams et al., 2012).

Future research

As with the original review, numerous conventional KT interventions (i.e. local opinion leaders, marketing and mass media, provider incentives) continue to be absent in this review update. Further exploration into the implementation and effectiveness of these types of interventions may be warranted as emerging KT interventions. It is evident that similar approaches to KT have continued to be used over the past decade with minimal benefits shown (e.g. educational interventions). The underutilization of certain KT interventions (e.g. multidisciplinary teams) demonstrates that future research is needed to develop, implement and evaluate underutilized strategies. While 'evidence-based medicine should be complemented by evidence-based implementation,' it is clear that the most effective implementation strategies are not always utilized (Grimshaw et al., 2012). The use of specific strategies to implement research based recommendations is necessary to ensure that practices change, and more intensive efforts to alter practice may prove to show more success.

Overall, this research has the potential to make meaningful contributions to KT science by informing KT recommendations in other specialty areas or settings. This review also serves as an information source to support the development of an international research standard for effective KT strategies in child health, especially given the high methodological quality of the studies. Additionally, there are currently no KT research standards for child health research that will help pediatric researchers implement their findings. Therefore, this review update will also assist in the development of an international research standard for KT.

Strengths and limitations

We followed a rigorous methodology for this review. In accordance with the original review, this review was limited to three robust study designs (RCT, CCT, CBA).

Conclusions

There continues to be an urgent need to provide recommendations to pediatric healthcare professionals and decision-makers responsible for increasing the utilization of research in child health care settings. This review update serves as an up-to-date 'state of the science' on KT strategies used in pediatric health professionals' clinical practice. Based upon the results of this review update, we can recommend that single component KT interventions may be as or more effective than multi-component interventions, a point which should be considered in the design and implementation of KT interventions for healthcare providers. Furthermore, we can conclude that while CDS are beginning to show benefit on patient outcomes, caution should be taken in regards to the study design, sample and reporting of these interventions. Lastly, educational interventions continue to be the most commonly used KT intervention for changing provider behavior with significantly positive results. However, we would recommend tailoring educational interventions to being more active, by incorporating new technology and more user guided actions, as they may be more effective in soliciting behavior changes.

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Shannon D Scott: Conceptualization, Supervision. Alyson Campbell: Investigation, Formal Analysis, Data curation, Writing-Original Draft Preparation. Samantha Louie-Poon: Formal Analysis. Linda Slater: Investigation. All Authors: Validation, Writing-Review and Editing.

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Conflicts of interest

None.

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