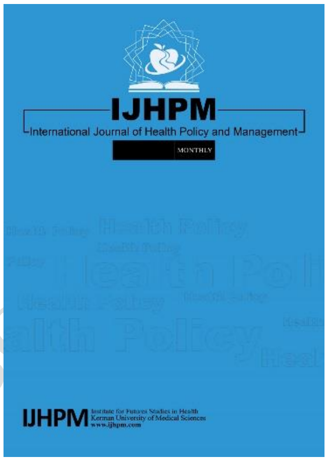

An Exploration of the Utility and Impacts of Implementation Science Strategies by Cancer Registries for Healthcare Improvement: A Systematic Review

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An Exploration of the Utility and Impacts of Implementation Science Strategies by Cancer Registries for Healthcare Improvement: A Systematic Review

Rob G. Stirling*[1,2], Angela Melder[3], Emily Eyles[4], Mark Reich[4], Paul Dawkins[5]

1. Department of Respiratory Medicine, Alfred Health, Melbourne, VIC, Australia.
2. Central Clinical School, Faculty of Medicine, Nursing and Health Sciences, Monash University, Melbourne, VIC, Australia.
3. Health and Social Care Unit, School of Public Health and Preventative Medicine, Monash University, Melbourne, VIC, Australia.
4. School of Public Health and Preventative Medicine, Monash University, Melbourne, VIC, Australia.
5. Department of Respiratory Medicine, Middlemore Hospital, Auckland, New Zealand.

Correspondence to: Rob G. Stirling; r.stirling@alfred.org.au

Abstract

Background: Cancer data registries are central elements of cancer control programs providing critical insights in measures of performance in cancer healthcare delivery. Evidence to practice gaps in cancer care remain substantial. Implementation science (IS) strategies target gaps between generated research evidence and guideline concordance in delivered healthcare. We performed a systematic review of the utilisation and effectiveness of IS strategies reported by cancer registries.

Methods: A research protocol and literature search were performed seeking studies incorporating implementation strategies utilised by cancer registries for quality improvement. Searches were undertaken in MEDLINE, Embase, CENTRAL and the grey literature for randomised trials and observational studies. The "Knowledge to Action framework" was used to explore implementation gaps in care delivery.

Results: Screening identified 1,496 studies, 37 studies identified by title and abstract review, and 9 included for full text review. Studies originated from the UK, USA, the Netherlands, and Australia reporting on lung, breast, colo-rectal and cancer clusters. Registry jurisdictions included 7 national, 4 state, and 4 local registries. Knowledge gap analysis consistently identified monitoring and evaluation of data outcomes in accord with registry primary purpose although limited exploration of the utilisation, translation and re-application of this data. Studies lacked description of strategies describing sustainability of generated knowledge, identification of barriers, knowledge adaptation to local contexts, and the selection, adaptation and implementation of interventions for improvement.

Conclusion: Available studies provide limited literature evidence of the effective utilisation of IS strategies reported by cancer registries for health-care improvement. A substantial opportunity presents to study the engagement of IS in cancer registry data use to close the evidence practice gap and facilitate data driven improvement in cancer healthcare.

Keywords: Cancer Registry; Implementation Science; Knowledge Translation

Introduction

The development of cancer registries has been described as essential for national cancer control programs targeting reduction in cancer incidence and mortality and improvement in quality of life for cancer patients [1-4]. Early cancer registries described burdens of cancer prevalence, incidence and survival [5]. Over time, these roles have expanded to include epidemiologic research, risk factor identification, investigation of cancer clusters, monitoring of impacts of healthcare interventions including screening and primary prevention, measurement of disparities in healthcare equity, policy development, resource planning, and as a tool for quality improvement [6, 7].

The cancer healthcare system has been described as, 'a system in crisis where care is not patient-centred, and decisions about care often are not based on the latest scientific evidence' [8]. Delays of decades have been demonstrated between generation of practice-changing research evidence to effective clinical evidence implementation, described as an 'evidence-practice gap' [9, 10]. The learning health system (LHS) strategy was developed to overcome this gap by addressing two key issues [11]. First, the integration of local, rapidly generated, clinical performance knowledge, with comprehensive research knowledge, gained from systematic literature review **Figure 1**. Second, making this combined evidence available to efficiently and effectively inform practice improvement [10, 12, 13]. This knowledge may then inform and drive iterative innovation and practice change to enhance system knowledge and performance.

Cancer Registries and Clinical Quality Registries (CQRs) provide the necessary framework to enable the integration of local, population-specific performance data in cancer management with the external research evidence that informs and updates registry purpose and design. Closing the LHS loop however demands data integration that facilitates the use of curated data to be represented, disseminated, and applied in innovation and implementation for healthcare improvement [10].

Implementation science (IS), encompassing dissemination and implementation approaches, provides strategies developed to improve the translation of research knowledge into practice to reduce evidence-practice gaps [14-17]. Little is known however of the extent of use and practical impacts of IS strategies in the translation of cancer registry data to prompt healthcare improvements or measure improved health-care outcomes.

We aimed to answer three questions: 1. What evidence is available to describe the use of IS strategies by cancer registries to improve cancer outcomes? 2. What evidence is available of the effectiveness of such IS strategies in utilising cancer registry data? 3. What are the potential opportunities for IS strategies for cancer registries to drive improvement in healthcare outcomes in cancer?

Methods

We performed a systematic review, undertaken to explore the characteristics and extent that IS strategies were used in reported research, and to explore the mapping, reporting or discussion of these characteristics and concepts in relation to cancer registry activities [18].

Protocol registration: A study protocol was created and registered in the PROSPERO registry of systematic reviews (CRD42021251860).

Knowledge Translation definition

Our definition of knowledge translation was based on the Canadian model [19]: 'a dynamic and iterative process that includes the synthesis, dissemination, exchange and ethically sound application of knowledge to improve health, provide more effective health services and products and strengthen the healthcare system', engaging the 7-step knowledge to action framework [20] **Figure 2**.

Eligibility criteria

Study designs: Retrospective and prospective studies including, randomized-controlled trials, clinical trials, case control, cohort, observational, follow-up, cross-sectional, qualitative research, systematic reviews and study protocols were included. Commentaries, editorials, letters, and news articles were excluded from this review process. A search strategy generated in Medline is included, **Supplementary Table 1**.

Types of participants: The participants included within the scope of this review included any possible knowledge users within cancer research, cancer policy, clinical, quality improvement or consumer communities that may be targets of IS strategies.

Included and excluded interventions: Studies including interventions that targeted improvement in cancer patients' care and outcomes were considered for inclusion. Interventions had to describe an IS intervention and report outcomes using data from a cancer registry. Studies were excluded if they did not identify an IS intervention or outcome.

Information sources

The searches covered these electronic databases: MEDLINE, Embase, Cochrane, CINAHL, PsycInfo, Web of Science, Scopus and ProQuest. The searches of the electronic databases were conducted on 11th April 2021.

Selection of sources of evidence

Title and abstract screening of imported studies were completed by two reviewers. Discrepancies were reviewed and lack of consensus resolved by a third reviewer. Full-text analysis followed to assess approved abstracts and abstracts that required further information to be considered for inclusion.

Evidence of utilisation of implementation science strategies

The knowledge to action (K2A) framework was used as a knowledge translation platform to identify the extent of utilisation of IS strategies and to define evidence gaps [20, 21]. Evidence addressing any of the 7 steps of the knowledge to action framework was sought to inform the evidence gap map **Figure 2**. Two reviewers categorised each study according to included knowledge to action steps. Further, we mapped discrete identified implementation science interventions using the consensus categorisation provided by the Expert Recommendations for Implementing Change (ERIC) project [22] and further mapped independent strategies to implementation concept clusters using the method of Waltz *et al* [23]. These consensus statements enable the definition of complex, diverse, multi-level implementation strategies, effectively improving the specifications and consensus reports of implementation strategies, assisting in the characterisation of discrete strategies published in implementation research.

Results

The search identified 2,126 references, with 1,495 remained after duplicate exclusion **Figure 3**. Inclusion and exclusion criteria resulted in 9 studies available for study inclusion after full text review [24-32], with details of selected studies described in **Table 1**. Reports emanated from the UK, USA, Netherlands and Australia, with 4 studies describing national registries and 5 regional or state-based registries. Four studies described efforts in multiple cancers, 4 lung cancer, and 1 breast cancer.

Summary of IS interventions

Becket *et al* reported outcomes of the UK National Lung Cancer Audit (NLCA) which disseminates registry outcomes through targeted reports to key institutional stakeholders, and through presentation at local, national and international meetings undertaken by the project team [25]. The authors identified the need to establish stakeholder trust within the report content by confirming data completeness and risk adjustment for key measures including deprivation, comorbidity and casemix. The report linked stakeholders to a quality improvement toolkit, providing a targeted checklist of eight key areas from the report for use by multidisciplinary teams [33].

The Improving Lung Cancer Outcomes (ILCOP) study group reported on a randomised controlled trial in which reciprocal peer to peer review (RP2PR) was conducted amongst 30 paired multidisciplinary teams using UK NLCA registry data [27]. Quality improvement facilitators provided a structured quality improvement planning template and education around models for improvement resulting in 67 quality improvement plans being implemented, resulting in a modest increase in active treatment in intervention groups (n=31) of 5.2% compared with 1.2% in control groups (p=0.055). The remainder of study measures improved similarly in intervention and control cohorts. Mean patient experience scores were not significantly impacted although improvement was observed for 5 of the teams with the worst baseline scores (p=0.001).

Aveling *et al* reported an ethnographic study of the RP2PR process from the ILCOP study, describing the improvement programme attempting to identify the implementation elements that appeared to optimise the function of this model [24]. Observation, interviews and documentary analysis was undertaken, and 5 identified core process elements were important in enhancing this model: peers and pairing methods, minimising logistic burden, structure of visits, independent facilitation and credibility of the process. RP2PR impacts were maximised when organised, undertaken in a safe learning environment, where credibility, implementation and impacts were promoted.

Klaiman *et al* evaluated registries to identify the tools and strategies associated with positive deviation in quality improvement, value-based purchasing and stakeholder reporting on quality of care [26]. The project group conducted web search, literature review and direct interviews with experts from the Louisiana, New York State and Texas Cancer Registries. Structural and functional diversity between registries made the identification of registry characteristics likely to deliver positive impacts difficult to identify. Six key themes of registry function however were identified in effective registries including data standardisation, transparency, accuracy and completeness of data, provider participation, financial sustainability, and feedback to providers.

McAlearney *et al* reported on tumour registry capture of breast cancer adjuvant therapies [28]. The authors identified barriers including lack of understanding of current research by clinicians and hospital managers, clinician time limitations, concurrent priorities within healthcare organisations, unsupportive information technology, incentive misalignment, and organisational / cultural factors. Four internal threats to implementation were identified including: loss of the innovation champion; a lack of shared commitment to implementation between different stakeholder groups: inconsistent management support of the implementation; and resource insecurity related to the concurrent implementation of an electronic medical record.

Smittenaar *et al* described the use of National Cancer Registration and Analysis Service (NCRAS) at Public Health England to provide real world validation of randomised controlled trial (RCT) results, adverse event reporting and to describe treatment adherence and variation in the context of breast cancer [29]. Participating centres were encouraged to engage quality improvement in exploration of variation in early (30-day) mortality and to identify improvement opportunities, by providing workbooks supporting mortality and morbidity meetings and providing early warnings regarding differing toxicities between RCTs and real world care.

Tucker *et al* addressed the problem of high colorectal cancer prevalence and low screening rates within the Kentucky Cancer Registry [30]. Public health advocacy was initiated resulting in mandated health insurance company coverage to ensure screening colonoscopy was remunerated for age-eligible individuals. Health navigators provided targeted education to the public, identified and managed cultural barriers to screening and provided logistic support to facilitate appointment scheduling, while focused education programs targeted primary care physicians to promote widespread screening uptake. Screening rates following this intervention rose from 34.7% in 1999 to 63.7% in 2008.

Van der Hout *et al* reporting on the Dutch PROFILES registry, aimed to provide a fully web-based behavioural intervention technology (Oncokompas) for use independently by cancer survivors. The tool incorporated measure, learn and act components supporting knowledge, skills and confidence in self-management aimed at improving symptoms and health related quality of life (HRQOL) by responding to symptom burden with a series of supportive care options [31]. The study included a randomised controlled design including multiple cancer types with the primary outcome of Patient Activation Measure. Trial enrolment included 21%

of available cancer survivors, with 52% using Oncokompas as proposed. Although the primary outcome of patient activation was not met, most tumour groups had significant and meaningful improvements in HRQOL and tumour specific symptoms.

Largey *et al* reported a quality improvement collaborative [32], engaging patient advocates, clinicians, hospital administration and governance, redesign experts and researchers to drive site specific innovation development and solution sharing, targeting national Optimal Care Pathway objectives for lung cancer[34] across 5 hospitals, sourcing Victorian Lung Cancer Registry data[35]. Marked improvements in timeliness of referral to first specialist appointment (median (IQR) from 6 (0-15) to 4 (1-10) days), proportion seen in specialist care within 14 days (74.3% to 84.2%) and proportion reviewed in a multidisciplinary meeting (61% to 67%) were observed.

Mapping utilised Implementation Science strategies.

Based on the K2A framework, we identified that studies routinely engaged monitoring and evaluation of data outcomes consistent with primary function of the registry and provided guidance in problem identification consistent with the project objectives. There was however minimal discussion of approaches to assessment of barriers to knowledge use, selecting, tailoring and implementation of interventions to address barriers and scant description of strategies to sustain knowledge translation behavioural changes **Table 2**.

We identified utilisation of 43 of 73 implementation strategies defined and summarised from the ERIC study [22] **Table 3**. Broadly utilised strategies included audit and feedback, development and delivery of education materials, project facilitation and convening expert advisory groups. Infrequently used strategies included engagement of governance, opinion of patients and families, ongoing consultation, enhancement of quality monitoring systems, relay of clinical data to providers, creation of financial incentives to enhance participation and the use of mandate for change.

Reported studies frequently utilised implementation strategies from categories including use evaluative and iterative strategies, training and education of stakeholders, adapting and tailoring to context and developing stakeholder interrelationships **Supplementary Table 2**. Infrequently utilised implementation categories included utilisation of financial strategies and change to infrastructure.

Discussion

Utilisation of IS strategies: We found only limited evidence of systematic utilisation of IS strategies by cancer registries in order to improve healthcare decision making for quality improvement. Studies included national and state-based registries describing lung, breast, colorectal and multiple cancers. When we mapped IS strategies from included studies to the K2A framework it revealed that monitoring and evaluation of data outcomes was common, however there was minimal description of strategies for sustaining behavioural interventions, adaptation of knowledge interventions, assessment of barriers to implementation, and selection of effective interventions for implementation.

The most commonly used implementation concept clusters included the use of evaluative and iterative strategies for data evaluation in 8 of 9 reports (8/9), development of stakeholder interrelationships (6/9), training and education of stakeholders (6/9) and adapt and tailoring to context (5/9). Infrastructural change (0/9) and the utilisation of financial strategies (1/9) were rarely used concept clusters.

In a broad review of registry capability including cancer, orthopaedic, obstetric and cardiovascular registries, Klaiman *et al* drew the disconcerting conclusion that state cancer registries, 'exhibited the fewest innovations to enhance QI applications' [26], potentially inviting cancer registries to more actively engage reported data to monitor knowledge use; evaluate outcomes of knowledge use and to identify problems and opportunities to review and select knowledge for quality improvement.

Effectiveness of IS strategies: Two studies reported clinical communities as quality improvement collaboratives [27, 32]. Van der Hout reported overall improvement in HRQOL, with no impact on the primary outcome of patient activation, while there was some minor improvement in the overall measures (28). Largey reported non-significant increases in receipt of active treatment +5.2% (p=0.055) and multidisciplinary meeting presentation, +6% (p=0.065) but no difference in the overall panel of measures [32]. No data was available to confirm sustained improvement beyond the trial periods.

The learning health system: Abernethy *et al* describe a rapid learning healthcare model using clinically developed healthcare data in which the health care system adapts by: (1) routinely and iteratively collecting data in a planned and strategic manner; (2) analysing captured data; (3) generating evidence through observational analysis of existing and prospective study data; (4) implementing new insights into subsequent clinical care; (5)

evaluating outcomes of changes in clinical practice; and (6) generating new hypotheses for investigation [36]. Key to the effectiveness of such a system is linkage and integration of disparate clinical cancer healthcare performance evidence held within repositories including electronic medical records, clinical quality registries, state and national cancer surveillance registries, insurance and funding bodies, civic and administrative datasets. Systematic review of effectiveness of disease registries in learning health systems suggests broad patient benefits including better symptom detection, shorter cancer treatment waiting times, and better evidence-based care delivery [11]. Benefits to clinician-patient encounters include enhanced symptom reporting, health status and HRQOL [37], while benefits to health system performance have included identification and management of process barriers and resistance to change, and alignment of system priorities for enhanced best practice care delivery [38].

Sustainability of change: Sustainability in healthcare improvement practice relates to the ability to ensure persisting behavioural change within a system. Inducement, incentivisation and data transparency provide motivation to sustainability through bonus programs, preferred provider network status, and reimbursement [30]. Transparent public reporting of provider and hospital level data have been highly effective in driving change in cardiac registry outcomes [38], but as yet has had limited translation to cancer registry activity. Legislatively mandated cancer registry participation is exemplified in Denmark and the UK, both providing substantial outcome improvement [39, 40]. To date, little evidence exists on sustainability of knowledge translation in the absence of clear incentivisation and inducement [41].

Cross-sector partnerships: Lawler *et al* reported on The Northern Ireland Cancer Registry and described the important ability to describe outcomes across the complete patient journey, achieved by linkage of social and health service delivery data [42] and the capture of Patient Reported Outcome Measures (PROMs). This initiative has seen the development of strong cross-sectoral partnerships uniting patients, investigators, health care professionals, hospital networks, bio-industry, and government initiatives. Key linkage partners include the Northern Ireland Biobank, the pharmaceutical industry through the Northern Ireland Cancer Trials Centre, and consumer forums providing strong patient support shaping personal and public engagement in research.

Data linkage: Cancer registries continue to evolve in both function and scope. Functional efficiencies are being gained through the use of more effective data capture using probabilistic record linkage to describe patient pathways better, especially when treatments may be delivered in multiple institutions over protracted periods of time [30]. Natural language processing using open-source information extraction algorithms within electronic medical records have the capacity to increase data linkage, extraction efficiency, case ascertainment and timeliness [43, 44]. Registry scope is increasing with users projecting findings from covered populations to similar neighbouring populations, and projecting predicted findings to future populations. Registries may also link tumour biobank and pathology datasets enabling access to comprehensive molecular profiling, confirmation of real-world effectiveness of clinical trial data and delivery of precision cancer medicine [45-47].

Consumer participation: The engagement of patients as key players in translational research has been embraced by community organisations including the Association of Cancer Online Resources and Patients Like Me (https://www.patientslikeme.com/). By promoting participatory medicine and the dissemination and exchange of information, social and patient networks have the capacity to facilitate patient access to relevant information, promulgate clinical trial outcomes, and facilitate clinical trial recruitment, and use online and personalised feedback to enhance clinical decision making and impact outcomes. The feasibility of incorporation of PROMs in cancer registries has been demonstrated [48], although the full attributable benefits remain to be demonstrated.

Research potential: The enhancement of cancer registries as research infrastructures to drive clinical decision making, quality, value and cost effectiveness of care is likely to be further enhanced by increased capture and linkage of informative data sources. These data may include environmental exposure, infection, lifestyle, diet activity, health behaviours, genomic and molecular Biobanks [45]. Cancer registries are key multifunctional data repositories with roles in cancer quality improvement in supporting performance knowledge utilisation and as a tool for implementation science engagement.

Cost effectiveness: Cost, cost effectiveness, cost constraint and value are key outcome measures in cancer care. The ability to accurately evaluate cost and comparative effectiveness of available treatments is achievable using registry function and of the utmost importance [49, 50]. An analysis of clinical disease quality registries suggested they are a cost-effective means of quality improvement, providing estimated overall return on investment of 1.6 - 5.5 multiples of the initial investment costing [51].

Limitations This systematic review contains a wide range of study designs with limited capacity for description of comparability of study quality and a risk of bias assessment. The lexicon of knowledge translation is rapidly evolving and there is potential selection bias by failing to identify all potential citations relevant to the search. Second, there is a risk of selection and publication bias in the failure of publication of negative studies. Third, the structure and capability of registry datasets to describe clinical performance and drive implementation may be determined by data content and characteristics included within registries and these characteristics are not well described in publications describing registry use. Further, clinical, research and academic teams may focus on knowledge generation rather than the full context of healthcare implementation strategies which may be undertaken by health system administration teams and therefore may not be captured in academic publications. It is further possible that other non-clinical health care policies have been enacted and implemented on the basis of this knowledge, yet not described in these publications, such as, health literacy training and education, legislation, remuneration, insurance and organisational alignment in these jurisdictions. Implementation Science is an emerging field with significant international variation in definition and terminology; we attempted to overcome this by developing the search strategy with a multidisciplinary team of researchers including a librarian with search strategy development expertise.

Conclusions We found limited evidence of utilisation of IS strategies to improve decision making in the context of cancer registries described as ‘essential to the support of national cancer control programs’, designed with the intention to reduce cancer incidence and mortality and improve the quality of life of cancer patients. Cancer registries may however provide the critical necessary infrastructural support to drive quality improvement and establish the basis for cancer learning health systems. The application of effective IS strategies in cancer registry function has the potential to improve cancer healthcare decision making and cancer outcomes.

Figure 1. The Learning Health System provides a cycle for integration of research evidence (Knowledge to Performance) with clinical performance evidence (Performance to Data) to inform practice improvement (Data to Knowledge).

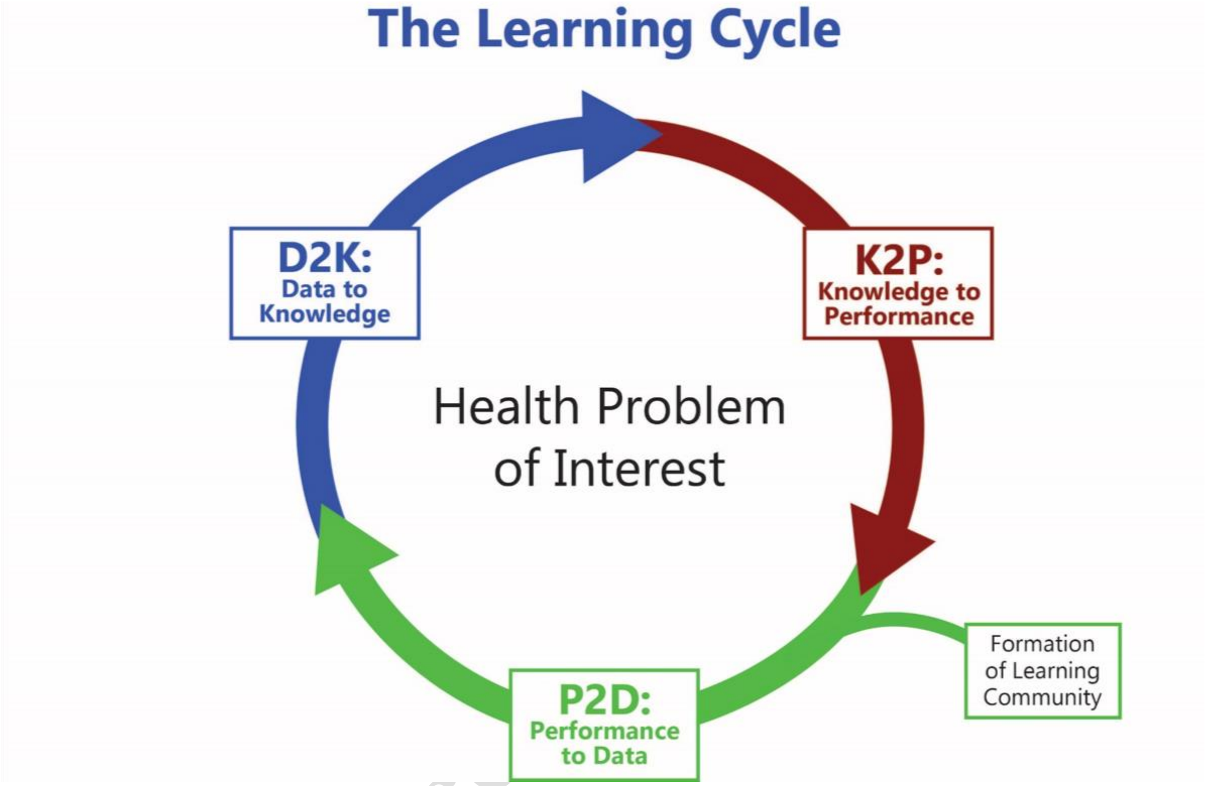

Figure 2. Knowledge translation: 7 step knowledge to action framework [20, 21].

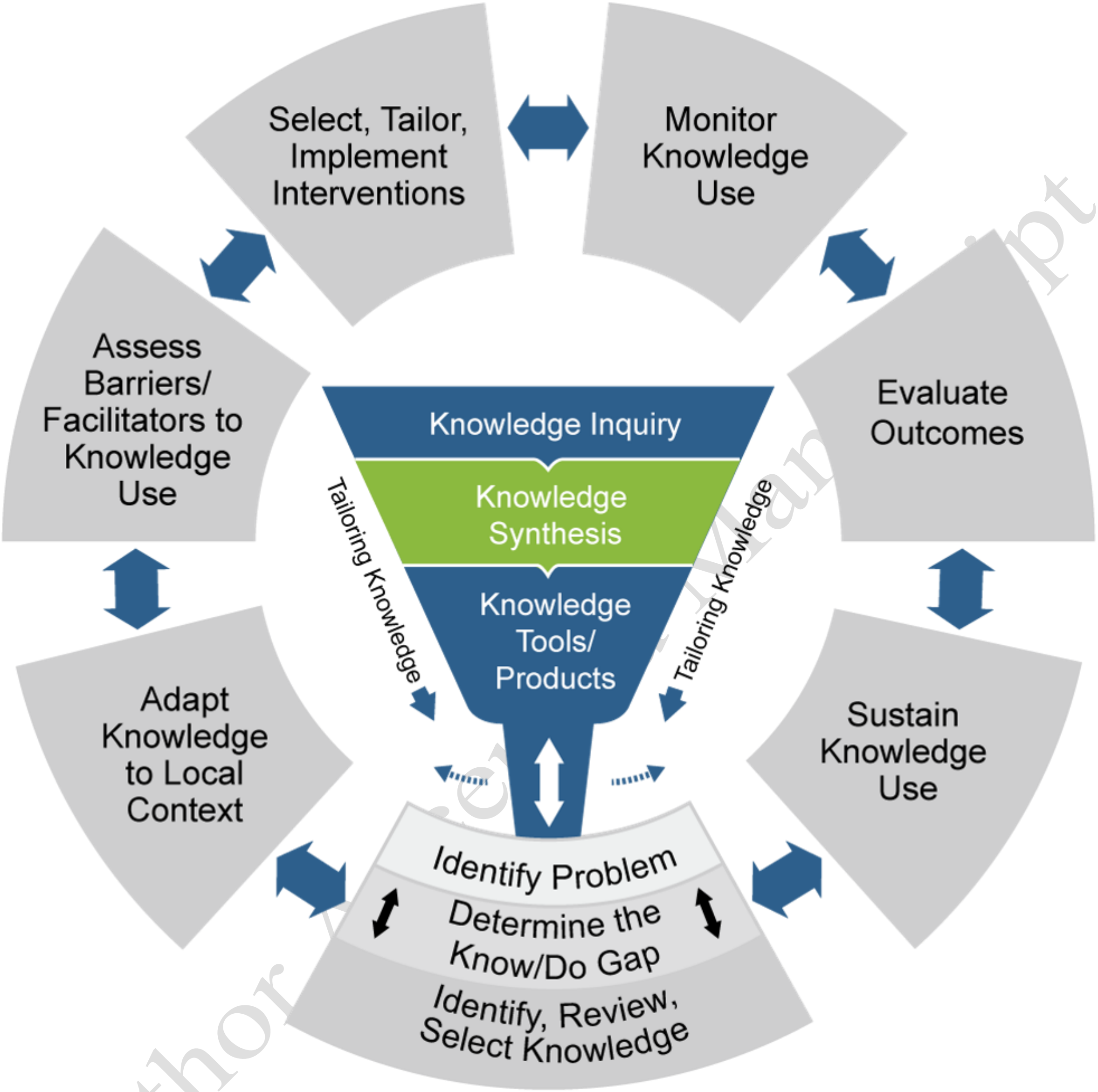

Figure 3. PRISMA diagram study selection.

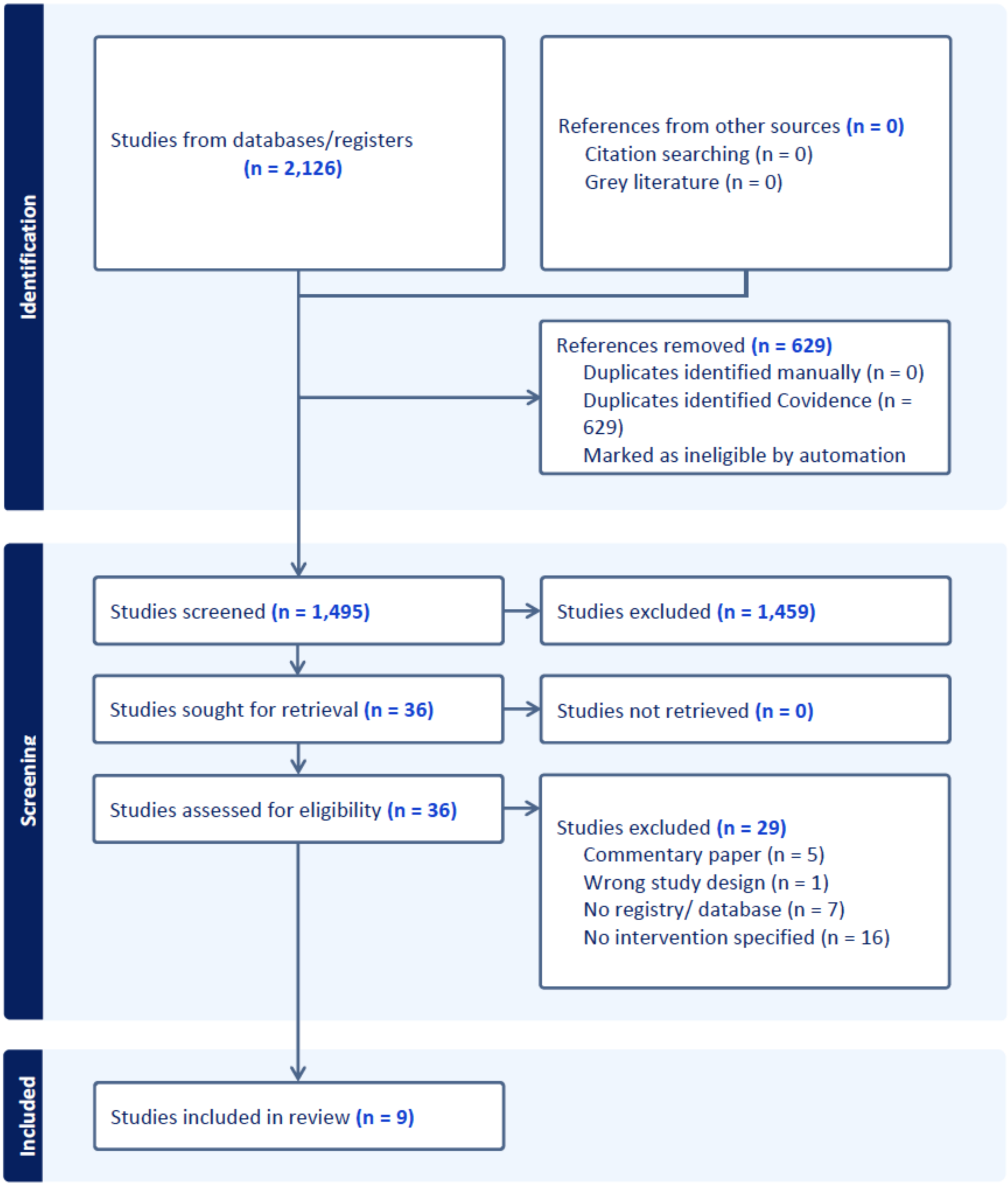

Table 1. Study characteristics

	Country	**Cancer**	**Registry**	**Study design**	**Participants**	**Intervention studied**	**Outcome**	**Impacts**
Aveling 2012	UK	Lung	NLCA LUCADA	Ethnographic mixed methods qualitative study	30 paired hospital multidisciplinary lung cancer teams	Reciprocal peer-to-peer review (RP2PR)	Nonparticipant observation, interviews and documentary analysis.	5 factors were identified as important in optimising RP2PR: peer and pairing methods; minimizing logistic burden; structure of visits; independent facilitation; and process credibility.
Beckett 2012	UK	Lung	NLCA	Observational study of NLCA establishment and progress 2005-2009.	All audit captured lung cancer registration (140,000).	Establishment and conduct of annual audit.	Lung cancer management process and outcome measures.	Histological confirmation rate (64–76%), the proportion of patients discussed in MDM (78–94%), proportion of patients having active anti-cancer treatment (43–59%), surgical resection (9–14%) and SCLC chemotherapy (58–66%).
Klaiman 2014	USA	Cancer	Louisiana, New York State and Texas Cancer	Qualitative inventory of cancer registries using literature review, web	State cancer registry inclusions.	Examination, literature review and expert panel discussion to identify best practices of	Evaluation of registries to define the factors that make them effective.	Effective registries were successful in >1 of 6 key areas: data standardisation, transparency, accuracy / completeness of data, participation by providers, financial sustainability, and/or feedback to providers.

			Registries	search and expert opinion to identify best practices of effective registries (positive deviance).		effective' registries.		
Russell 2014	UK	Lung	NLCA	Prospective randomised controlled trial.	30 paired hospital multidisciplinary lung cancer teams.	Reciprocal peer-to-peer review (RP2PR).	Proportion of patients discussed in a MDM, histological confirmation rate, active treatment rate, surgical resection rate, the proportion of patients with SCLC receiving chemotherapy and the proportion of patients seen by a lung cancer nurse specialist.	Proportion receiving active anti-cancer treatment in the intervention group increased by 5.2% compared with 1.2% in the controls (mean difference 4.1%, 95% CI 0.1 - 8.2%, P.0.055). The remainder of NLCA indicators improved consistently in intervention and control groups.
McAlearney 2016	USA	Breast	AMCR	Qualitative research interview and expert	Hospital- and community-based	Intervention designed to increase registration	Challenges to implementation included lack of understanding of research evidence,	Tumour treatment detail registration increased from 2.6 to 64%.

				panel discussion of barriers and facilitators to implementation of intervention.	oncologists and hospital cancer leaders recruited for participation based on medical center affiliation.	of cancer treatment information.	provider time constraints, competing priorities within health care organizations, unsupportive information technology, misaligned incentives, organizational and cultural factors.	
Smittenaar 2019	England	Breast	NCRAS RTDS SACT HES	Population level observational data / Review.	Breast cancer patients receiving systemic anti-cancer therapy.	Provision of anti cancer treatment outcome data, data helpline access and improvement workbook.	Early mortality for breast cancer patients treated with curative intent was 0.3%. Impacts of workbooks unreported.	Real world evidence of 30-day mortality confirmed as similar to trial evidence.
Tucker 2019	USA	Cancer Colorectal Cancer	SEER Medicare KCR	Review	CRC eligible subjects > 50 years in Kentucky.	Lay health navigators, academic detailing primary care physicians, assistance in	Proportion of age-eligible adults in Kentucky undergoing either lower colonic endoscopy.	Screening uptake rose from 34.7% in 1999 to 63.7% in 2008.

						screening scheduling. Mandated CRC insurance screening coverage for age eligible individuals.		
Van der Hout 2020	Netherlands	Head and neck, Colorectal, Breast, Hodgkin or non-Hodgkin lymphoma	NCR PROFILES	Non-blinded, randomised, controlled trial.	Cancer survivors in 14 hospitals in the Netherlands (n=625).	Oncokompas; web-based eHealth application supporting self-management by monitoring general cancer and cancer-specific symptoms and HR-QOL, providing personalised	Primary outcome was patient activation (knowledge, skills and confidence for self-management).	Patient activation did not differ between intervention control groups over time (6-months follow-up 1.7 (95% CI −0.8 to 4.1; p=0.41). HRQOL score was significantly improved at 6 months p=0.048.

						feedback to reduce symptom burden and improve HR-QOL.		
Largey 2020	Australia	Lung	VLCR CQR	Prospective quality improvement cohort study.	Consecutive patients from 5 participating hospitals (n=205).	Community of practice forums to identify service gaps, variation drivers and barriers to improvement.	Quality improvement process and outcome measures from the VLCR.	There was an increase in proportion of new referrals seen by a specialist within 14 days (74.3% to 84.2%), reduction in variation in timeliness between sites. The proportion of subjects with documented presentation to an MDM (61% to 67%, p>0.05). No observed effects on timeliness from first specialist appointment to first staging test or PET scan. Trend to increase in supportive care screening documentation (22% to 26.3% p=0.06).

SEER Surveillance, Epidemiology, and End Results; LUCADA National Lung Cancer Audit; AMCR Academic Medical Centre Registry; KCR Kentucky Cancer Registry; NCRAS National Cancer Registration and Analysis Service; SACT Systemic AntiCancer Therapy; HES Hospital Episode Statistics; MDM Multidisciplinary Meeting; SCLC Small Cell Lung Cancer; NCR Netherlands Cancer Registry; PROFILES Patient Reported Outcomes Following Initial Treatment and Long term Evaluation of Survivorship; VLCR Victorian Lung Cancer Registry; CQR Clinical Quality Registry, NCRAS National Cancer Registration and Analysis Service; PHE Public Health England; CRC Colorectal Cancer; RTDS National Radiotherapy Dataset.

Table 2. Evidence of utilisation of the knowledge to action framework steps.

Study	**Setting**	**Cancer type**	**Knowledge to action framework steps**						
			Monitor Knowledge Use	Evaluate Outcomes of Knowledge use	Developing mechanisms to Sustain Knowledge Use	Identifying the problem, and identifying, reviewing and selecting knowledge	Adapting knowledge to local context	Assessing barriers & facilitators to knowledge use	Selecting, tailoring and implementing intervention to address barriers to knowledge use
Aveling 2012	National	Lung	-	-	-	+	+	+	+
Beckett 2012	National	Lung	+	+	+	+	-	-	-
Klaiman 2014	Regional / state	All cancer	+	-	+	-	-	-	-
Russell 2014	National	Lung	+	+	-	+	+	+	+

McAlearney 2016	Regional	Breast	+	+	-	+	+	+	+
Smittenaar 2019	National	All cancer	+	+	-	+	+	-	-
Tucker 2019	Regional / state	All cancer / CRC	+	+	+	+	+	+	+
Van der Hout 2020	Regional	Head and neck, colorectal, breast, lymphoma	+	+	-	-	-	-	-
Largey 2020	Regional	Lung	+	+	-	+	+	+	+
Total			8	7	3	7	6	5	5

Table 3. Intervention strategies utilised and ERIC Category correlates.

Study	**Reported study implementation strategies**	**ERIC Discrete Implementation Strategies** [22]	**Implementation concept cluster** [23]
Aveling 2012	Nonparticipant observation. Semi structured interviews. Documentary analysis.	Purposefully re-examine the implementation. Conduct local need assessment. Conduct cyclical small tests of change.	A
Beckett 2012	Multidisciplinary workshops. Collaboration with clinical effectiveness unit. Expert reference group including patient/carer representation. Create clinical dataset. Online data entry portal. Provide telephone helpdesk. Centralised data repository. Central data analysis. Provide casemix adjusted data reports to clinicians.	Audit and provide feedback. Develop and implement tools for quality monitoring. Develop and organize quality monitoring systems. Develop a formal implementation blueprint. Stage implementation scale up. Obtain and use patients/consumers and family feedback. Facilitation. Provide local technical assistance. Use data experts. Use data warehousing techniques. Build a coalition. Use advisory boards and workgroups. Promote network weaving. Work with educational institutions. Facilitate relay of clinical data to providers. Involve patients/consumers and family members.	ACDEFG

Klaiman 2014	Develop expert panel research team to define validated, objective criteria for identifying effective registries in key clinical areas and the factors that make them effective.	Use of advisory boards and workgroups	D
Russell 2014	Introductory educational workshop. Facilitated peer to peer visits. Observation of MDM. Discussion of MDM function. Audit data review. Patient experience questionnaire. Focus of improvement workshop. Facilitated QI template. Follow up email, telephone and visit. Web based collaborative teleconferences. Face to face redesign review workshops.	Audit and provide feedback. Purposefully re-examine the implementation. Develop and implement tools for quality monitoring. Develop and organize quality monitoring systems. Conduct local need assessment. Facilitation. Provide local technical assistance. Organize clinician implementation team meetings. Conduct local consensus discussions. Capture and share local knowledge. Use advisory boards and workgroups. Use an implementation advisor. Visit other sites. Provide ongoing consultation. Make training dynamic. Conduct educational meetings. Conduct educational outreach visits. Create a learning collaborative.	ABDEF

		Facilitate relay of clinical data to providers.	
McAlearney 2016	In person interviews with key informants. Semi structured interview guides. Coding dictionary. Dynamic coding evaluation. Convene expert panel. Soliciting feedback. Regular investigator consensus discussions.	Assess for readiness and identify barriers and facilitators. Purposefully re-examine the implementation. Conduct local need assessment. Conduct cyclical small tests of change. Tailor strategies. Conduct local consensus discussion.	ACD
Smittenaar 2019	Study risk factors early mortality after SACT. Provide early mortality workbook to clinicians. Provide SACT helpdesk.	Audit and provide feedback. Develop and implement tools for quality monitoring. Capture and share local knowledge. Develop educational materials. Facilitate relay of clinical data to providers.	ADEF
Tucker 2019	Advocate for insurance coverage for age eligible colonoscopy for CRC cancer screening. Use lay health navigators to overcome cultural barriers. Persuade primary care providers to recommend screening. Schedule CRC screening appointments.	Conduct local need assessment. Audit and provide feedback. Develop and organize quality monitoring systems. Facilitation. Tailor strategies. Organize clinician implementation team meetings. Conduct educational outreach visits. Intervene with patients/consumers to enhance uptake and adherence.	ABCEGH

	Measuring changes in the CRC incidence rate over time.	Alter incentive/allowance structures.	
Van der Hout 2020	Develop web-based eHealth survivor self-management application. Provide feedback and patient-specific advice on self-management. Data measures linked to tailored feedback. Health care provider invites participants. Central data storage. Longitudinal reassessment.	Audit and provide feed. Develop and implement tools for quality monitoring. Develop and organize quality monitoring systems. Centralize technical assistance. Use data experts. Use data warehousing techniques. Develop educational materials. Distribute educational materials. Remind clinicians. Involve patients/consumers and family members. Intervene with patients/consumers to enhance uptake and adherence.	ABCEFG
Largey 2021	Convene multidisciplinary evaluation and solution committee. Stakeholder workshops. Baseline process evaluation. Variation and barrier analysis. QI toolbox engagement. Service redesign modelling. Root cause analysis. Targets prioritised for improvement. Design solutions generated.	Build a coalition. Conduct educational meetings. Conduct local consensus discussions. Create a learning collaborative. Facilitation. Conduct ongoing training. Conduct educational meetings. Develop educational materials. Capture and share local knowledge. Conduct local consensus discussions. Create a learning collaborative.	ABCDEG

	Community of practice forums. Collaborative learning. QI education and support. Shared problem identification and solution sharing. Web based data capture. Secure central data management. Defined performance indicators.	Build a coalition. Develop educational materials. Distribute educational materials. Identify and prepare champions. Involve executive boards. Involve patients/consumers and family members. Obtain and use patients/consumers and family feedback. Audit and provide feedback. Promote adaptability. Promote network weaving. Use data experts. Use data warehousing techniques.	

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